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Exploring the Feeding Habits of Green Lobster (Panulirus Homarus) in Submersible Cages on the East Coast of Pangandaran Using Underwater CCTV

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Abstract

Lobster farming is increasingly capturing the attention of Indonesia's Ministry of Maritime Affairs and Fisheries, emerging as a significant sector alongside shrimp, tilapia, and seaweed cultivation. However, despite this growing interest, essential aspects of lobster farming technology remain underdeveloped. A critical area needing exploration is feeding behavior and dietary preferences of lobsters, as these factors are vital for their growth, survival, and behaviors such as cannibalism and molting. In this study, we aim to observe how green lobsters (Panulirus homarus) react to different types of natural food, specifically Acetes sp. and fresh anchovies, in varying quantities. We will evaluate the lobsters' growth by measuring weight gain and length increase, alongside their overall survival rate. the research was conducted in submersible cages off the picturesque East Coast of Pangandaran, utilizing underwater CCTV technology to capture detailed footage of their feeding behaviors from June to November 2024. We applied a Completely Randomized Design (CRD) for our experimental setting, featuring four distinct treatments, each replicated four times. The treatments included: A (5% Acetes sp.), B (8% Acetes sp.), C (5% anchovies), and D (8% anchovies). Preliminary findings reveal varied growth rates across different treatments: treatment A showed a growth rate of x%, while B was at xx%, treatment C at xx%, and treatment D reached 35%. The most considerable length increase was noted at 20 mm for treatment A, followed closely by 21 mm for treatments B, C, and D. Regarding weight, treatment A averaged 44 mg, treatment B 63 mg, treatment C 56 mg, and treatment D 30 mg. Notably, observations from the underwater CCTV indicated that the lobsters exhibited consistent food preference patterns, demonstrating a strong inclination toward natural food sources.

Keywords: Lobster, Growth, Survival Rate, Natural Food, Feeding Behavior.

1. Introduction

Green lobster (Panulirus homarus) is one of Indonesia's high-value marine fisheries commodities with strong demand in both domestic and international markets. According to data from the Ministry of Marine Affairs and Fisheries, lobster production from capture fisheries reached 8,719.92 tons in 2021 with an estimated value of IDR 2.8 trillion (KKP, 2022). However, lobster production from aquaculture remains relatively low, accounting for only 433 tons in 2023, despite Indonesia's substantial potential for lobster farming (BPS, 2024). This condition highlights the need to strengthen aquaculture-based lobster production to ensure sustainability and reduce pressure on wild lobster stocks.

Lobster aquaculture has been developed in several countries, including Japan, Australia, Vietnam, and New Zealand, primarily using submersible cage systems that are more suitable for the benthic behavior of lobsters (Phillips & Matsuda, 2011; Williams, 2019). In Indonesia, lobster cultivation is still largely conducted using floating net cages (keramba jaring apung), which are considered less optimal for bottom-dwelling species. Lobsters are highly sensitive to fluctuations in water quality caused by environmental changes, and inappropriate culture systems often result in low survival rates, reported to range between 40–50% (Utomo et al., 2022).

Feed management is another critical factor influencing lobster growth and survival. Lobsters undergo periodic molting during their growth cycle, a process that requires sufficient mineral intake, particularly calcium and phosphorus, to support exoskeleton hardening (Lall, 2000; Romano & Zeng, 2017). In practice, lobster feeding in Indonesia still relies heavily on trash fish, which presents several limitations, including low feed efficiency, high organic waste production, and inconsistent nutrient composition (Said & Sya'bani, 2014). Previous studies have indicated that natural feeds rich in calcium and phosphorus, such as anchovies

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(Stolephorus sp.) and Acetes sp., may improve growth performance and feed utilization efficiency in crustaceans (Lisandari et al., 2020; Buwono et al., 2023).

Most existing lobster feeding studies primarily evaluate feed effectiveness based on growth and survival parameters, while feeding behavior is commonly assessed using conventional visual observations. These observation methods are largely manual, intermittent, and dependent on human interpretation, which limits the ability to capture continuous feeding activity, feeding responses, and subtle behavioral variations related to feed preference and competition (Utomo et al., 2022). Consequently, behavioral mechanisms underlying feeding efficiency remain insufficiently explored.

