Post puerulus of scalloped spiny lobster, *Panulirus homarus* (Linnaeus 1758) rearing in floating net cage with different artificial diet

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**Abstract.** Scalloped spiny lobster (*Panulirus homarus*) is an export commodity and high economic value in Asian-Pacific markets. The purpose of this study was to determine the best artificial feed for scalloped spiny lobster nursery in floating net cage. The nursery was conducted using 9 floating net cage 1 × 1 × 1 m in size with three treatments and 3 replicates. Three different artificial diets were used as treatments, i.e.: A, commercial pellet for grouper, with higher protein level (53.56%) but lower stability, less durable in water and will break within 3-4 hours after administration; B, commercial pellet for shrimp, with lower protein level (33.07%) but higher stability, will break within 10-12 hours after administration and C: pellet formula IMRAD Gondol, with middle protein level (46.51%) and higher stability, will break within 10-12 hours after administration. The post puerulus with total length 2.1±0.18 cm and body weight 0.28±0.04 g was reared at density of 100 ind/cage. A complete random design was used as an experiment design and analyzed by ANOVA. Feeding were given twice a day, 5% of biomass/day. The study was conducted for 4 months. The sampling of survival rate, total length and body weight were conducted every month and total haemocyte on the end of experiment was measured. The result showed that there was significant different (P<0.05) for survival rate, but not significant different (P>0.05) among treatments for growth of total length and body weight. The best survival rate was on treatment C (39.0%), followed by treatment A (29.7%): and treatment B (16.7%). The number of haemocyte was almost the same between treatments with total haemocyte 250-285 x 10⁴ per ml. From these results it can be concluded that pellet formula IMRAD Gondol can be used for rearing of scallop spiny lobster post puerulus.

**Keywords:** Scalloped spiny lobster, nursery, artificial diet

1. **Introduction**

   Spiny lobster is one of very valuable seafood in the world and supports some of the world's largest commercial fisheries. Scalloped spiny lobster (*Panulirus homarus*) is an export commodity and high economic value in Asian-Pacific markets. In some locations, spiny lobsters have shown overfishing [1, 2]. There are some species of spiny lobster in Indonesia i.e. scalloped spiny lobster (*Panulirus homarus*), ornated lobster (*P. ornatus*), bamboo lobster (*P. versicolor*), Pakistan lobster (*P. polyphagus*), rock lobster (*P. penicillatus*) and red lobster (*P. longipes*). Scalloped spiny lobster was
potential for aquaculture because of high value and supported by availability of wild fry [3]. Lobster cage culture has great potential to develop in Indonesia. Indonesia has 5.8 million km$^2$ of marine area, 17,504 islands and 81,000 km of coastline, including many lagoons and bays that are suitable for sea cage culture.

The main problem of spiny lobster aquaculture is high mortality because of cannibalism during mounting [4] and disease caused by mall nutrition and handling stress. High mortality during nursery of post puerulus also a problem of spiny lobster aquaculture in Indonesia [5]. Scalloped spiny lobster grow out in India start from 70-100 g body weight with high survival rate, about 70-75% [6]. Usualy for grow out of scalloped spiny lobster start from 50 g body weight conducted in floating net cage in the sea, while nursery in the tank. Reported for nursery of scalloped spiny lobster in concrete tank with low survival rate of 10-30% [7]. Commercially, lobsters usually fed with fresh fish, crustaceans, and mollusks, although sometimes the inconsistency in quality of those foods leads to reduced growth and survival rate. At higher scales, the restricted access to the appropriated natural items and their storage would become a problem. Thus, formulated diet development is one of the key issues in successful aquaculture of lobsters in term of both profitability and sustainability. Natural foods have proved to promote higher growth than pellet diets in spiny lobsters [8-11]. It has been suggested that the differences in spiny lobster growth between fresh foods and formulated diets are probably due to differences in efficiency of the utilization of protein [8, 12].

From that case need to study on nursery with feeding more effective and efficient than that of using artificial diet (dry pellet). The purpose of this study was to determine the best artificial feed for scalloped spiny lobster nursery in floating net cage.

