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Growth and Body Composition of Spiny Lobster (*Panulirus homarus*) Reared with Short-Term Fasting

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Abstract: Slow growth rate tends to be a challenge in the cultivation of spiny lobster (*P. homarus*) because it impact on long rearing periods and high operational costs, especially for feeds. Short-term starvation or fasting has known to allow the minimum feed usage without inhibiting biota growth, also improves digestive function, reduces the amount of water-soluble nutrient metabolites, and reduces operational costs. Spiny lobster (*P. homarus*) measuring 50.0 ± 10.0 g was reared for 6 weeks in floating net cages. Lobsters were fasted at intervals of 1 fasting day/1 day of feeding, 1 fasting day/2 days of feeding, and fed daily. Survival, growth, and feed efficiency of spiny lobster (*P. homarus*) were analyzed. Higher growth rate and energy retention were found in spiny lobster (*P. homarus*) reared with short-term fasting system. Lower FCR also found in the same rearing system. Spiny lobster (*P. homarus*) body content indicate its ability to store nutrient in mucle and hepatopancreas in order to adapt to starved condition. Short-term fasting can improve growth and feed efficiency in spiny lobster (*P. homarus*) cultivation.

Keywords: Feeding regime; Growth; Lobster; Panulirus

Introduction

Spiny lobster cultivation activities are currently developing in various countries (Amali et al., 2020). The stocks of lobster seeds in nature, simple cultivation technology (Jones, 2010), as well as high selling value and market demand in both the domestic and international markets make marine lobster cultivation in demand and developing (Taridala et al., 2019). Feed is one factor that determines the success of spiny lobster cultivation. Feed management is related to the growth rate. Optimal utilization of nutrient from feed will result in an increase in body weight (Setiawati et al., 2013). Efficient use of feed is expected to reduce feed usage without disrupting the growth of spiny lobster (*P. homarus*) (Karimah et al., 2018).

Restricted feeding is a feeding regime in which the amount of feed given is less than the normal amount of feed. It can be applied by reducing the daily amount of feed or limiting the feeding time (Rahman et al., 2020). The application of restricted feeding can be done by doing short fasting on the cultivated organism. In such a system, feeding is divided into 2 periods, namely the period when the biota are not fed/starved and the period when the biota are fed (refeeding). Fasted organisms will experience hyperphagia that will increase feed consumption when the organism is fed again. The organism will adapt to conditions of limited food by lowering the basal metabolic rate so that when it consumes feed again, the nutrients obtained from the feed will be utilized for growth rather than metabolism. That may impact to growth acceleration also known as compensatory growth (Zhu et al., 2016; Jena et al., 2017; Hasanah et al., 2020; Stumpf et al., 2020).

Fasting in spiny lobster rearing can be done because lobster has the ability to survive under conditions of limited feed availability. Spiny lobsters had been know to utilize energy reserves in the form of lipids and proteins to meet specific energy requirements without reducing life and growth performance when feed availability is limited and reducing energy use when feed is available (Wang et al., 2019). Energy is obtained

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from protein, fat and carbohydrates in feed. The amount of nutrients from feed that are stored as energy reserves in the body can be described by muscle and hepatopancreas nutrient content. The energy reserves are used when the lobster is in a state of food deprivation (Johnston et al., 2004).

A number of researches about restricted feeding regime by fasting in cruscatea had been done and resulted to normal growth rate and improvement in feed utilization. Giant prawns (*Macrobrachium rosenbergii*), vannamei shrimp (*Litopenaeus vannamei*), and crayfish (*Cherax quadricarinatus*) that were fasted for 1 day after several days of feeding period were found to have the same growth as organism reared by being fed every day (Utomo, 2018; Yildirim et al., 2018; Iransyah, 2021). Application of the fasting system to freshwater decapod species is thought to be applicable to the cultivation of the sand lobster (*P. homarus*).

Method

Location and Time of Research

The research was conducted from August to September 2022. The rearing of test animals was carried out in floating net cages located at Hurun Bay, Lampung Regency, Indonesia. Proximat analysis was conducted at Laboratory of Fish and Environmental Health, Marine Aquaculture Development Center of Lampung, Lampung Regency, Indonesia.

Research Design

The study were using completely randomized design with 3 treatments and 3 trials each. Spiny lobsters were fed with 3 different feeding regime: (A) 1 day fasting after 1 day of feeding, (B) 1 day fasting after 2 days feeding, and (C) Fed daily.

Spiny Lobster Rearing

Spiny lobsters (*P. homarus*) (50.0 ± 0.4 g) were reared for 6 weeks in floating net cages. Fresh feed were given during the rearing period with feeding rate 20%. Feeding were done 2 times/day at 08.00 and 17.00. Body weight were measured by using electric balance every 2 weeks. Survival, specific growth rate (SGR), absolute weight gain, and FCR were calculated at the end of rearing period by using the following formulas:

$$SR = \frac{Nt}{No} \times 100\% \quad (1)$$

Description: SR = Survival rate (%), Nt = Initial population (ind), No = Final population (ind).

$$WG = W_f - W_0 \quad (2)$$

Description: WG = Absolute weight gain (g), W_f = Final body weight (g), W_0 = Initial body weight (g).

$$SGR = \frac{\ln Wt - \ln W0}{t} \times 100 \quad (3)$$

Description: SGR = Specific growth rate (%), W_t = Final body weight (g), W_0 = Initial body weight (g), t =Time (day).

$$FCR = \frac{W}{F} \quad (4)$$

Description: FCR = Feed conversion ratio F = Total feed (g), W = Total body weight gain (g).

