Fisheries Journal, 14 (2), 459-469 (2024)
http://doi.org/10.29303/jp.v14i2.805

ARTICLE REVIEW: PROTEIN AND LIPID REQUIREMENTS OF MUD CRAB (*Scylla* spp.)

Artikel Reviu: Kebutuhan Protein dan Lipid Kepiting Bakau (*Scylla* spp.)

Wastu Ayu Diamahesa[1*], Rangga Idris Affandi[1]

[1]Aquaculture Study Program, Department of Fisheries and Marine Sciences, Faculty of Agriculture, University of Mataram

Pendidikan Road No. 37 Mataram City

*Coresponding email: wastuayu@unram.ac.id

(Received March 17th 2024; Accepted May 15th 2024)

ABSTRACT

This article discusses the nutritional requirements, particularly protein and lipid, in mud crabs (*Scylla* spp.). Mud crabs are one of the seafood types with a continuously increasing global demand. This literature review aims to provide an overview of the protein and lipid requirements in three mud crab species, namely *Scylla paramamosain, Scylla olivacea*, and *Scylla serrata*, which are the focus of aquaculture research. The research method involves comprehensive and systematic literature searches using predefined keywords. The findings indicate that protein and lipid requirements can vary depending on the growth phase, water temperature, and other environmental conditions. During the early growth phases, such as the larval and juvenile stages, mud crabs require higher protein levels to support rapid growth and optimal organism development. However, as they reach adulthood, protein requirements tend to decrease alongside metabolic changes and reproductive activity. Several studies have identified protein and lipid requirements for various mud crab species. The results show that optimal protein and lipid levels may vary depending on the species and growth stage of mud crabs. Therefore, this information is crucial for the development of suitable artificial feeds to effectively support the growth and health of mud crabs. In conclusion, this research provides important insights into the nutritional requirements of mud crabs and can serve as a guide for farmers to formulate feeds tailored to the daily needs of the crabs. Thus, this article makes a valuable contribution to the development of sustainable and efficient mud crab aquaculture industries.

Keywords : Mud Crab, Protein Requirement, Lipid Requirement, *Scylla* spp.

ABSTRAK

Artikel ini membahas tentang kebutuhan nutrisi, khususnya protein dan lipid, pada kepiting bakau (*Scylla* spp.). Kepiting bakau adalah salah satu jenis makanan laut yang memiliki permintaan global yang terus meningkat. Studi literatur ini bertujuan untuk memberikan gambaran tentang kebutuhan protein dan lipid pada tiga spesies kepiting bakau, yaitu *Scylla paramamosain*, *Scylla olivacea*, dan *Scylla serrata*, yang merupakan fokus utama dalam penelitian akuakultur. Metode penelitian menggunakan penelusuran literatur yang

komprehensif dan sistematis dengan kata kunci yang ditentukan. Hasil penelitian menunjukkan bahwa kebutuhan protein dan lipid dapat bervariasi tergantung pada fase pertumbuhan, suhu air, dan kondisi lingkungan lainnya. Pada fase pertumbuhan awal, seperti fase larva dan juvenil, kepiting bakau membutuhkan tingkat protein yang lebih tinggi untuk mendukung pertumbuhan yang cepat dan perkembangan organisme yang optimal. Namun, saat mencapai fase dewasa, kebutuhan protein cenderung menurun seiring dengan perubahan metabolisme dan aktivitas reproduksi. Beberapa penelitian telah menemukan kebutuhan protein dan lipid untuk berbagai spesies kepiting bakau. Hasil penelitian menunjukkan bahwa kadar protein dan lipid yang optimal dapat berbeda-beda tergantung pada spesies dan tahap pertumbuhan kepiting bakau. Oleh karena itu, informasi ini penting untuk pengembangan pakan buatan yang tepat guna dalam mendukung pertumbuhan dan kesehatan kepiting bakau secara efektif. Kesimpulannya, penelitian ini memberikan wawasan yang penting tentang kebutuhan nutrisi pada kepiting bakau dan dapat menjadi panduan bagi pembudidaya untuk menyusun pakan secara mandiri sesuai dengan kebutuhan harian kepiting tersebut. Dengan demikian, artikel ini memberikan kontribusi yang berharga dalam pengembangan industri perikanan kepiting bakau yang berkelanjutan dan efisien.

Kata Kunci : Kepiting Bakau, Kebutuhan Protein, Kebutuhan Lipid, *Scylla* spp.

