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Performance of perisel as shelter and periphyton substrate in the floating cage of Pacific white shrimp culture

Kinerja perisel sebagai selter dan substrat penumbuh perifiton pada budidaya udang vaname di karamba jaring apung

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ABSTRACT

Shrimp culture in the floating cage is expected to reduce the utilization of land and its possible negative impact to the environment. The advantages of shrimp farming in the sea include the high dissolved oxygen concentration and the better meat quality. This research aimed to enhance the production performance of shrimp through the utilization of periphyton as a natural feed for shrimp. A completely randomized design with 3 treatments (in triplicates) were applied in this experiment, i.e floating cage without perishel (control), floating cage with PE perishel and PA perishel. Shrimp with body weight of 2.5 ± 0.2 g were stocked at the initial density of 2,000 shrimp in each cage, and maintained for 90 days. No significant difference was observed in the survival amongst treatments. The lowest feed conversion ratio (1.74) and coefficient of variance (3.21) were showed in treatment PA. The highest attachment and abundances of periphyton were found in treatment PA. It was concluded that the addition of perishel inside the floating cage may contribute as natural feed source for the shrimp and thus increase the production performance of shrimp.

Keywords: floating cage, *Litopenaeus vannamei*, periphyton, perisel, shelter

ABSTRAK

Budidaya udang di KJA diharapkan dapat menekan isu pemanfaatan daratan sebagai tambak yang berdampak pada permasalahan lingkungan. Keunggulan laut untuk budidaya udang, antara lain adalah kadar oksigen terlarut relatif tinggi sehingga tidak perlu kincir, dan mutu daging udang yang dihasilkan relatif lebih baik. Penelitian ini ditujukan untuk meningkatkan kinerja produksi dan memanfaatkan kesuburan perairan laut berupa perifiton sebagai pakan alami bagi udang. Penelitian ini terdiri atas tiga perlakuan, yakni: (A) kontrol (tanpa perishel), (B) jaring benang nilon (PE), dan (C) jaring benang serabut pendek (PA 6.6), masing-masing perlakuan terdiri dari tiga ulangan. Udang dengan bobot 2,5 ± 0,2 g ditebar sebanyak 2.000 ekor perwadah, dan dipelihara selama 90 hari. Hasil analisis kinerja produksi menunjukkan bahwa kelangsungan hidup tidak berbeda nyata antarperlakuan. Nilai konversi pakan terendah diperoleh pada perlakuan jaring benang PA dengan nilai 1,74. Nilai koefisien keragaman terendah diperoleh pada perlakuan jaring benang PA dengan nilai 3,21. Penempelan dan kepadatan perifiton yang cukup baik diperoleh pada jenis perishel jaring benang serabut pendek PA. Dengan demikian dapat disimpulkan bahwa dengan penambahan perishel sebagai shelter dan penumbuh perifiton diperoleh hasil produksi yang baik. Udang dapat memanfaatkan keberadaan perishel dalam wadah pemeliharaan sebagai tempat berlindung dan memperoleh makanan tambahan berupa pakan alami yang menempel pada perishel.

Kata kunci: karamba jaring apung, perifiton, perisel, selter, udang vaname

INTRODUCTION

Pacific white shrimp has been considered as high valuable export commodity from Indonesia fishery product (the second largest of shrimp exporter after China), contributing to 11.34% of world fishery trade (FAO, 2015). Shrimp-derived products have high quality in term of taste and protein content. Fry of white shrimp from Indonesia have been considered as specific pathogen free and as well as lower production cost than tiger shrimp, thus promising high potential in the future market (Lebel *et al*., 2010). The use of coastal area for shrimp culture needs to be improved. According to biological feasibility evaluation, shrimp farm using floating cage was deemed as productive activity in Mexico (Zarain-Herzberg *et al*., 2006). This technique is expected to reduce the utilization of land and its possible negative impact to the environment (Sanchez-Jerez *et al*., 2016; Lester *et al.*, 2018).

Coastal area has many advantageous characteristics for shrimp culture such as high dissolved oxygen and stability, as well as yielding high quality shrimp meat (Kasnir *et al*., 2014, Maicá *et al*., 2014), and producing low accumulation of solid waste around floating cage (Almuqaramah *et al*., 2018). Currently, several obstacles were observed for application of floating cage for shrimp culture. Low growth and survival rate in high density shrimp culture may result from combined factors such as space utilization, feed efficiency, presence of cannibalism (especially during molting), degradation of water quality from sediment accumulation.

