Feeding behavior analysis of lobster *Panulirus homarus* with a different feed shape and size

Amelia S. Lubis, Efrizal, Syaifullah

Biology Department of Andalas University, Padang, West Sumatra, Indonesia.
Corresponding author: Efrizal, efrizal@sci.unand.ac.id

Abstract. Lobsters have the property of tearing and chopping food, then putting it in their mouths using the claws. The shape and size of the feed must be adjusted to the lobster to suit the function of its organs. The composition, nature, and physical quality of the feed must be compatible with the feeding behavior and should not interfere with the feeding response. The feed shape and size should be chosen in order to avoid it to negatively affect the productivity and performance of the lobsters. This study aimed to analyze the feeding behavior of lobsters *Panulirus homarus* for feed of different shapes and sizes. This research used an experimental method with a completely randomized design consisting of 4 treatments and six replications. The treatment in this study consists of using: noodle-shaped feed with 2 cm length (treatment A); noodle-shaped feed with 4 cm length (treatment B); disc-shaped feed with 2 cm diameter (treatment C), and disk-shaped feed with 4 cm diameter (treatment D). The parameter observed consisted of a breakdown by activity of the feeding behavior of lobsters, and data were analyzed descriptively based on the results of observations. The data is presented in images and then narrated with related references. Based on the results of observations during the study, the feeding behavior of lobsters *P. homarus* significant differences among the treatments. The observation of the feeding behavior of lobsters concerned several feeding activities: looking, approaching, taking, and opening the mouth for the test feed. Lobster feeding activities are mostly carried out from 06.00 p.m. until 10.00 p.m. and from 10.00 p.m. until 02.00 a.m., showing that the lobster is a nocturnal animal (active at night).
Key Words: feeding activity, feeding behavior, lobster, nocturnal.

Introduction. Lobsters are aquatic biota with different developmental specificities, living in shallow water habitats. Lobster, *Panulirus homarus*, aquaculture is one of Indonesia's economic cornerstones due to its high economic value (Mashaii et al 2011; Petersen et al 2013; Liliyanti et al 2016). Lobsters are nocturnal animals that have high activity at night, live in groups, migrate and take shelter among rocks and corals. Feed availability in the tropics affects the characteristics and diversity of lobsters. The formation of nutritional needs and interactions with other organisms are known as being based on their natural diet. Each organism has a different way of obtaining food (Rombe et al 2018; Priyambodo et al 2020; Efrizal et al 2020; Lubis et al 2021; Efrizal et al 2023).

P. homarus are omnivores that use a lot of detritus, macrophytes, and mollusks as their main food. The survival of lobsters is influenced by the availability of food and shelter; if this is lacking it can increase cannibalism so that many lobsters die while rearing in controlled containers (Romano & Zeng 2017; Wahyudin et al 2017; Subhan et al 2018). Crustaceans are natural predators of a mollusk species, as a source of protein for the process of forming the structure and function of their limbs. The main part of the lobster's body is the head with attach to the chest, the body, consisting of meat, the back being covered with a carapace, and the tail (Amali & Sari 2020; Priyambodo et al 2020). Lobsters have nine pairs of pleopods: five pairs of walking legs, and four pairs of swimming legs. Swimming legs' function, apart swimming, is to carry eggs before they are released in nature. Lobsters have the property of tearing and chopping food, then putting it in their mouths using the claws (Corey et al 2013; Vital et al 2018). The shape and size of the feed must be adjusted to the lobster to suit the function of its organs. Lobsters live in a murky environment on the ocean floor and use their antennae as

sensors. They have mandibles as food shredders and maxillae as food taste buds (Haryono et al 2016; Subhan et al 2018; Rombe et al 2018).

In cultivation activities, many factors become obstacles, such as the number, size, and stock of seeds. To ensure production stability locally and globally, a stable amount of product is required. Basic knowledge of the patterns of feeding behavior is needed for the intensive development of lobsters under controlled conditions. Cultivation activities are related to the behavior, especially feeding behavior, of aquatic biota such as lobsters (Mashaii et al 2011; Liliyanti et al 2016; Wijaya et al 2018). However, information and studies on the feeding behavior of lobsters on a laboratory scale are still limited. The feed must be adjusted, in the shape and size, to avoid affecting the productivity and performance of the lobsters. Standard feed for lobsters is not yet available, while cultivators generally provide feed that does not match their nutritional and physiological status. The composition, nature, and physical quality of the feed given should be considered in order to make it compatible with the feeding behavior and to prevent an inhibition of the feeding response (Nunes et al 2006; Patroni el al 2018).

The shape and size of the pellets that do not match a species' preferences and eating habits will reduce the consumption of the feed given (De Paula et al 2018). An appropriate form is necessary to overcome some of the weaknesses of the artificial feed. This study aimed to analyze the feeding behavior of lobsters *P. homarus*, with different shapes and sizes of feed.

Material and Method

Time and location of research. This research was conducted from May to August 2022. Observations of the feeding behavior of lobsters were carried out at the Brackish Water Aquaculture Fishery Center Sungai Nipah, Pesisir Selatan, West Sumatra.