INTRODUCTION

Mud crab is the common name for a species of crab from the genus Scylla. Crab is a type of seafood that is distributed globally, with demand continuing to increase (Gunarto & Herlinah, 2015; Waiho *et al*., 2018). Based on FAO 2020 data, *Scylla* spp. is one of the main commodities of all species of crabs in the world with details of the largest production quantities, namely giant mud crabs (*Scylla serrata* Forsskal, 1775) of 249,000 tons, green mud crabs (*Scylla paramamosain* Estampador, 1949) of 160,000 tons, other mud crabs that are caught or cultivated are orange crab (*Scylla olivacea* Herbst, 1796), purple crab (*Scylla tranquebarica* Fabricius, 1798). Of all the species of *Scylla* spp. mentioned previously, the majority have been researched because they are the most commonly cultivated species (FAO, 2020). All of these species are known to have great potential for commercial aquaculture and high economic value because they are resistant to environments with poor water quality and are very resistant to pathogens. Mud crabs are currently widely cultivated in many countries, especially Southeast Asian countries (Gunarto & Herlinah, 2015; Waiho *et al*., 2018; Omn, 2013; Hai, 2017).

In cultivating aquatic animals, including mud crabs (*Scylla* spp.), fulfillment appropriate nutritional needs is the key to achieving optimal growth, good productivity, reproductive development and optimal health (Martínez-Palacios *et al*., 2007; Deng *et al*., 2011; Huo *et al*., 2014). One of the main aspects in fulfillment the macronutrient needs of mud crabs, especially protein and lipids.

Protein is an important component in the formation of body tissue and plays a role in various physiological processes, including growth and development. Lipids, an important source of energy, are also necessary for vitamin absorption and cell membrane formation. However, if the amount of protein consumed is less than daily requirements, it will inhibit growth due to lack of tissue protein anabolism (Wilson, 2002; Lee *et al*., 2001; Méndez-Martínez *et al*., 2017). On the other hand, if the amount of protein consumed is more than daily requirements, it will be degraded and oxidized to become nitrogen waste in the form of ammonia or urea which pollutes water (Wilson, 2002).

The second macronutrient that is no less important is lipids. Lipids are one of the important components in the feed of mud crabs (*Scylla* spp.) which have a vital role in supporting growth, organism development and reproduction. However, excessive levels of feed lipids will result in poor growth performance, reduced feed consumption, and reduced

ability to utilize other nutrients (Zhao *et al*., 2015). Meanwhile, if the lipid levels are not sufficient for the crab's daily needs, it can result in a slow maturation process due to a lack of important lipid acids.

The study of macronutrient requirements in mud crabs has become a major focus in aquaculture research in the last decade. Recent studies have provided deeper insight into nutritional requirements, optimal proportions, and their impact on mud crab growth and health. Several researchers have discovered the dietary protein requirements of several species of mud crabs *Scylla serrata*, *Scylla paramamosain*, and *Scylla olivacea*. Recent studies show that protein requirements in mud crabs can vary depending on growth phase, water temperature, and other environmental conditions. In the early growth phases, such as the larval and juvenile stages, mud crabs require higher levels of protein to support rapid growth and optimal organism development. However, when reaching the adult phase, protein requirements tend to decrease along with changes in metabolism and reproductive activities (Zheng *et al*., 2019; Ly *et al*., 2024; Aaqillah-Amr *et al*., 2022; Unnikrishnan & Paulraj, 2010; Jolpano *et al*., 2023; Dayal *et al*., 2019; Likewise, the dietary lipid requirements of the three mud crab species *Scylla serrata*, *Scylla paramamosain*, and *Scylla olivacea* have also been studied by several researchers (Aaqillah-Amr *et al*., 2022; Xu *et al*., 2020; Zhao *et al*., 2015; Catacutan, 2002; Alava *et al*., 2007).

Information about protein and lipid requirements is essential during the development of artificial feeds to ensure nutrients support proper growth and maturation of crustaceans (Aaqillah-Amr *et al*., 2022). Therefore, the aim of this literature study is to provide a clear picture regarding the latest status of developments in nutritional needs, especially protein and lipids in *Scylla* spp. species so that this information can be used or utilized by feed formulators or mud crab cultivators in preparing feed independently according to their crab needs daily effectively.