Periphyton is one the nutritional sources for aquatic organism. White shrimp was reported to show feed retention of 17% used for meat production, while the rest was released as unconsumed feeds and metabolite that are accumulated in the sea water (Avnimelech, 2007). Periphyton shows several functions such as providing alternative feed with high nutritional content, stimulating non-specific immune system of shrimp larvae. High periphyton availability in nature is expected to result in high commercial feed efficiency and reduce cannibalism (Pandey *et al*., 2014). Periphyton-assisted aquaculture is applicable, but periphyton production was low due to limited attachment substrate. Beneficial effects of artificial substrate (perishel) for shrimp growth may show differences in some aspects including improvement of water quality, addition of natural feed supplement, and limited reproduction ability of pathogen bacteria. As shelter may provide protection against cannibalism during molting, and new space (Zarain-Herzberg *et al.*, 2006). This research aimed to observe effects of perishel as periphyton substrate and shelter on shrimp culture performance in floating cage.

MATERIALS AND METHOD

Experimental setup

The experiment was conducted in Sendang bay, Pemuteran, North Bali during April-June 2016. A completely randomized design with 3 treatments (in triplicates) were applied in this experiment, i.e floating cage without perishel (control), floating cage with PE/polyethylene perishel and PA/polyamide perishel**.** A total of 9 floating cages made of wood were used. Each cage was covered by layers (3m × 3m × 3m) with mesh size 5 mm and 7 mm. The cage was covered by net at the top to reduce light and protect against predators, and supported by PVC tubes in the bottom for ballast. Perishel (1m × 1m × 2m) was combination of periphyton substrate and shelter seems like apartment 4 layers: PE (mesh size 5 mm) and PA (mesh size 7 mm). Feeding tray was set in the center of cage. A perishel was horizontally set in each cage, and submerged for 5 days before experiment to produce biofilm layers (Burford *et al*., 2004).

Shrimp culture

Shrimp *Litopenaeus vannamei* (average weight of 2.5 ± 0.2 g) was obtained from PT TOP Bali at salinity of 32 mg/L with culture of 35 days. The shrimp was selected for its size and health status (visual, SPF and SPR). Adaptation was performed in floating cage in Pemuteran. Shrimp (density of 200 individuals/m^2 or 2000 individuals/cage) was culture for 90 days. Determination of water quality, feeding, periphyton, and shrimp sampling, and net substitution were carried out during culture. Feeding with commercial pellet (protein 40%) was conducted at 5 times a day (07.00, 10.00, 14.00, 18.00 and 22.00 WITA). Water quality (temperature, pH, salinity, DO, lightness) was daily determined *in situ* at 07.00 and 22.00, while determination of alkalinity, ammonia, nitrite and nitrate was performed each 10 days.

Data analysis

Growth performance were evaluated using Microsoft Office Excel 2010 and analysis of variance (ANOVA) using SPSS 22 at significance level of 0.05. The significance of variance was then verified by Tukey test. Periphyton density, shrimp glucose haemolymph and water quality were analyzed descriptively (Apún-Molina *et al.*, 2015; Novianti *et al.*, 2016; Arsad *et al.*, 2019; Martínez-Antonio *et al.*, 2019).

RESULTS AND DISCUSSION

Results

Table 1 exhibits growth performance of shrimp, including survival rate (SR), average daily growth (ADG), specific grow rate (SGR), feed conversion ratio (FCR), coefficient of variance (CV), and production. Data revealed that SR, ADG, SGR, and production showed no significant difference (P>0.05). FCR and CV with perishel treatment showed lower compared with the control (P<0.05). Figure 1 displays periphyton density pattern in two types of perishel. Perishel PA showed higher production in comparison with perishel PE.

Determination of glucose haemolymph was to understand stress condition, and performed in day-0, day-1, day-45, and day-90. High glucose haemolymph was detected in the initial period of culture, and it showed a decrease in the middle of period. However, there was an increase of glucose haemolymph in the end of experiment. Table 2 exhibits that water quality (temperature, salinity, pH, DO, lightness, alkalinity, ammonia, nitrite and nitrate) is in acceptable condition for shrimp culture.