Body Content Analysis

Muscle and hepatopancreas content were measured by proximat analysis (AOAC, 2005) at the beginning and the end of trial.

Data Analysis

Collected data were tested for assumption of normality and homogenecity. Variations between all treatments were compared using One-Way ANOVA with a 95% confidence level (p> 0.05) and continued with LSD test. Statistical analyses were performed using using SPSS 22.0 software for Windows.

Result and Discussion

Growth, Survival, and FCR of Spiny Lobster (P. homarus)

Spiny lobsters (*P. homarus*) reared in treatment A (1 day of fasting per 1 day of feeding) showed the highest increase in weight (32.97 g), while the lowest was found in lobsters that fed daily (27.97 g) (Fig. 1.). The highest SGR were also found in treatment A and significantly different (p <0.05) treatment B and C. SR of spiny lobsters (*P. homarus*) during the study was relatively high (Table 1.) with no significant difference between all treatments (p <0.05). FCR of all treatments were significantly different (p <0.05) which the values were related with the amount of feed intake.

Table 1. Growth Performance (mean ± SD) of Spiny Lobster (*P. homarus*) Fed with Short-Term Fasting Feeding Regime

Parameters	Treatments		
	A	B	C
Survival rate (%)	98 ± 1.63^a	98 ± 1.63^a	99 ± 0.94^a
Initial weight (g)	44.33 ± 1.2^a	53.00 ± 1.3^b	52.60 ± 0.6^b
Final weight (g)	77.03 ± 0.9^a	84.77 ± 1.0^b	80.57 ± 1.6^c
AWG (g)	32.70 ± 0.41^a	31.78 ± 0.75^a	27.97 ± 2.07^b
SGR (%weight/day)	1.32 ± 0.04^a	1.12 ± 0.04^b	1.01 ± 0.07^b
FCR	17.1 ± 0.24^a	10.9 ± 0.38^b	18.8 ± 1.16^c

Description: Different superscripts in the same column shows that there are significant differences (p <0.05).

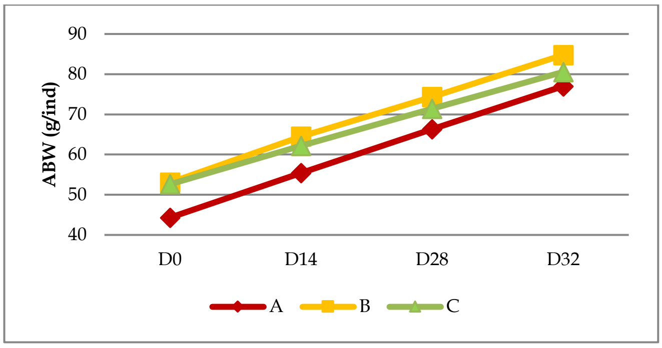

Figure 1. Absolute weight gain of spiny lobster (*P. homarus*)

Description: ABW: average body weight, D: day of culture, A: 1 day fasting /1 day feeding, B: 1 day fasting/2 day feeding, C: 0 day fasting/feed daily

Growth is defined as the increase in body weight and length during rearing period (Prariska et al., 2020). Spiny lobster in treatment A and B showed acceleration in weight gain during D14 until D32. The phenomenon was assumpted as a compensatory growth, i.e. growth acceleration due to restricted feed. The assumption was appropriate with the statement of Hasanah et al. (2020) that short-term fasting can have an impact on a growth acceleration or compensatory growth.

According to Wu et al. (2001), one of the parameters in detecting compensatory growth is specific growth rate. Specific growth rate (SGR) is the growth of organism in a certain period of time. In this study, the average SGR of spiny lobsters (*P. homarus*) reared with short-term fasting (1.32% weight/day and 1.12% weight/day) were higher than lobsters that fed daily (1.01% weightday). Those was higher than average SGR of spiny lobster (*P. homarus*) fed with fresh food, namely 0.5-1% per day (Adiputra et al., 2020) and 0.3-0.5% per day (Jayakumar et al., 2011). Differences in SGR can be caused by environmental conditions, feeding frequency (Mazlum et al., 2011), aquaculture management, and feed nutrition (Adiputra et al., 2020). According to Zaidy et al. (2008), high growth rate is the consequence of higher feed consumption rate. High feed consumption rate of spiny lobster (*P. homarus*) in this study was suspected to be the effect of hyperphagia that was caused by starvation that came as the effect of fasting period. Increased feed consumption after a short period of starvation can result in a growth acceleration that also known as compensatory growth (Hasanah et al., 2020).