Methods and research design. The experimental method was a completely randomized design consisting of 4 treatments and 6 replications. The feed's dimensions, in particular its shape and size, can create obstacles to consumption, especially when they are incongruent with the feeding behavior exhibited by lobsters, consequently resulting in an adverse effect on the lobsters' feeding response. The treatments in this study consisted of combining different shapes and sizes of feed for lobsters. The 4 treatments included:
A = noodle-shaped feed with a 2 cm length;
B = noodle-shaped feed with a 4 cm length;
C = disc-shaped feed with a 2 cm diameter;
D = disk-shaped feed with a 4 cm diameter.

Research procedure. The research work procedure consisted of 5 stages. This research phase started with making artificial feed, making spinach extract, preparing test feed, preparing containers and culture media, then rearing lobsters:

- Make the artificial feed; feed formulations were obtained from Lubis et al (2021). All the ingredients used are flour mixed gradually to form a dough. The dough is printed in the form of noodles and disks. The feed that has been printed is then dried in the sun to dry.
- Make spinach extract; the spinach plants used are the stems and leaves. Spinach is washed, cut into small pieces, and dried in the sun. The dried spinach is blended until smooth and sifted. The powdered spinach was then weighed at 0.5 mg kg^{-1} of feed.
- Prepare test feed; the spinach powder is put into a spray bottle and dissolved in 80% ethanol at a ratio of 1:1 until it is homogeneous. After a homogeneous solution, 20 ml of 80% ethanol was added again and sprayed evenly onto the artificial feed (Efrizal et al 2019); then, the feed was air-dried. After drying, the feed is ready to be given to lobsters with a 3% dose of the lobster weight, and the rest is stored for further feeding.
- Prepare maintenance containers; the research container was prepared by cleaning the fiber tub to remove dirt that could cause pests and diseases. The fiber tub was

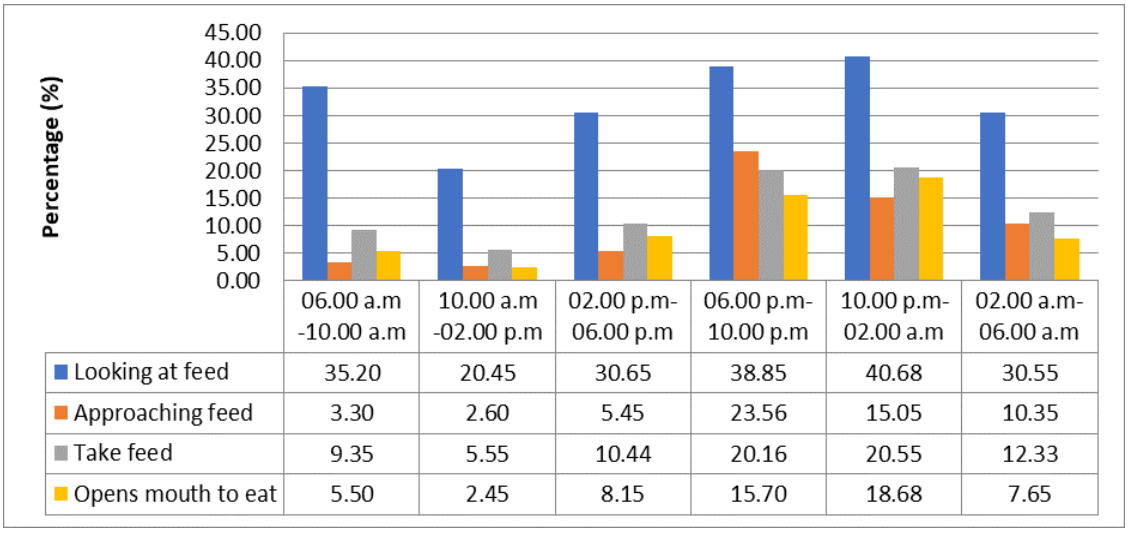
divided into six parts according to the research replication. Then the tub is filled with seawater with a salinity of 30-36 ppt, which has been sterilized using chlorine at a dose of 30 ppm.

- At the beginning of the rearing process, the lobsters weighed ±95 g and there were a total of 48 individuals. The measured activity pertains to the percentage of each individual sub-activity. Lobster maintenance was performed for 90 days to observe the feeding behavior of lobsters fed according to the research treatment. The dose of feeding is 3% of the lobster biomass. During the maintenance period, water quality is controlled by changing 25% of the water every week.