Discussion

Survival rate (SR) is a major parameter of an aquaculture, and its high value is meaningful for production successful. Table 1 showed that SR was insignificant, ranging from 67.47% until 69.98%, that was lower than results observed by Zarain-Herzberg *et al* . (2006). Their work was able to attempt SR of 81.2% until 94% using similar density of 200 individuals/m^2 with artificial substrate. SR of white shrimp was 80% until 85% intensive culture in pond (Ditjen Budidaya 2016). Our data suggest that perisel seems to be uneffective to improve SR, which is linked with limited shrimp distribution and shrimp accumulation in the bottom.

Table 1. Growth performance of shrimp maintained in floating cage for 90 days

Parameters	Treatments		
	Control	PE	PA
Survival rate (%)	67.47 ± 2.73^a	69.22 ± 1.81^a	69.98 ± 1.19^a
Average daily growth (g/day)	0.19 ± 0.01^a	0.20 ± 0.01^a	0.20 ± 0.01^a
Specific growth rate (%/day)	2.40 ± 0.04^a	2.41 ± 0.04^a	2.44 ± 0.04^a
Feed conversion ratio	1.98 ± 0.06^b	1.81 ± 0.02^a	1.74 ± 0.11^a
Coefficient of variance (%)	3.57 ± 0.13^b	3.30 ± 0.11^{ab}	3.21 ± 0.11^a
Production (kg/m^2)	2.74 ± 1.81^a	2.85 ± 1.40^a	2.93 ± 1.12^a

Different superscripts letters in the same row indicate significant difference (P < 0.05).

Table 2. Water quality (temperature, salinity, pH, DO, lightness, alkalinity, ammonia, nitrite, and nitrate) of shrimp culture in floating cage for 90 days

Parameters	Value range		Optimum value
	07.00	22.00	
Temperature (°C)	30–31	30–31	28–30 (Sudaryono *et al*., 2018)
Salinity (g/L)	31–34	30–35	32–33 (Sudaryono *et al*., 2018)
pH	7.5–8.2	7.4–8.3	6–9 (Ferreira *et al*., 2015)
DO (mg/L)	4.1–4.9	4.0–5.3	> 3 (Ferreira *et al*., 2015
Lightness (m)	8–15		> 5 (Effendi, 2016)
Alkalinity (mg/L)	116		50–300 (Furtado *et al*., 2015)
Ammonia (mg/L)	0.00–0.17		< 0.2 (Ferreira *et al*., 2015)
Nitrite (mg/L)	0.014–0.016		< 0.2 (Ferreira *et al*., 2015)
Nitrate (mg/L)	0.117–0.561		< 0.7 (Ferreira *et al*., 2015)

Growth is also an important parameter, and influenced by density, space availability, amount of feed, feed quality, and water quality. Average daily growth (ADG) and specific growth rate (SGR) showed insignifcant difference (P>0.05). We found that daily growth was 0.20 g/day in perishel treatment, which was almost similar to result reported by Zarain-Herzberg *et al* . (2006), but higher than result reported by Fendjalang *et al.* (2016), namely 0.11 g/day. Similar growth rate in all our treatments indicated that feeding and water quality were acceptable for shrimp growth. The bay provided more beneficial condition than strait as conducted by Fendjalang *et al*. (2016). Generally, strait has strong water wave, thus shrimp need more energy for their survival.

Feed conversion ration (FCR) is defined as feed (kg) converted to produce 1 kg of fish biomass (Fry *et al*, 2018; Rana, 2018). Higher FCR means that higher amount of feed required to production 1 kg of shrimp meat (Sudaryono *et al.*, 2013). Statistical analysis revealed that perisel showed significant effects (P<0.05) on FCR, 1.98 for control, 1.81 for perisel PE, and 1.71 for perisel PA. These FCR values were higher in comparison with values obtained from shrimp culture in pond (1.3). The lowest FCR was attributed to perisel PA6.6. Our visual observation showed that vannamei shrimp was responsive to biofouling attatched in perisel, that is able to used as source of additional feed.