2. Material and methods
The nursery was conducted using nine floating net cages (1 $\times$ 1 $\times$ 1 m in size) with three treatments and three replicates. Puerulus of scalloped spiny lobster used for this research was obtained from the catch of fishermen in Lombok. Lobsters were acclimated for seven days before the experiment was conducted to be interested in eating artificial feed. Three different artificial diets were used as treatments, i.e.: A, pellet commercial for grouper, with higher protein level (53.56%) but lower stability, less durable in water and broken within 3-4 hours after administration; B, pellet commercial for shrimp, with lower protein level (33.07%) but higher stability, broken within 10-12 hours after administration and C: pellet formula IMRAD Gondol, with middle protein level (46.51%) and higher stability, broken within 10-12 hours after administration. The post puerulus with total length 2.1±0.18 cm and body weight 0.28±0.04 g was reared at density of 100 ind/cage; each treatment with 3 replicates. A complete random design was used as an experiment design and analyzed by ANOVA. Feeding were twice a day, 5% of biomass/day. The sampling of survival rate, total length and body weight were conducted every month and total haemocyte on the end of experiment. For supporting data was observed water quality parameters i.e. temperature, pH, DO, salinity, ammonia, and nitrite.

3. Results and discussion
The data of survival rate, total length, and body weight scalloped spiny lobster post puerulus reared at floating net cages for 4 month, fed with different dry pellet are shown in Table 1. Data of survival rate of scalloped spiny lobster (Panulirus homarus) fry, nursery in floating net cage with different of feed are shown in Figure 1. From data survival rate on experiment during 4 month rearing (Table 1 and Figure 1) showed that there was significant different (P<0.05) among treatments. The highest survival rate was on C treatment (pellet IMRAD Gondol formula) (39.0%), followed by treatment A (commercial pellet for grouper) (29.7%) and the lowest was on B treatment (commercial pellet for shrimp) (16.7%).
Table 1. Survival rate, carapace length gain, total length gain, body weight gain of scalloped spiny lobster (Panulirus homarus) fry during four months nursery in floating net cage with different feed.

| Parameter                        | Commercial pellet for grouper (A) | Commercial pellet for shrimp (B) | Dry pellet for lobster experiment result of IMRAD (C) |
|----------------------------------|----------------------------------|----------------------------------|-----------------------------------------------|
| Survival Rate (%)                | 29.7±3.06^a                      | 16.7±1.52^b                      | 39.0±3.5^c                                    |
| Initial carapace length (cm)     | 0.96                             | 0.96                             | 0.96                                          |
| Initial total length (cm)        | 2.1                              | 2.1                              | 2.1                                           |
| Final carapace length (mm)       | 1.95±0.61^a                      | 1.91±0.56^a                      | 1.98±0.62^a                                   |
| Final total length (mm)          | 4.9 ± 0.95^a                     | 4.7±0.93^a                       | 5.1±0.98^a                                    |
| Carapace length gain(cm)         | 0.99                             | 0.95                             | 1.02                                          |
| Daily carapace length growth (mm/day) | 0.083                             | 0.079                            | 0.85                                          |
| Total length gain(cm)            | 2.8                              | 2.6                              | 3.0                                           |
| Daily total length growth (mm/day) | 0.233                             | 0.217                            | 0.250                                         |
| Initial weight (g)               | 0.28                             | 0.28                             | 0.28                                          |
| Final weight (g)                 | 4.29±2.13^a                      | 3.84 ± 1.95^a                    | 4.44 ± 2.27^a                                 |
| Body weight gain (g)             | 4.01                             | 3.56                             | 4.16                                          |
| Daily weight growth (g/day)      | 0.033                            | 0.030                            | 0.035                                         |
| Food conversion ratio            | 3.0^a                            | 3.19^a                           | 3.20^a                                        |
| Final total haemocyte (x 10^4)   | 265±26^a                         | 285±35^a                         | 250±25^a                                      |

Figure 1. Survival rate of scalloped spiny lobster (Panulirus homarus) fry reared in floating net cage with different of feed.

Body weight growth of scalloped spiny lobster (Panulirus homarus) reared in floating net cage with different of feed are shown in Figure 2. From the data of body weight on experiment during four month rearing (Table 1 and Figure 2) showed that the highest on C treatment (pellet IMRAD Gondol formula) with mean of body weight in the end of experiment was 4.44 g; followed by A treatment (commercial pellet for grouper) (4.29 g) and the lowest on B treatment (commercial pellet for shrimp) (3.84 g); but from statistic analyze not significant different among treatment (P>0.05).
Figure 2. Body weight grow of scalloped spiny lobster (*Panulirus homarus*) reared in floating net cage with different of feed

Body total length growth of scalloped spiny lobster (*Panulirus homarus*) nursery in floating net cage with different of feed are shown in Figure 3. From data total length on experiment during 4 month rearing (Table 1 and Figure 3) showed that the highest on C treatment (pellet IMRAD Gondol formula) with mean of total length in the end of experiment was 5.1 cm; followed by A treatment (commercial pellet for grouper) with mean of total length in the end of experiment was (4.9 cm) and the lowest on B treatment (commercial pellet for shrimp) with mean of total length in the end of experiment was 4.7 cm); but from statistic analyze not significant different among treatment (p>0.05).