Observed parameters. These observed parameters refer to the feeding behavior of lobsters, referring to Zakaria & Saragih (2021). Their process of eating is almost the same as other crustaceans in general. There are several eating activities involved, including looking at the feed, approaching it, taking it, and placing it into their mouth. The eating process begins with the lobster catching the feed and securely holding it with both claws. They then proceed to put the food into their mouth, followed by a deliberate process of biting it slowly, chewing, and finally swallowing it until it's completely consumed. Percentage calculations are conducted by assessing the lobster's reaction within each specific feeding sub-activity in response to its food. The observations pertaining to feeding times encompass the quantification of feed consumption during six discrete temporal intervals. Morning feeding is initiated at 6:00 a.m. and persists until 10:00 a.m. Pre-noon feeding commences at 10:00 a.m. and extends until 2:00 p.m. Daytime feeding is instigated at 2:00 p.m. and concludes at 6:00 pm. Evening feeding is undertaken at 6:00 p.m. and persists until 10:00 p.m. Midnight feeding commences at 10:00 p.m. and endures until 2:00 a.m. Morning feeding recommences at 2:00 a.m. and persists until 6:00 a.m., thus concluding the comprehensive observation cycle.

Data analysis. The data for all lobster eating activities is computed by considering its constituent sub-activities. Subsequently, the percentage for each eating sub-activity is determined based on the speed of response exhibited in response to each respective sub-activity. The percentage data for each sub-activity in lobster feeding is aligned with each specific observation time interval. Lobster's feeding behavior data were analyzed descriptively based on the results of observations. The resulting data is shown in images and then narrated with related references.

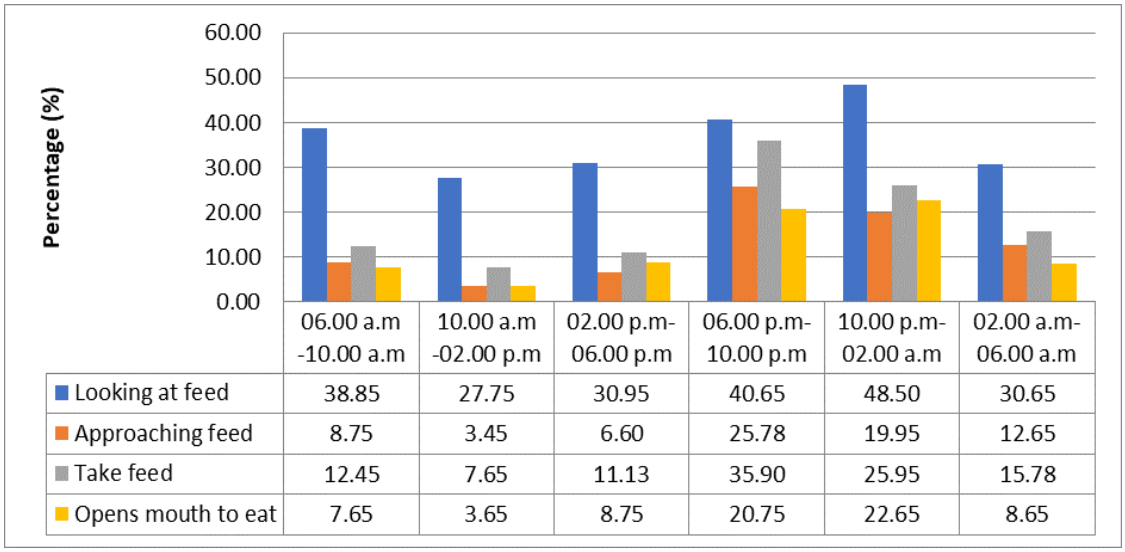
Results. Based on the results of observations during the study of the feeding behavior of lobsters, there was no significant difference among treatments. Observation of feeding behavior was carried out in stages, over 24 hours. The results of observing the feeding activity of lobsters in each treatment are presented in Figures 1, 2, 3, and 4.



	06.00 a.m -10.00 a.m	10.00 a.m -02.00 p.m	02.00 p.m-06.00 p.m	06.00 p.m-10.00 p.m	10.00 p.m-02.00 a.m	02.00 a.m-06.00 a.m
Looking at feed	35.20	20.45	30.65	38.85	40.68	30.55
Approaching feed	3.30	2.60	5.45	23.56	15.05	10.35
Take feed	9.35	5.55	10.44	20.16	20.55	12.33
Opens mouth to eat	5.50	2.45	8.15	15.70	18.68	7.65

Figure 1. Lobster feeding activity in treatment A.