Coefficient of variance (CV) represents the degree of shrimp weight similarty in the end of culture. Higher CV is attributed to lower weight variance. Low CV was more desirable, which means degree of shrimp weight variance in the same cage. CV was affected by amount of feed, feed quality, and feed utilization. We found that CV of shrimp was 3.57 (control), 3.30 (perisel PE), and 3.21 (perisel PA). Our experiment revealed that perisel significantly affected CV (p<0.05). Presence of perishel is meaningful for shrimp as source of additional feed and higher space availability. Luan *et al.* (2020) reported that the coefficient of variance of body weight were lower under the *ad libitum* regime than the restricted regime. The competition for food under the restricted regime was definitely higher amongst individuals in the same environment. It was presumably caused by the limited amount of feed and space. The existance of perishel added the feed source besides the actual feed so that the perishel PA treatment obtained lower CV.

High production was expected to provide profitable shrimp culture. Table 1 exhibited that yield was not different in all treatments. The yield was 2.74 (control), 2.85 (perisel PE), and 2.93 (perisel PA). Low production level in our research was a consequence of low SR. The shrimp death was calculated by counting the living shrimp in the end of culture period. However, we also observed loss shrimp during culture. The shrimp death mostly occurred when shrimp weight was at 10 g/individual.

Periphyton is inexpensive feed source, easy to produce, and consumable for all stages of shrimp. In larvae stages, shrimp consumed diatom, algae filament, sea grass, zooplankton, small mollusc, small shrimp, polychaeta, other invertebrata, and detritus aggregate (Ekawati *et al.*, 2013; Kawamura *et al.*, 2017). Periphyton technology for reduction of FCR for shrimp culture in pond

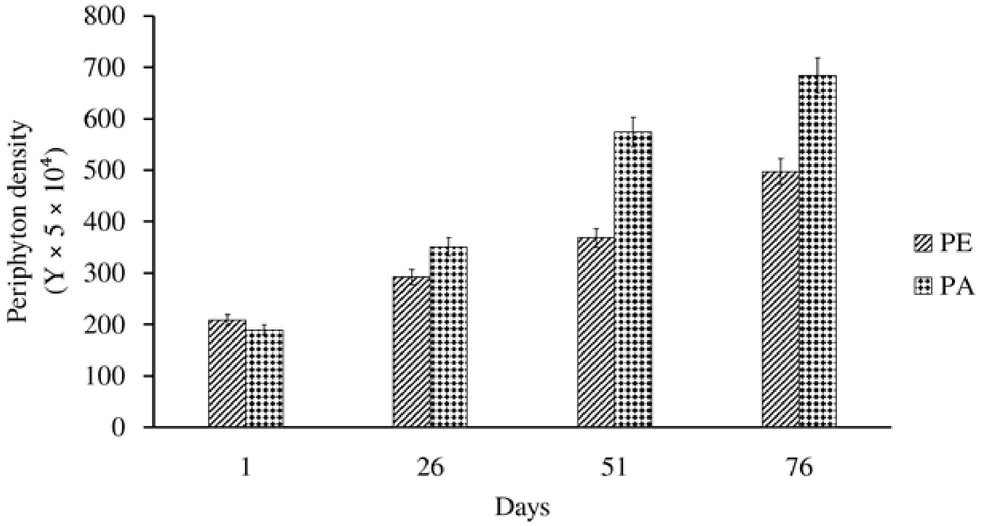

Figure 1. Periphyton density in two types of perishel (PA and PE) during 90 days of culture in floating cage.

has been widely applied and showed desirable results (Haque *et al.*, 2016; Jhaa *et al.*, 2018; Kumar *et al*., 2015). In our experiment, we made perisel to help production of periphyton, leading to growth of biofouling and production of natural feed for shrimp. Figure 1 exhibited that high periphyton density was observed in perisel PA. Perisel PA resulted in lower FCR and CC than control and perisel PE, indicating that shrimp was able to utilize periphyton available in perisel surface. Perisel PA with coarse surface seems to be more acceptable for periphyton growth than perisel PE with glossy surface.