METHODS

This research uses a comprehensive and systematic literature search method by accessing the Google Scholar, Proquest and Elsevier data bases. In total, there are 30 journals used as references in this research. This methodological approach involves the process of collecting references data, reading, recording and managing data objectively, systematically, analytically and critically using the keywords used, namely: "dietary protein requirement for mud crab", and "dietary lipid requirement for mud crab". Meanwhile, in Indonesian it is searched using "kebutuhan protein kepiting bakau" and "kebutuhan lipid kepiting bakau". All articles collected were then selected and only *Scylla* spp.

Analysis of this literature study was carried out thoroughly to ensure objective results. The data collected and analyzed is secondary and consists of various research sources such as books, journals and relevant articles. The data analysis technique used is content analysis, which involves evaluating the research results that are most relevant, relevant, and quite relevant. Assessment is carried out by reading the abstract of each study and noting the parts that are relevant to the research objectives. The final results of this analysis are then used to draw conclusions that are appropriate to the problems studied (Affandi & Diamahesa, 2023; Muahiddah & Diamahesa, 2023; Diamahesa & Muahiddah, 2022; Diamahesa & Muahiddah, 2023).

RESULT

Based on the results of a literature study that we conducted, it was found that there are three species of mud crabs that have been studied for their protein needs in order to grow optimally. The mud crab species are: *Scylla paramamosain* (megalopa and juvenile size), *Scylla olivacea* (broodstock), and *Scylla serrata* (juvenile and fattening). The following more

complete information regarding species, crab size, type and size of feed, protein content, methods and results of our study can be seen in Table 1 below.

Table 1. Protein Requirements for Some Species of Mud Crabs

Species	Size	Type and Size of Feed	Protein Content (dry weight)	Method	Result	Reference
Scylla paramamosain	0.04 gr	Fishmeal based granular feed; 0.8 mm	32.69%, 38.54%, 42.92%, 49.89%, 52.09%, and 60.07%.	At satiation (every 2 days), 8 weeks	Best protein 47.06% (polynomial regression analysis results)	Zheng *et al*., 2019
Scylla paramamosain	5.8 mg (megalopa)	Artemia frozen, shrimp meat, Lansy pellets, NRD pellets; 500 µm	54.5%, 81%, 48%, 55%	15-20% of biomass, 4 times a day every 6 hours	The best feed protein 48% Lansy Pellets, stocking density 20 crabs/liter	Ly *et al*., 2024
Scylla olivacea	186.42 g (broodstock)	Pellets measuring 3.0 × 1.5 × 1.5 cm are based on mangrove shell flour	Protein 42%, Lipid 6, 8, 10, 12%	At satiation for 90 days	42% protein and 12% lipid are best for growth and reproduction	Aaqillah-Amr *et al*., 2022
Scylla serrata	5 g juvenil	Pellets size 1.2 mm	15-55% (interval 5%)	At satiation (every 2 days), 63 days	Best protein 46.9-47.03 % (polynomial regression analysis)	Unnikrishnan & Paulraj, 2010
Scylla serrata	11 g	Pellets size 3-5 mm	32, 40, 48%	At satiation (around 2-3.5% body	Best growth at 32-40% protein	Catacutan, 2002

Species	Size	Type and Size of Feed	Protein Content (dry weight)	Method	Result	Reference
				weight)		
Scylla serrata	55-65 g	Trash fish cut into 1-2 cm pieces	Not tested	5, 10, 15, 20% of body weight	Best FCR at 5% dose, but best growth at 20% dose	Hanif & Herlina, 2021
Scylla serrata	55-65 g	Trash fish 1-2 cm	Not tested	15% body weight, 30 days, battery system, frequency (1, 2, 3 times a day)	Treatment twice a day accelerates molting on day 21	Tulangow *et al*., 2019
Scylla serrata	200 g	Trash fish	58.97 % (Utomo *et al*., 2013)	5, 10, 15% of body weight	The 15% dose obtained the best growth and FCR (7.39)	Adila *et al*., 2020
Scylla serrata	200-280 g	Trash fish	Not tested	Addition of key ginger extract in doses of 0, 20, 25, and 30 ml/kg	20 ml/kg is the best dose for growth, molting and FCR parameters	Jolpano *et al*., 2023
Scylla serrata	200-1000 g juvenile	Pellets size 4.5 mm (crab <500g) and 6 mm (crab >500g)	32 and 36%	8% and 2.5% at the beginning then adjusted according to the feed intake; 1 month	Pellet feed protein 36% and 5.59 ether extract is the best dose for fattening mud crabs	Dayal *et al*., 2019

This is different from research regarding the protein level requirements for mud crab species. We found only five studies that focused on lipid requirements for mud crabs. From the literature study we conducted, there are three species of mud crabs whose lipid content requirements have been studied, such as *Scylla olivacea* (broodstock), *Scylla paramamosain* (juveniles), and *Scylla serrata* (juveniles and broodstock). The complete description can be seen in Table 2 below.