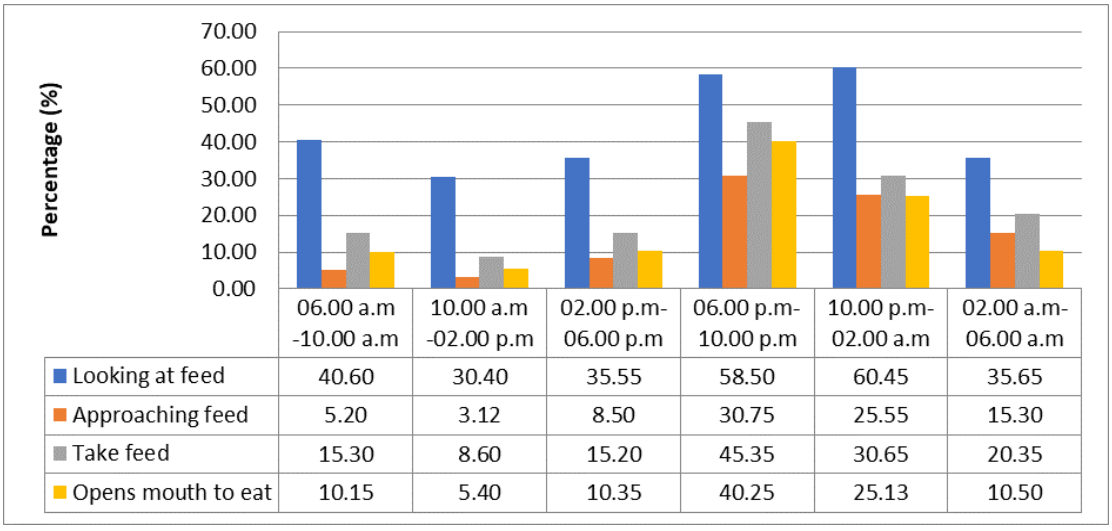
Figure 1 shows that treatment A, namely artificial feed with a noodle shape measuring 2 cm, shows some feeding activity on lobsters. At the time of feeding, it showed that the lobsters saw the feed given at a level of around 20.56-40.68%. The attractiveness of the feed made the lobsters approach the feed with an activity percentage of around 3.30-23.56%. Lobsters that approach the feed may take the food (using claws) or not; the level of taking food is 5.55-20.55%. Finally, lobsters tear the food and put it into their mouth, with a percentage of 2.45-18.68%. Based on Figure 1, most lobster-eating activities are carried out between 06.00 p.m. until 10.00 p.m. and 10.00 p.m. until 02.00 a.m.



	06.00 a.m -10.00 a.m	10.00 a.m -02.00 p.m	02.00 p.m-06.00 p.m	06.00 p.m-10.00 p.m	10.00 p.m-02.00 a.m	02.00 a.m-06.00 a.m
Looking at feed	38.85	27.75	30.95	40.65	48.50	30.65
Approaching feed	8.75	3.45	6.60	25.78	19.95	12.65
Take feed	12.45	7.65	11.13	35.90	25.95	15.78
Opens mouth to eat	7.65	3.65	8.75	20.75	22.65	8.65

Figure 2. Lobster feeding activity in treatment B.

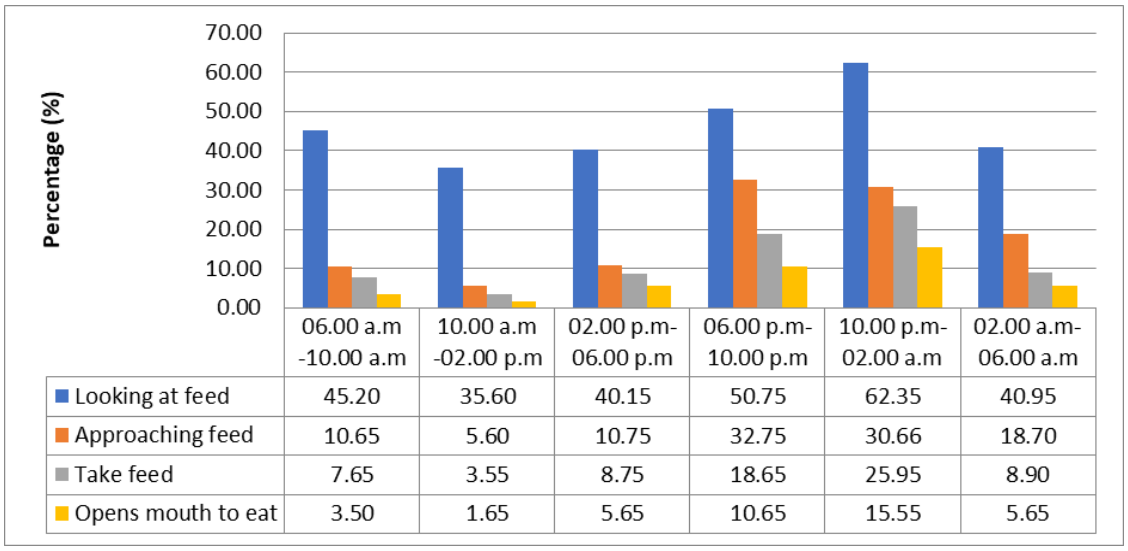
Based on Figure 2, treatment B with artificial feed in the form of noodles with a size of 4 cm shows some feeding activity on lobsters. Treatment B showed the activity of eating lobsters when they saw the feed around 27.75-48.50%; then lobsters approached the feed with a percentage of activity around 3.45-25.78%. After the lobster approaches the feed, the lobster will take the feed with a range of 7.65-35.90%, and then the lobster will open its mouth to eat the feed given with a percentage range of 3.65-22.65%. Figure 2 shows that most eating activities occur between 06.00 p.m. until 10.00 p.m. and 10.00 p.m. until 02.00 a.m.