Recent advancements in monitoring technologies, including computer vision and Internet of Things (IoT)-based systems, provide new opportunities to improve behavioral observation in aquaculture. Smart monitoring systems allow continuous, non-invasive observation of aquatic organisms and enable feeding behavior to be quantified more systematically (Sastradipraja, 2020). However, the application of such technologies in lobster aquaculture remains limited, particularly in studies that integrate behavioral monitoring outputs with growth performance evaluation.

This study addresses this research gap by integrating Smart Lobster Culture through underwater CCTV-based monitoring with controlled natural feed treatments. Unlike conventional feeding observations, this approach enables continuous and behavior-oriented monitoring of lobster feeding activity in submersible cages. The novelty of this research lies in the combined application of natural feeds rich in calcium and phosphorus and smart visual monitoring technology to simultaneously evaluate feeding behavior, growth performance, and survival of green lobster (P. homarus). This integrated approach provides behavioral evidence to support feeding strategy optimization, which has not been explicitly addressed in previous lobster feeding studies.

Based on the identified research gap, this study aims to analyze the effect of different natural feed types on the growth performance of green lobster (P. homarus). In addition, feeding behavior parameters, including feeding frequency, feeding duration, response time to feed, and feed preference, are evaluated using Smart Lobster Culture to better understand lobster feeding responses to different natural feed treatments.

Therefore, this study aims to evaluate the effects of different natural feed types on the growth performance and feeding behavior of green lobster (Panulirus homarus) using Smart Lobster Culture.

2. Methods

The study was conducted in submersible lobster cages located in coastal waters of Pangandaran Regency, West Java, Indonesia. The experimental period was carried out for 60 days, from May–July, 2025 The experiment employed a completely randomized design with natural feed treatments. Two types of natural feeds rich in calcium and phosphorus were applied, namely anchovies (Stolephorus sp.) and Acetes sp. Feeds were provided at a rate of 20% of total biomass per day and administered once in the dusk daily. Each treatment consisted of 25 replicates with 25 lobsters per cage. The experimental framework, including feed treatments, observed parameters, and measured responses, is illustrated in Figure 1.

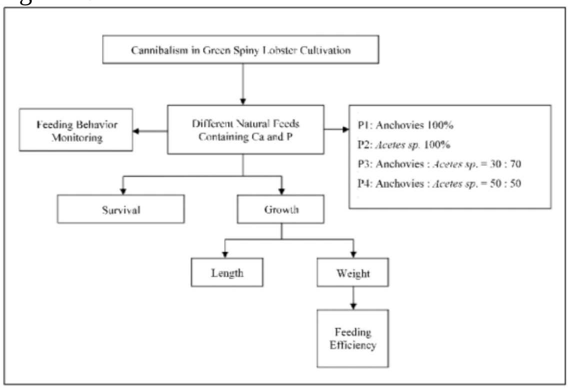

Figure 1. Experimental framework of natural feed treatments, feeding behavior monitoring using Smart Lobster Culture, and measured responses of green lobster *(Panulirus homarus)*.

Feeding behavior was monitored using Smart Lobster Culture through underwater CCTV installed inside each submersible cage. Video recordings during feeding sessions were used to observe feeding frequency, feeding duration, response time to feed, and feed preference. The green lobster (P. homarus) used as the experimental animal in this study is shown in Figure 2.

Figure 2. Green lobster *(Panulirus homarus)* used as the experimental animal in the feeding trial conducted in submersible cages.

Growth performance was evaluated based on changes in body weight and carapace length measured at the beginning and end of the experiment. Survival rate was calculated as the percentage of lobsters remaining alive at the end of the study. Growth, survival, and feeding behavior data were analyzed using analysis of variance (ANOVA) at a 95% confidence level, followed by Duncan's multiple range test when significant differences were detected.