Figure 3. Total length grow of scalloped spiny lobster (*Panulirus homarus*) fry, nursery in floating net cage with different of feed

From Table 1, Figure 1, 2, and 3 showed that the best result (survival rate, body weight, and total length grow) was in C treatment (pellet IMRAD Gondol formula), followed by A treatment (commercial pellet for grouper) and the lowest on B treatment (commercial pellet for shrimp).
Table 2. Water quality on nursery of scalloped spiny lobster (*Panulirus homarus*)

| Parameter       | Value     | Optimum range |
|-----------------|-----------|---------------|
| Temperature (°C) | 28.95 – 29.5 | 28°C [25] |
| pH              | 7.9-8.2   | 7.07-7.86 [24] |
| DO (mg/L)       | 6.5-7.3   | 2.7-5.4 ppm [25] |
| Salinity (ppt)  | 33.9-34.2 | 30-40 ppt [26] |
| Ammonia (ppm)   | 0.018-0.025 | < 0.1 ppm [25] |
| Nitrite (ppm)   | 0.002-0.003 | <5 ppm [27] |

The data of proximate analyze of feed used on experiment of scallop spiny lobster nursery in floating net cage showed at Table 3.

Table 3. Proximate analysis of feed used on experiment of scallop spiny lobster nursery in floating net cage

| Nutrition  | A (commercial pellet for grouper) | B (commercial pellet for shrimp) | C (pellet IMRAD Gondol formula) |
|------------|----------------------------------|---------------------------------|---------------------------------|
| Protein    | 53.56                            | 33.07                           | 46.51                           |
| Fat        | 8.85                             | 7.07                            | 8.08                            |
| Ash        | 10.34                            | 9.72                            | 10.82                           |

The survival rate of scalloped spiny lobster post puerulus reared at floating net cages for 4 month (Table 1 and Figure 1) show that the highest survival rate is in C treatment (pellet IMRAD Gondol formula) (39.0%), followed by treatment A (commercial pellet for grouper) (29.7%) and lowest on treatment B (commercial pellet for shrimp) (16.7%). This result showed that pellet formula of IMRAD Gondol (C treatment was suitable as food for scallop spiny lobster nursery in floating net cage, because it had nutrition content as suitable for scallop spiny lobster fry. This pellet made from commercial shrimp pellet mixed with trash fish, mussel meat and krill. Spiny lobster has some similarity of character with shrimp. Spiny lobster and shrimp have similarity feeding strategy and use chemical and anthenulae for feeding censor. Spiny lobster also needs pellet with similar character as shrimp pellet, such as attractant and high stability in the water [13]. The survival rate during the nursery (Figure 1) sharply decreased in the first two months, then got slower in the next month because of cannibalism when molting. The molting frequency is related to the size of the spiny lobster; the younger spiny lobster with higher molting frequency and cannibalism than the larger size [14]. Spiny lobster grow out by battery system cannibalism can be reduced to 100% [15].

The result of survival rate of fry in this experiment (16.7-39.0%) is still lower than that another result. The growth of *P. homarus* started from 85 g body weight by feeding with trash fish in bottom cage with survival rate 75-85% during five months [16]. On ornate spiny lobster (*Panulirus ornatus*) grew out from 40 g body weigh using dry pellet as food [17], with result of survival about 84%. The best result (survival rate, body weight and total length grow) was in C treatment (pellet formula of IMRAD Gondol) followed by A treatment (commercial pellet for grouper) and lowest on treatment B (commercial pellet for shrimp) (Table 1, Figure 1, 2, and 3). The growth of *P. homarus* by giving dry pellet combination with clam meal diet gave the higher growth than that of giving squid meal and fish meal [18]. The differences in spiny lobster growth among diets (dry pellet) are probably due to differences in efficiency of the utilization of protein [6, 8, 12, 19].

The efficiency of protein utilization depends, in part, of the digestive process itself. Proteins ingested are hydrolyzed in the digestive tract into their constitutive amino acids by proteases that play the central role in protein digestion. This is of particular significance in crustaceans since they lack the
acids are needed for growth and maintenance and are the most expensive component in a diet. Thus, the selection of nutritional valuable protein sources is a key step in feed development for the on-growing of spiny lobsters.