	06.00 a.m -10.00 a.m	10.00 a.m -02.00 p.m	02.00 p.m-06.00 p.m	06.00 p.m-10.00 p.m	10.00 p.m-02.00 a.m	02.00 a.m-06.00 a.m
Looking at feed	40.60	30.40	35.55	58.50	60.45	35.65
Approaching feed	5.20	3.12	8.50	30.75	25.55	15.30
Take feed	15.30	8.60	15.20	45.35	30.65	20.35
Opens mouth to eat	10.15	5.40	10.35	40.25	25.13	10.50

Figure 3. Lobster feeding activity in treatment C.

Figure 3 showed that in treatment C, artificial feed with a disk shape of 2 cm in diameter, showed some feeding activity on lobsters. At the time of feeding, it showed that the lobsters saw the feed given around 30.40-58.50%, then the attractiveness of the feed made the lobsters approach the feed with an activity percentage of around 3.12-30.75%. Lobsters that approach the feed sometimes take food using claws, and some don't, so the range of lobsters taking food is 8.60-45.35%. After the lobster takes the food with its claws, it tears the food and puts it into its mouth with a percentage of 5.40-40.25%. The lobster eating activity presented in Figure 3 is mainly carried out at 06.00 p.m. until 10.00 p.m. and 10.00 p.m. until 02.00 a.m.



	06.00 a.m -10.00 a.m	10.00 a.m -02.00 p.m	02.00 p.m-06.00 p.m	06.00 p.m-10.00 p.m	10.00 p.m-02.00 a.m	02.00 a.m-06.00 a.m
Looking at feed	45.20	35.60	40.15	50.75	62.35	40.95
Approaching feed	10.65	5.60	10.75	32.75	30.66	18.70
Take feed	7.65	3.55	8.75	18.65	25.95	8.90
Opens mouth to eat	3.50	1.65	5.65	10.65	15.55	5.65

Figure 4. Lobster feeding activity in treatment D.

Based on Figure 4, treatment D with disc-shaped artificial feed with a diameter of 4 cm showed some feeding activity on lobsters. Treatment B showed the activity of eating lobsters when they saw the feed was around 35.60-62.35%; then lobsters approached the feed with a percentage of activity around 5.60-32.75%. After the lobster approaches the feed, the lobster will take the feed with a range of 3.55-25.95%, and then the lobster will open its mouth to eat the feed given with a percentage range of 1.65-15.55%. Figure 4 shows that most eating activities occur between 06.00 p.m-10.00 p.m. and 10.00 p.m-02.00 a.m. Observation of the feeding activities, namely looking, approaching, taking and opening the mouth, for the test feed and for all treatments showed that lobster feeding activities are mainly carried out between 06.00 p.m. and 10.00 p.m., and between 10.00 p.m. and 02.00 a.m. The lobsters' feeding activity for all treatments based on time is presented in Figure 5.

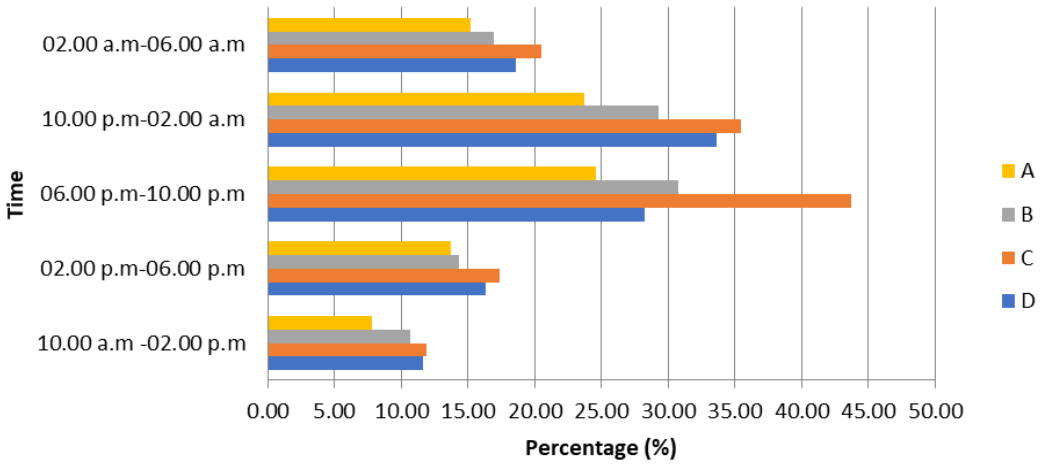


Figure 5. Lobster feeding activity based on time.

Discussion. Based on the results of observations, the lobsters' process of eating comprised the same steps for all treatments: it started by gripping the feed using both claws and walking legs, then breaking it with their claws in order to put small pieces of feed into their mouths (Barosso et al 2013; Fujaya et al 2016). After the lobsters tear the food provided, the next step is tasting the food by putting it in the nearest mouth, namely the upper and lower jaws. The taste organs, namely the mouths, are more selective about the food given, so it is not uncommon to refuse food and drop it, then the walking legs take it again and put it back into the mouth, with several repetitions before the food is finally digested or rejected (Jayakumar et al 2011; Harzsch & Krieger 2017). Lobsters have the habit of quickly responding to food with both claws and walking legs. However, these organs have a different anatomy, although both of them are built of muscles and nerve fibers. Therefore, the two types of claws are used differently for feeding and fighting (John & Daniel 1997; Liu & Chui 2011; Marchese et al 2019).