Survival rate (SR) is the percentage of the number of organisms that lived at the end of the cultivation period. The mortality of spiny lobsters (*P. homarus*) on this study were suspected due to cannibalism, as lobster population had decreased yet no dead lobsters were found in the rearing containers. Cannibalism in crustaceans can occurs during the molting phase (Romano et al., 2016; Pratiwi et al., 2016). Cannibalism generally appears in healthy lobsters, while lobsters that are weak due to moderate conditions or after molting are prone to being targeted (Supriyono et al., 2017; Nugraha, 2019). Nutritional deficiency was also suspected to be the cause of death in reared lobsters. Lobsters that experience nutritional deficits are characterized by a pale to milky white shell color and very passive movements. During the rearing period, 2 lobsters in treatment A were found to have symptoms of nutritional deficits. According to Sanchez-Paz et al. (2006), nutritional deficiency can be caused by limited amount of feed available, that in this case it might be happened on the period when lobster was fasted.

FCR is the ratio of lobster weight gain to the amount of feed spent during rearing periods. The lower the FCR means feed were utilized more efficiently (Nugraha et al., 2019). The low FCR in treatment A (Table 1) was due to the high growth rate while less feed was given. The same trend was also found in the rearing of *M. rosenbergii* (Rahman et al., 2019) and *A. leptodactylus* (Mazlum et al., 2011), where feeding with a restriced feeding system resulted in a lower FCR compared to daily feeding. The application of 1 day fed per 1 day fasting in *L. vannamei* cultivation was known to reduce feed requirements by up to 50% (Rocha et al., 2019). The same results were also shown by this study, where the maintenance of sand lobster (*P. homarus*) with a feeding system reduced feed use by 53% and reduced FCR by 60%.

Body Composition

Spiny lobster (*P. homarus*) that fasted 1 day after 2 day of feeding (treatment B) showed lower protein and lipid values, while lobster fasted 1 day after 1 day of feeding (treatment A) showed the opposite result (Table 2.).

Table 2. Muscle and Hepatopancreas Content (mean ± SD) of Spiny Lobster (*P. homarus*) Fed with Short-Term Fasting Feeding Regime

Parameters	Treatments		
	A	B	C
Muscle			
Protein (%)	60.18±0.04[a]	59.44±0.06[b]	58.01±0.14[c]
Lipid (%)	3.2±0.15[a]	2.6±0.26[b]	3.1±0.08[a]
Carbohydrate (%)	11.2 ± 0.22[a]	11.6 ± 0.30[a]	11.7 ± 0.10[a]
Hepatopancreas			
Protein (%)	60.48 ± 0.18[a]	59.92 ± 0.18[b]	60.67 ± 0.05[a]
Lipid (%)	6.3 ± 0.57[a]	6.5 ± 0.31[a]	5.8 ± 0.09[a]
Carbohydrate (%)	8.5 ± 0.11[a]	8.6 ± 0.25[a]	8.6 ± 0.12[a]

Description: Different superscripts in the same column shows that there are significant differences (p <0.05).

Protein and lipid content were significantly different in all treatment both in muscle and hepatopancreas (p <0.05), while carbohydate had no significat different. The amount of heaptopancreas lipid in all treatments was higher compared to the muscle lipid. This indicated the role of hepatopancreas in body lipid storage. The same trend were also found in *L. vannamei* (Yildrim et al., 2018). Hepatopancreas is known to play a role in the storage and mobilization of nutrient reserves when lobsters are hungry or lack of food (Albalat et al., 2017; Li et al., 2022).

Lobsters utilize most of the energy from feed for metabolism, and the rest is used for activity, growth, and reproduction (Nugraha et al., 2019), and stored to be utilized when food is not available (Johnston et al., 2004). According to Wang et al. (2019), metabolic energy in starved lobsters comes from lipid oxidation and protein (amino acid) oxidation, while carbohydrates play only a minor role. Nutrient molecules that enter the body will undergo a synthesis process, used in the digestive process, or oxidized into simpler compounds (amino acids, fatty acids, and glucose), and produce adenosine triphosphate (ATP) which can be absorbed by the body to be used or stored as energy reserves (Arief et al., 2012).

Conclusion

The application of short-term fasting resulted better growth and FCR compared to the daily-feeding system. Spiny lobster (*P. homarus*) that was fasted for 1 day after 1 day of feeding showed the best growth performance with average SR 98%, weight gain 32 g, SGR 1.32% weight/day, and FCR 7.1. Muscle and hepatopancreas composition of spiny lobster (*P. homarus*) showed its ability to adapt with short-term fasting feeding regime by reserving lipid and protein to be used in the condition of feed deprivation. Short—term fasting feeding regime can be applied to improve the productivity of spiny lobster cultivation.

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Author Contribution

Conceptualization, Pranawengrum, Arning, and Fadjar; Data curation, Pranawengrum; Writing original draft, Pranawengrum; Writing-review and editing, Pranawengrum, Arning, and Fadjar

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Conflicts of Interest

No conflict of interest.

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