3. Results and Discussion

Monitoring using Smart Lobster Culture enabled the observation of feeding behavior parameters, including feeding frequency, feeding duration, response time to feed, and feed preference. These behavioral indicators were used to assess the feeding responses of green lobster to different natural feed treatments.

Lobsters that exhibited shorter response times to feed and longer feeding durations tended to show higher weight gain and carapace length increment, indicating more efficient feed utilization. In contrast, delayed feeding responses and reduced feeding frequency were associated with lower growth performance. These observations demonstrate a clear relationship between feeding behavior and growth performance as monitored through underwater CCTV-based observation.

Anchovies (Stolephorus sp.) are widely available in Indonesian waters and are known to be rich in essential nutrients for crustacean growth. Fresh anchovies contain approximately 500 mg of calcium and 500 mg of phosphorus per 100 g, which are critical minerals supporting molting and exoskeleton formation in lobsters (Astawan, 2008). Previous studies have shown that anchovy-based feeds can promote high growth rates in lobsters, with Rostika et al. (2024) reporting growth rates of up to 1.92%.

Similarly, Acetes sp. is commonly used as a low-cost natural feed due to its small size and availability. Fresh shrimp contain approximately 757 mg of calcium and 292 mg of phosphorus per 100 g (Indonesian Ministry of Health, 2018). Rostika et al. (2024) reported that both anchovy and shrimp-based feeds resulted in comparable daily growth rates (1.88%), with no significant differences detected by Duncan's multiple range test. This similarity is likely attributed to their relatively balanced and complete nutritional profiles.

Lisandari et al. (2020) demonstrated that mixed feeds containing anchovies and sardines significantly improved carapace length growth in lobster hatchlings, emphasizing the role of calcium-rich diets in crustacean development. Adequate feed combinations not only support growth but may also enhance disease resistance and survival, as noted by Haryanti and Khalik (1994).

The integration of Smart Lobster Culture in this study enabled the linkage between feeding behavior and growth performance through continuous underwater visual monitoring. Feeding behavior parameters such as response time to feed, feeding frequency, and feeding duration were derived from CCTV recordings and used as behavioral indicators of feed utilization efficiency. Shorter response times and longer feeding durations reflected a higher feeding motivation and more effective feed consumption, which corresponded with greater weight gain and carapace length increment observed in green lobster (P. homarus).

By quantifying these behavioral parameters, Smart Lobster Culture functioned not only as a monitoring tool but also as an analytical approach to interpret feeding efficiency beyond conventional growth measurements. This integration allowed behavioral evidence to support the evaluation of natural feed effectiveness, thereby bridging the gap between feeding trials and growth outcomes. Similar applications of visual monitoring and smart aquaculture technologies have been reported to improve feeding assessment and decision-making accuracy in aquaculture systems (Sastradipraja, 2020; Syahputra & Hanifah, 2024).

The incorporation of smart monitoring technologies aligns with recent developments in smart aquaculture, where visual-based observation systems are increasingly applied to optimize feeding strategies, improve growth performance, and enhance production efficiency through data-driven management (Sastradipraja, 2020; Syahputra & Hanifah, 2024)

4. Conclusion

This study demonstrates that feeding behavior is closely linked to the growth performance of green lobster (P. homarus) cultured in submersible cages. Lobsters exhibiting shorter response times to feed and longer feeding durations showed more efficient feed utilization, resulting in higher weight gain and carapace length increment.

The application of Smart Lobster Culture using underwater CCTV-based monitoring enabled continuous and non-invasive observation of key feeding behavior parameters, including feeding frequency, feeding duration, response time to feed, and feed preference. These behavioral indicators complemented conventional growth measurements and allowed a more comprehensive evaluation of feeding effectiveness. Natural feeds rich in calcium and phosphorus, such as anchovies (Stolephorus sp.) and Acetes sp., remain relevant feeding options; however, this study highlights the importance of integrating behavioral observation to optimize feeding strategies. Overall, the findings support the adoption of smart monitoring technologies to improve feed management and promote more efficient and sustainable green lobster aquaculture.

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