The research results in Figures 1, 2, 3, and 4 showed that the response of lobsters to the test feed, until it is put into the mouth, is low and increases over time. According to Huu & Huong (2015), lobsters prefer the smell of food that is familiar to them, but this preference reverses after a period of eating new food. The test feed in this study triggered a gradual increase in response but still inadequate. At the beginning of rearing, lobsters did not respond to feed, and their responses increased daily. Low response to the smell of the test feed resulted in low food capture, so energy expenditure was also low (Suresh et al 2011; Kruk et al 2022).

The initial stages of the work process of cells and chemoreceptor organs are related to the smell and taste. The nose contains the olfactory receptors, and the smell or aroma is the chemical stimulus. The nose captures odors from the environment and is closely related to detecting mechanoreceptive flow in the odor-tracking task (Nunes et al 2006; Barosso et al 2013; Vital et al 2018). The olfactory nerve has a vomeronasal organ that directly projects the smell to the forebrain, by processing through connected nerves, called glomeruli. Furthermore, taste perception is associated with food evaluation. A specific group of epithelial cells is innervated by several cranial nerves that project the signal to the corresponding lobes in the hindbrain (Corey et al 2013; Utne-palm et al 2020).

In aquatic biota, the process of taste perception is so extensive that it covers the lips and barbels or even the whole body, so a low feeding response often occurs. The lobes of the brain are organized to defend the body's spatial system of taste buds. The taste buds combine with the mechanoreceptive tactile nerves to form a dual-modality sense (Harzsch & Krieger 2017). External taste system of the body and mouth are situated in the facial and mouth lobes, and in the vagal lobes. External taste systems may accept food items that are then rejected by more restrictive internal systems. Lobsters also taste their food with their feet; lobster legs are also a bimodal tactile sensory organ that can track an odor with a taster (external) and smell it in the water to follow the smell (Corey et al 2013; Kruk et al 2022).

Figure 5 shows the percentage of eating activity in each treatment based on time. Figure 5 also proves that eating activities generally occur between 06.00 p.m. and 10.00 p.m., and between 10.00 p.m. and 02.00 a.m. This is due to the perception of a chemical signal which identifies the source of smell or light. Then, the lobster approaches the smell or light so that the chemoreceptors detect it and produce a movement in the lobster's body. The movement of lobsters in approaching the test feed shows that the organs and chemoreceptor cells are active at certain times. The lobster will track and find the smell or aroma of the food until the last chemoreceptor cell is marked and then the lobster is opening its mouth to eat the food provided (Liu & Cui 2011; Harzsch & Krieger 2017).

Based on the research of Zakaria & Saragih (2021), there are several activities in the behavior of crustaceans, namely resting, moving, agonizing, eating, and reproduction. Mud crabs showed a feeding activity mostly occurring after midnight (nocturnal). With varying feeding times, crabs have more activity at night than during the day. This living habit allows the mud crab to detect certain foods using its olfactory organs and eyes. Crabs eat fresh fish pieces of 1-3 cm in size, caught and held with both claws; the left claw is used for cutting, while the right claw is used for holding. Pieces of

fish are put into the mouth, then bitten slowly, chewed, and swallowed until their complete consumption. Before the feed is fully eaten, the mangrove crabs do not take other feed. To consume the food, mud crabs need a long time, about 10-30 minutes. The crustacean group usually spends its time on hiding and is always alert to its surroundings, as a strategy to avoid predators (Corey et al 2013; Huu & Huong 2015).

Based on the results of Viera & Perera (2012), fresh squid given to *Panulirus argus* generates a higher growth compared to pellets. The shape and size of the pellets that do not match a species' preferences and eating habits will reduce the consumption of the feed given. It is necessary to develop based on the appropriate form to overcome some of the weaknesses in artificial feeding. Lobster feed must fit the size of the mouth; the feed's length and diameter also affect its palatability (Syafrizal et al 2018; Adiputra et al 2020). The material's particle size can affect the pellets' strength because a large surface area can increase the interactions between the particles, so that the pellets cannot be easily crushed. Conversely, a low durability index value in the feed pellets formulation will cause the segregation of the components and nutrients, ultimately affecting the feed consumption and lobster growth. Feed size also matters because lobsters have the property of tearing when eating (Supriyono et al 2017; Irwani et al 2019).

Conclusions. Based on the results of observations during the study, the feeding behavior of lobsters *P. homarus* did not show a significant difference among treatments. Observations concerned several feeding activities, namely looking, approaching, taking, and opening the mouth for test feed, showing that the lobster is active mostly at night.

Conflict of interest. The authors declare no conflict of interest.