Table 2. Utilization of Lipids in Mud Crab Feed

Species	Size	Type and Size of Feed	Lipid Levels	Method	Result	Reference
Scylla olivacea	178 g (broodstock)	Pellets measuring 3.0 × 1.5 × 1.5 cm are based on mangrove shell flour	Protein 42%, Lipid 6, 8, 10, 12%	At satiation for 90 days	42% protein and 12% lipid are best for growth and reproduction	Aaqillah-Amr *et al*., 2022
Scylla paramamosain	42 mg	Pellets size 1 mm	Lipid 7, 9, 11, 13, and 15%, protein 50%	At satiation, 2 times a day	Optimum lipid is 10.31% (based on polynomial analysis)	Xu *et al*., 2020
Scylla paramamosain	11 g	Pellets 4-6 mm	Lipid 0, 3, 6, 9, 12%, protein 45%	8 weeks	Optimum lipid is 9.5% for growth	Zhao *et al*., 2015
Scylla serrata	11 g	Pellets size 3-5 mm	Lipids 6 and 12% with protein 32, 40, 48%	At satiation (around 2-3.5% body weight)	Best growth at 30-40% protein and 6 and 12% lipids	Catacutan, 2002
Scylla serrata	625 g	Natural feed (shellfish, squid, petek fish), artificial feed (10 mm), and a	Artificial feed lipid content 10, 12, and 14%	Some in the morning and some in the afternoon, but mixed treatment: natural feed (morning), artificial feed	Optimum lipids are 10% combination of natural feed and artificial feed	Alava *et al*., 2007

Species	Size	Type and Size of Feed	Lipid Levels	Method	Result	Reference
		combinati on of both		(afternoon)		

DISCUSSION

The first research conducted by Zheng *et al*. (2019) in China used six types of isolipidic and iso-energetic feed with final protein concentrations of 32.69%, 38.54%, 42.92%, 49.89%, 52.09% and 60.07% were tested on mud *crab Scylla paramamosain* with an initial weight of 0.04 g (28 individuals) and maintained for 8 weeks. From the results of this research, it was found that higher weight gain was found when giving feed protein 42.92%, 49.89% and 52.09%. The results of crude protein content in the whole body increased with increasing feed protein content. For hepatic aspartase aminotransferase (AST) activity, the lowest was found in the feed protein 49.89%, while for liver alkaline phosphatase (AKP) activity the highest was found in the feed group 42.92 and 49.89%. Other additional information is that daily superoxide dismutase (SOD) activity increases with increasing feed protein content up to 49.89%, then levels off. To obtain the growth of juvenile mud crabs, a protein content of around 47.06% is required using polynomial regression analysis.

Then Ly *et al*. (2024) reported the results of research using similar crabs but using megalopa size (5.8 mg) with different types of feed and protein levels in Vietnam. They did two experiments. In the first experiment, the density was 10/L and the feed used was frozen Artemia biomass, shrimp pulp, Lansy pellet feed (48% protein), and NRD pellet feed (55% protein). Meanwhile, in experiment 2, around 5.4 mg of megalopae were stocked at densities of 20, 30, and 40/L and given the best feed in the first experiment (Lansy pellet feed). From the results of the parameters of daily body weight gain and specific growth rate, frozen Lansy and Artemia feeds were better than shrimp pulp and NRD pellet feed. For the second experiment, it was reported that a density of more than 30/L resulted in a decrease in growth and specific growth rate. From the results of this research, it was found that the best feed efficiency for megalopa stage mud crabs (*S. paramamosain*) was found in Lansy pellet feed with a stocking density of 20/L. So the temporary conclusion for the protein requirements of *Scylla paramamosain* mud crabs measuring 5.8 mg and 0.04 g is 48% and 47.06%.