Similar to other animals, intolerable changes in enviromental condition may also induce stress condition for crustaceae (Shields *et al*., 2019; Yusran *et al.*, 2021). Stress condition is responsible for changes in physiological condition and immune system. Glucose haemolymph is an indicator of stress occurrence (Stoner, 2012; Jayasree *et al.*, 2017). Glucose plays important role in regulating homeostasis condition through utilization of energy from glicolysis regulated by crustacean hyperglycemic hormone (Nagai *et al*., 2011; Wang *et al.*, 2016; Zhang *et al.*, 2019). Wang *et al*. (2019) and Zhao *et al.* (2020) found that shrimp with stress condition had high glucose haemolymph and total hepatopancreatic lipid levels. In our experiment, level of glucose haemolymph was high in the initial period, but it tend to decrease in day-50 and increase in the end of experimental period (Figure 2).

Presence of stress may resulted from extreme changes of environmental condition (from nursery pond to floating cage) and small shrimp size. In addition, physical disturbance during transportation is also responsible for inducing stress (Masud *et al.*, 2019). At day-50, glucose haemolymph was decreased (61.01 until 71.35 mg/dL), almost similar to value in the initial stage of culture (before transferring into cage). Decreased glucose level indicated that shrimp was able to adapt with new environment. During grow out experiment, shrimp is able to use perisel as shelter for protection (during molting phase) and provide wider space. However, improper shrimp distribution leads to cannibalism. In the end of culture, blood glucose levels were slightly increased (100 mg/dL), caused by physical factors of water such as jelly fish blooming and high intensity raining.

Water condition that is similar to natural habitat is an important factor for shrimp culture in coastal area. Effect of natural factors is fundamental, although these factors are uncontrollable. To deal with this situation, fry was stocked in nursery cages until juvenile reached 2.5 g/individual, as conducted by Zarain-Herzberg *et al*. (2006) and Zarain-Herzberg *et al*. (2010). As presented in Table 2, water quality included temperature, salinity, pH, DO, lightness, alkalinity, ammonia, nitrite, and nitrate. Our data demonstrated that all these parameters were in optimum range for shrimp culture.

CONCLUSION

Our data demonstrated that the use of perishel for white shrimp culture in floating net cage was beneficial as substrate for periphyton

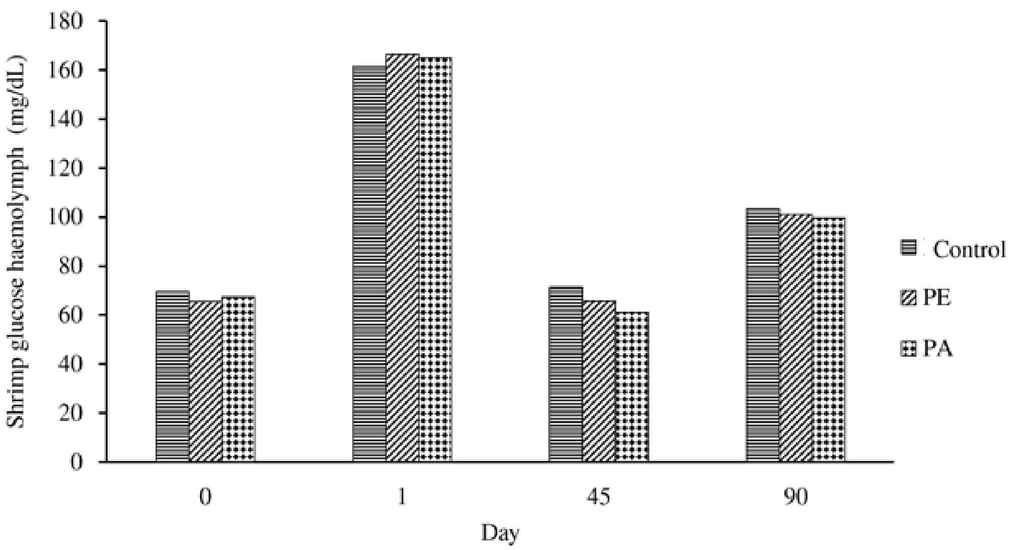

Figure 2. Shrimp glucose haemolymph measured at day-0, day-1, day-45, and day-90.

and shelter, especially perishel PA. Perishel was also meaningful for providing natural feed for shrimp thus improving feed efficiency and growth, contributing to maximum production performance.

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