Acknowledgements. The authors thank the Rector and Head of Research Institution and Community Service (HRICS) of Andalas University to give the opportunity and approval for funding this research. This research was funded by the grant of Andalas University, moderated by Professor Publication Research Cluster, Fiscal Year 2023 with Contract Number (No). 20/UN16.19/PT.01.03/Pangan-PDU-KRP1GB-Unand/2023.

References

Adiputra Y. T., Zairin M., Suprayudi M. A., Manalu W., Widanarni, Brite M., 2020 The effects of thyroxine hormone on gonadal maturation and growth of male spiny lobster (*Panulirus homarus*). Malaysian Journal of Science 39(1):30–40.

Amali I., Sari P. W., 2020 Growth performance of cultivated spiny Lobster (*Panulirus homarus*, linnaeus 1758) in Tuban, East Java, Indonesia. Egyptian Journal of Aquatic Biology and Fisheries 24(3):381–388.

Barosso F. G., Rodiles A., Vizcaino A. J., Martínez T. F., Alarcón F. J., 2013 Evaluation of Feed Attractants in Juvenile Senegalese Sole, Solea senegalensis. Journal of the World Aquaculture Society 44(5):682–693.

Corey E. A., Bobkov Y., Ukhanov K., Ache B. W., 2013 Ionotropic crustacean olfactory receptors. PLOS ONE 8(4):1-10.

De Paula Y. C., Schiavetti A., Calderon E., Estadual U., Cruz D. S., Amado R. J., Salobrinho B., Estadual U., Cruz D. S., Jorge R., Salobrinho B., Alagoas U. F., Penedo U. E., 2018 The effects of fish feeding by visitors on reef fish in a Marine Protected Area open to tourism. Biota Neotropica 18(3):1-9.

Efrizal, Andre S. R., Lubis A. S., Eriza M., 2023 The quality of artificial feed test by adding thyroxine hormones on the growth of selais fish *Kryptopterus lais* (Bleeker, 1851). AACL Bioflux 16(3):1410-1417.

Efrizal, Zakaria I. J., Rusnam, 2020 Effects of formulated diets supplemented with vitamin e on the egg quality and ovi somatic index of female *Portunus pelagicus* (Linnaeus, 1758) broodstock. AACL Bioflux 13(2):768-799.

Efrizal E., Syam Z., Rusnam R., Suryati S., 2019 Growth performance and survival rate of *Portunus pelagicus* (Linnaeus, 1758) broodstock females fed varying doses of amaranth extracts. F1000 Research 8:1–13.
Fujaya Y., Trijuno D. D., Aslamyah S., 2016 Domestication and selective breeding for producing fast growing and high meat quality of blue swimming crab (*Portunus pelagicus*). AACL Bioflux 9(3):670–679
Haryono F. E. D., Hutabarat J., Ambriyanto, 2016 Comparation of spiny lobster (*Panulirus* sp.) populations from Bantul and Cilacap, Central Java, Indonesia. Jurnal Teknologi Science & Engineering 78:51–54.
Harzsch S., Krieger J., 2017 Crustacean olfactory systems: a comparative review and a crustacean perspective on insect olfactory systems. Progress in Neurobiology, pp. 23-60.
Huu D. H., Lan H. L., 2015 Effects of pellet shape and size on production of spiny lobster (*Panulirus ornatus*). Proceedings of the International Lobster Aquaculture Symposium, Lombok, Indonesia, pp. 89-91.
Irwani, Sabdono A., Wijayanti D. P., 2019 Growth, mortality and exploitation rate of spiny lobster (*Panulirus homarus*) from Kebumen and Cilacap coast. IOP Conference Series: Earth and Environmental Science 246(1):1-9.
Jayakumar V. L., Ramanathan N., Jeyaseelan P., Athithan S., 2011 Growth performance of spiny lobster *Panulirus homarus* (Linnaeus) fed with natural animal food. Indian Journal Fisheries 58(3):149-152.
John C. B., Daniel P. C., 1997 Chemosensory activation of an antennular grooming behavior in the spiny lobster, *Panulirus argus*, is tuned narrowly to L-glutamate. Biological Bulletin 193(2):107-115
Kruk K. K., Fitzgibbon Q. P., Codabaccus B. M., Trotter A. J., Giosio D. R., Carter C. G., Smith G. G., 2022 The effect of feed frequency on growth, survival and behaviour of juvenile spiny lobster (*Panulirus ornatus*). Animals 12(2241):1-16.
Liliyanti M. A., Ali M., Faturrahman, 2016 Growth of spiny lobster (*Panulirus homarus*) in the integrated multi tropic aquaculture system. International Research Journal of Natural and Applied Sciences 3(8):55–67.
Liu Y., Cui Z., 2011 Complete mitochondrial genome of the Chinese spiny lobster *Panulirus stimpsoni* (Crustacea: Decapoda): genome characterization and phylogenetic considerations. Molecular Biology Reports 38:403–410.
Lubis A. S., Zakaria I. J., Efrizal, 2021 Organoleptic, physical and chemical tests of formulated feed for *Panulirus homarus*, enriched with spinach extract. AACL Bioflux 14(2):866–873.
Marchese G., Fitzgibbon Q. P., Trotter A. J., Carter C. G., Jones C. M., Smith G. G., 2019 The influence of flesh ingredients format and krill meal on growth and feeding behaviour of juvenile tropical spiny lobster *Panulirus ornatus*. Aquaculture 499:128–139.
Mashaii N., Rajabipour F., Shakouri A., 2011 Feeding habits of the scalloped spiny lobster, *Panulirus homarus* (Linnaeus, 1758) (Decapoda: Palinuridae) from the South East Coast of Iran. Turkish Journal of Fisheries and Aquatic Sciences 11:45-54.
Nunes A. J. P., Marcelo V. C., Neto F. A., Lemos D., 2006 Behavioral respons to selected feed attractants and stimulants in pasific white shrimp, *Litopenaeus vannamei*. Aquaculture 260:244-254.
Patroni J., Simpson G., Newsome D., 2018 Feeding wild fish for tourism — A systematic quantitative literature review of impacts and management. International Journal Tourism research 20:286-298.
Petersen E. H., Jones C., Priyambodo B., 2013 Bioeconomics of spiny lobster farming in Indonesia. Asian Journal of Agriculture and Development 10(1):25-39.
Priyambodo B., Jones C. M., Sammut J., 2020 Assessment of the lobster puerulus (*Panulirus homarus* and *Panulirus ornatus*, Decapoda: Palinuridae) resource of Indonesia and its potential for sustainable harvest for aquaculture. Aquaculture 528:1-17.