Still discussed in Table 1, the only literature we found is for the mud crab species *Scylla olivacea*. Their research focused on the reproductive maturation of female mud crabs. This is the same as research conducted by Ly *et al*. (2024) who conducted two experiments in their publication. Research by Aaqillah-Amr *et al*. (2022) also conducted two experiments in Malaysia. The first experiment was to determine which natural feed raw material sources were most suitable: fish innards (discarded organs), mangrove shells (*Polymesoda erosa*), black devil snails (*Faunus ater*), and commercial shrimp feed (control). From these initial experiments it was found that the mangrove shells *P. erosa* with a protein content of 81.63% and lipid 13.54% was the most suitable ingredient for feeding mud crabs. Then in the second experiment, the mangrove shells were used as the main raw material for the experimental feed formulation with a protein content of around 42% and different lipid contents: 6, 8, 10, and 12% to determine the effect of providing different lipids on crab reproduction. For palatability tests, feed water stability, nutrient leaching, buoyancy, and total solids were studied before feeding experiments. In the feeding test, 120 adult female mud crabs weighing 186.42 g were used in semi-humid conditions that were easily accepted by the crabs. From the results of this experiment, it was found that a lipid dose of 12% and a protein content of 42% were ideal for somatic growth and reproduction of *S. olivacea*.

In contrast to the research conducted on the two species above, which are relatively small

in number based on the results of our literature study, more research has been researched on the *Scylla serrata* species regarding its protein needs from the juvenile stage to the broodstock stage. There are seven research results that we have summarized starting from those conducted by Unnikrishnan & Paulraj (2010) in India using juvenile mud crab *Scylla serrata* weighing 5 g. The feed given is isoenergetic, isolipid with protein levels ranging from 15 to 55% with 5% intervals and is carried out for 63 days to determine the minimum and optimum protein levels for juvenile crabs. From the results of this research, it was found that high mortality was found in feed with a protein content of 15% (100% mortality) and 20% (12.5% mortality). Apart from this feed, optimal survival is 100%. 45% protein content is the best nutrition to support optimal growth performance. However, from the results of the polynomial regression analysis, it was found that the best protein content was 46.9-47 to support the growth and retention (storage) of juvenile protein from mud crab *S. serrata*.

Furthermore, in the Philippines Catacutan *et al*. (2002), using the same species *Scylla serrata*, they experimented with 6 types of feed with protein levels of 32, 40, and 48% and two different lipid levels, 6 and 12%. The average initial weight of the crabs was 11 g for 30 days of rearing. From the results of their research, it was found that mud crabs, *S. serrata*, grew well when given feed containing 32-40% feed protein with 6 or 12% lipid.

On the other hand, in Indonesia Hanif & Herlina (2021), Indonesia uses trash fish as the main source of protein for mud crab *S. serrata* measuring 55-65 g with different feeding percentages, namely 5, 10, 15 and 20% of the crab's body weight. The results of their research showed that the best FCR level was at a percentage of 5%, while the best growth was at a percentage of 20%. This could indicate that a small amount is more efficient for crabs to utilize than a large amount. We suspect that when administering a dose of 20%, a lot of feed is wasted and not recorded, causing the 20% FCR to have lower growth. In contrast to the research results of Hanif & Herlina (2021), still in Indonesia, Adila *et al*. (2020), used crabs of a larger size, namely 200 g, to test different feeding percentages (5, 10, 15 %) of the body weight of crabs in cages for 15 days. The results of this research show that a percentage of 15% trash fish feeding results in the best increase in crab weight of 77.37 grams. It can be concluded from the two studies above that crabs measuring 55-65 g produce the best growth at a feeding percentage of 20%, while larger crabs achieve the best growth at a feeding percentage of 15%. So the bigger the crab, the lower the percentage of feed consumed compared to smaller crabs.

Other research still being conducted in Indonesia also reported that Tulangow *et al*. (2019) conducted an experiment on the frequency of feeding trash fish on the growth of *Scylla serrata* mud crabs measuring 55-65 g using a battery system for 30 days. The frequency used is 1 time, 2 times, 3 times/day with 5 repetitions. The results of their research showed that a feeding frequency of 2 times/day was the best for accelerating molting and growth, although protein levels and types of trash fish were not mentioned in their research.