The result on observation of total haemocyte (THC) (Table 1) showed that highest on treatment B (commercial pellet for shrimp) with total haemocyte (285±35)x10⁷ cells/mL, followed by treatment A (commercial pellet for grouper) with total haemocyte (265±26)x10⁴ cells/mL and lowest on treatment C (pellet IMRAD Gondol formula) with total haemocyte 250±25 x10⁴ cells/mL but from statistic analyze not significant different among treatment (p>0.05). The increasing of the THC concentration indicated that lobster exposed to stress. The stress response in the lobster can be caused by several things including environmental factors, handling and bacterial infections [21]. According to Jusilla et al. [22] the THC concentration of P. cygnus in normal conditions was in the range of 5.6±0.7 x 10⁶ cells/mL, therefore if the THC concentration was beyond these range, it can be assumed that lobster is in unstable condition.

Data of water quality during experiment i.e. temperature was 28.95-29.5°C; pH was 7.90-8.20; DO was 6.5-7.3; salinity was 33.9-34.2 ppt; amonia was 0.018-0.025; phosphate was 0.15-0.18, and nitrite 0.002-0.003 (Table 2); still in the range of good value for spiny lobster grow out in floating net cage. The results of Kulmye and Mavuti [14], that the scalloped spiny lobster grow well in water conditions at 25.5-29.5°C, pH 7.5-8.5, DO 4.5-7.5 and salinity 25-35 ppt. Spiny lobster P. homarus grow well at salinity of 30-35 ppt [23]. Water quality parameters showed optimal conditions supporting lobster life during study. The condition of pH is relatively stable in the range of 7.9-8.2 (Table 2). According to Adiyana [24], pH value within the range of 7.07-7.86 was still supported the life of P. homarus juvenile. The temperature condition during the study was in the range of 28.95-29.5°C (Table 2). The water temperature was also relatively stable throughout the study. Generally, P. homarus’s fastest growth can be generated at the water temperature of 28°C, so that it could be achieved in normal weather [25]. The salinity during the study was between 33.9-34.2 ppt (Table 2). Salinity conditions were still appropriate and could support the lobster’s life. P. homarus have a fairly broad salinity tolerance that was 30-40 ppt [26]. The value of water DO (dissolved oxygen) during the study was ranged from 6.5-7.3 ppm (Table 2). The optimal conditions of dissolved oxygen to support lobster’s life in aquaculture was ranged from 2.7 to 5.4 ppm [25]. The water nitrite’s concentration during the maintenance period was in the range 0.002-0.003 ppm (Table 2). The condition of nitrite in the water during the study remain relevant and could supported lobster’s life. Nitrite concentration < 5 ppm was recommended for Homarus gammarus lobster’s culture [27]. The ammonia concentration in the water during the maintenance period was in the range of 0.018-0.025 ppm (Table 2). It was still below the lethal limit (< 0.1 ppm) and still qualify for support the lobster’s [25].

Protein level of pellet used for treatment in this experiment were shown in Table 3. The highest protein level was pellet on treatment A (commercial pellet for grouper) (53.56%), followed by treatment C (pellet IMRAD Gondol formula) (46.51%) and lowest on treatment B (commercial pellet for shrimp) (33.07%). Fat content of pellet used for treatment in this experiment were shown in Table 3. The highest fat content was pellet on treatment A (commercial pellet for grouper) (8.85%), followed by treatment B (commercial pellet for shrimp) (8.08%) and lowest on treatment C (pellet IMRAD Gondol formula) (7.07%). From data of proximate analyzed showed that the highest protein and fat level was pellet on treatment A (commercial pellet for grouper) (53.56% protein, 8.85 fat), followed by treatment C (pellet IMRAD Gondol formula) (46.51% protein, 8.08 fat) and lowest on treatment B (commercial pellet for shrimp) (33.07% protein, 7.07 fat). Protein and fat content of commercial pellet for grouper (treatment A) is highest, but this feed is less durable in water and will break within 7-8 hours after administration. Commercial grouper pellets have stronger attractant, with lower stability than commercial shrimp pellets [16].
4. Conclusion
Pellet IMRAD Gondol formula can be used as food for spiny lobster post puerulus nursery in floating net cages with higher survival rate than commercial grouper pellet and commercial shrimp pellet.

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