Romano N., Zeng C., 2017 Cannibalism of decapod crustaceans and implications for their aquaculture: A review of its prevalence, influencing factors and mitigating methods. Reviews in Fisheries Science & Aquaculture 25(1):42–69.
Subhan R. Y., Supriyono E., Djokosetiyanto D., 2018 Grow-out of spiny lobster *Panulirus* sp. with high stocking density in controlled tanks experiment period. Jurnal Akuakultur Indonesia 17(1):53–60.
Supriyono E., Prihardianto R. W., Nirmala K., 2017 The stress and growth responses of spiny lobster *Panulirus homarus* reared in recirculation system equipped by PVC shelter. AACL Bioflux 10(2):147–155.
Suresh A. V., Vassagam K. P. K., Nates S., 2011 Attractability and palatability of protein ingredients of aquatic and terrestrial animal origin, and their practical value for blue shrimp, *Litopenaus stylirostris* fed diets formulated with high levels of poultry byproduct meal. Aquaculture 319:132-140.
Syafrizal, Jones C. M., Permana I. G., Utomo N. B. P., 2018 Effect of feeding frequency on survival and growth of juvenile spiny lobster *Panulirus versicolor* in Indonesia. AACL Bioflux 11(5):1427–1434.
Utne-palm A. C., Bogevik A. S., Humborstad O., Aspevik T., Pennington M., Løkkeborg S., 2020 Feeding response of Atlantic cod (*Gadus morhua*) to attractants made from by-products from the fishing industry. Fisheries Research 227:105535.
Viera L. R., Perera E., 2012 *Panulirus argus* postlarva performance fed with fresh squid. Rev Invest Mar 32(1):9–15.
Vital V. D. S., Diane K., Didier F. E., 2018 Feed of crustaceans for a durable development of the aquaculture: shrimps feeding: A review. International Journal of Fisheries and Aquatic Studies 6(5):121-126.
Wahyudin R. A., Hakim A. A., Qonita Y., Boer M., Farajallah A., Mashar A., Wardiatno Y., 2017 Lobster diversity of Palabuhanratu bay, South Java, Indonesia with new distribution record of *Panulirus ornatus*, *P. polyphagus* and *Parribacus antarcticus*. AACL Bioflux 10(2):308–327.
Wijaya D., Nurfiarini A., Nastiti A. S., Riswanto R., 2018 Food habit, niche breadthand overlap of some spiny lobsters from gulf of Prigi, Trenggalek. BAWAL Widya Riset Perikanan Tangkap 9(3):153-161.
Zakaria I. J., Saragih D. K., 2021 Observation of behavior and daily activity of the mud crab, *Scylla serrata* (Forskal, 1775) under control condition. Egyptian Journal of Aquatic Biology & Fisheries 25(3):1079-1093.

Received: 28 May 2023. Accepted: 06 November 2023. Published online: 25 November 2023.
Authors:
Amelia Sriwahyuni Lubis, Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, Padang 25163, Indonesia, e-mail: amelialubis6@gmail.com
Efrizal, Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, 25163 Padang, Indonesia, e-mail: efrizal.unand@gmail.com
Syaifullah, Biology Department, Faculty of Mathematics and Natural Sciences, Andalas University, Limau Manis, 25163 Padang, Indonesia, e-mail: syaifullah@sci.unand.ac.id

How to cite this article:
Lubis A. S., Efrizal, Syaifullah, 2023 Feeding behavior analysis of lobster *Panulirus homarus* with a different feed shape and size. AACL Bioflux 16(6):3005-3013.