Another research using trash fish in Indonesia was carried out by Jolpano *et al*. (2023), by adding *B. pandurate* extract to trash fish at different doses: 0, 20, 25, and 30 mL/kg feed. This material was tested on crabs measuring 200-280 g and cultivated for 4 weeks. Feeding is done twice a day, namely in the morning and evening, but the feeding is done twice a day at 5% of the crab's weight. From the results of this research, it was found that the treatment dose of 20 mL/kg had an effect on molting percentage, growth, survival and feed conversion ratio.

Another case in India, Dayal *et al*. (2019) carried out a demonstration of fattening mud crabs in the mangrove ecosystem using a holistic approach "Integrated Mangrove Aquaculture System." Their research used two feeds with protein levels of 32 and 36% and then tested them on mud crabs according to the target market size (200-1000 g). The feed is made in two sizes according to the weight of the crab, 4.5 mm pellets for crabs <500g and 6 mm for crabs >500g. The best protein content in this study was 36% in all size groups and 5.59 ether extract was the best dose for fattening mud crabs.

Research on the lipid requirements of the mud crab *Scylla olivacea* has only been conducted on broodstock with a size of 178 g (Aaqillah-Amr *et al*., 2022). The feed used is iso-nitrogen (42%) in block form with lipid doses of 6, 8, 10, and 12%. From the results of his research, a lipid content of 12% is the best for crab growth and reproduction.

In contrast to the previous species, the lipid requirements of *Scylla paramamosain* have only been studied at juvenile size (2 studies). The first study by Zhao *et al*. (2015) used mud crabs measuring 11 g with iso-nitrogen feed (45% protein). The pellets used were 4-6 mm in size with different lipid levels of 0, 3, 6, 9, 12% to determine the effect of feed lipid content on growth performance, feed utilization, body composition and antioxidant parameters of juvenile mud crabs (*Scylla paramamosain*) for 8 weeks. From the results of this research, it was found that the optimum lipid content to maintain good growth performance and antioxidant capacity of mud crab juveniles was 9.5%. The next research using *Scylla paramamosain* with a size of 42 mg to determine the lipid requirements of this species was carried out by Xu *et al*. (2020). The feed used was isonitrogenic (50% crude protein content) with lipid levels of 7, 9, 11, 13, and 15% to test the level of lipids in the feed on survival, growth performance, body composition, and antioxidant ability of *S. paramamosain* juveniles. Feed is given for 8 weeks. From the research results, it was found that the optimum lipid content to support the growth of juvenile crabs was 10.31% (results of polynomial regression equation analysis).

The last species of mud crab we discovered that had its lipid requirements studied was *Scylla serrata* in the juvenile stage (Catacutan, 2002) and broodstock (Alava *et al*., 2007). Catacutan (2002) used 11 g crabs with 3-5 mm pellets given at satiation of 2-3.5% body weight. From the results of his research, it was found that the best lipid content used for the growth of mud crabs was 6 and 12% lipid with a protein inclusion of 32-40%. On the other hand, Alava *et al*. (2007) conducted research on the lipid needs of *Scylla serrata* broodstock. The broodstock were treated with natural food (shells meat, squid, petek fish), pellet (10 mm), and a combination of both. Pellet had lipid levels of 10, 12, and 14% given for 112 days to see its effect on reproduction and lipid profiles in broodstock and zoea tissues. From the results of this research, it was found that a total lipid of 10% in pellet combined with natural feed was sufficient to provide essential lipids to crabs to increase larval production and quality.

CONCLUSION

Mud crabs (*Scylla* spp.) are an important commodity in the fishing industry which continues to grow. To achieve optimal growth, good productivity and optimal health, meeting nutritional needs, especially protein and lipids, is very important. Based on the literature studies we reviewed, these nutritional requirements can vary depending on the species, size, and growth phase of the crab. For *Scylla paramamosain*, protein requirements range from 47% to 48%, while lipid requirements range from 9.5% to 10.31%. *Scylla olivacea* requires approximately 42% protein and approximately 12% lipid for optimal growth and reproduction. Meanwhile for *Scylla serrata*, protein requirements range from 32% to 40% (11 g), and lipid requirements range from 6% to 12%, depending on the growth stage and size of the crab. This information is important in developing artificial feed that fit the nutritional needs of mud crabs to support a sustainable aquaculture industry. Apart from that, there are still many opportunities to research further regarding the protein and lipid needs of several other stages that have not been studied by previous researchers.

ACKNOWLEDGEMENT

Thank you to LPPM University of Mataram for the competitive grant from University of Mataram with contract number: 2453/UN18.L1/PP/2023 which has funded the writing of this article.

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