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FOOD PREFERENCES OF EARLY JUVENILE SCALLOPED SPINY LOBSTER IN EKAS BAY, LOMBOK, INDONESIA

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ABSTRACT

Ekas Bay is the largest bay on the island of Lombok which is the location for catching and cultivating spiny lobsters. This research was conducted from May to July 2021 on the Scalloped spiny lobster (*Panulirus homarus*). This study aims to identify the types of natural foods consumed and determine the preferred types of food, as well as the early juvenile feeding time of Scalloped spiny lobster located in Ekas Bay, East Lombok Regency, West Nusa Tenggara Province (NTB). Puerulus samples were collected in the last week of May 2021, enlarged puerulus was performed in submerged cages measuring 15 cm × 15 cm × 15 cm, mesh size <3 mm, with a density of 4 puerulus/m^2. The cages are placed at a location 70 m to the sea from the shoreline, at a depth of 0.5, 1.0, and 1.5 m. After reaching the juvenile phase, lobsters are collected during the new and full moon phases (06.00 am, 06.00 pm and 12.00 am, respectively) in June to July 2021. A total of 60 individual juvenile lobsters (algal phase) were analyzed for their stomach contents. The average percentage of the total Index of Relative Important (IRI) obtained for the identified taxa were bivalves (22.32%), copepods (23.64%), demosponges (24.98%), while digestibdle material was 29.06%. The electivity index data (Ei) shows that lobsters prefer bivalves over other taxa. Lobster samples taken in the morning had a stomach fullness rate of 50%, indicating active feeding at night.

KEYWORDS: Spiny lobster; Ekas Bay; Food Preferences; Juvenile

INTRODUCTION

Tropical spiny lobsters of the genus *Panulirus* have high species diversity in the East Indian Ocean of Indonesia. Generally, the people around Ekas Bay, Lombok, Indonesia refer to lobsters as “udang”. Six species of Panulirus lobsters are found in the waters of Banyuwangi, Lombok, Pacitan, Trenggalek, and Tulungangung, including Long legged spiny lobster (*Panulirus longipes*), Pronghorn spiny lobster (*P. penicillatus),* Painted spiny lobster (*P. versicolor*), Ornate spiny lobster (*P. ornatus*), Mud spiny lobster (*P. polyphagus*), Scalloped spiny Lobster *(P. homarus*) (Setyanto *et al*., 2019). *P. homarus* is the second species of spiny lobster with high economic value in Indonesia, after *P. ornatus*. These two species of lobsters are the most dominant species caught (Damora *et al*., 2018; Permana *et al*., 2019; Yonvitner *et al*., 2019). The percentage of catches of *P. homarus* landed in Situbondo, East Java, Indonesia originating from the Madura Strait was 52%, followed by *P. ornatus* (37%) (Setyanto *et al*., 2021).

The development of lobster cultivation is hampered by the existence of The issuance of Minister of Marine Affairs and Fisheries Regulation (Permen-KP) No. 1 of 2015 concerning catching lobsters (*Panulirus* spp.), crabs (*Scylla* spp.), and blue swimming crabs (*Portunus* spp.) (KKP, 2015), and Permen-KP No. 56 of 2016 concerning Prohibition of catching and exporting lobsters (*Panulirus* spp.), crabs (*Scylla* spp.), and blue swimming crabs (*Portunus* spp.) from the territory of the Republic of Indonesia (KKP,, 2016). In 2020, the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia established Permen-KP No. 12 of 2020 and No. 17 in 2021, which was later replaced by Permen-KP No. 16 of 2022, which

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allows the development of lobster cultivation using puerulus seeds (apparent lobster seeds) and juveniles (young lobsters) which in the previous Ministerial Regulation prohibited catching (KKP, 2020). The locations for catching puerulus are scattered along the south coast of Java Island to Sumbawa Island (Priyambodo *et al*., 2017, 2020). The abundance of puerulus caught during the new moon phase was lower than that caught during the full moon (Diatin *et al*., 2022). In Lombok waters, the fishing season for puerulus needs to be clarified. However, the lowest catch of puerulus was between December and March, and the highest was from April to November, with the percentage of *P. homarus* puerulus was 63-87% and *P. ornatus* was 13-37% (Priyambodo *et al*., 2020). Although the natural abundance of lobster seeds is relatively high, this trend is not followed by high lobster production due to limited cultivation skills and less nutritious feed (Jones, 2018). The total production of lobster cultivation in Indonesia from 12 lobster-producing provinces in 2021 is 512.23 tons, of which West Nusa Tenggara Province produced 137.7 tons (KKP, 2022).

In Ekas Bay, fishermen cultivating lobsters use trash fish from the Clupeiformes group and *Portunus* spp. as lobster feed at all lobster stages, except for the puerulus stage which is only fed once it enters the juvenile phase. In nature, the late-stage larva metamorphoses into a non-feeding puerulus which actively swims towards the shore to inhabit shallow habitats and does not continue feeding until it molts into the early juvenile stage (Martínez-Calderón, 2018). The juvenile phase is a crucial phase for the growth of spiny lobsters. The early juvenile stage is the key to the transition from the larval (planktonic) stage to the adult (benthic) stage, characterized by high mortality (Small *et al*., 2016). Searching for information related to natural food for juveniles in their natural habitat is urgently needed to develop aquaculture as a basis for managing feeding to increase the chances of success in raising lobster seeds. This study aimed to identify the types of natural foods consumed and determine the preferred types of food, as well as the early juvenile feeding time of Scalloped spiny lobster located in Ekas Bay, East Lombok Regency, West Nusa Tenggara Province (NTB).

MATERIALS AND METHODS

Sample Collection

This research was conducted from May to July 2021 in the eastern part of the Ekas Bay waters, East Lombok Regency, West Nusa Tenggara Province (NTB), Indonesia (Figure 1). Puerulus are caught using a fishing gear made of cement paper in the form of a bow tie with many folds called pocong or pocongan (Fig. 1b), a tool commonly used by fishermen catching lobster seeds on the study site. The collected puerulus was then grown until it reached a juvenile size at a depth of 0.5; 1; 1.5 m in a submersible cage (SC) measuring 15 cm × 15 cm × 15 cm, mesh size <3 mm. SC was spaced 70 m from the beach with a treatment density of 4 individuals/m^2. Lobsters that had entered the juvenile stage were collected during the new and complete moon phases at three sampling intervals, namely at 06.00 am, 06.00 pm, and 12.00 am, and preserved using 70% ethanol.

Observation and Identification of Samples

In the laboratory, samples of juvenile lobsters were measured for carapace length, weighed, and then grouped into juvenile phases according to Briones-Fourzán *et al.* (2003), namely algal (5–15 mm carapace length; CL); post algal (15–45 mm CL); and subadult (45–80 mm CL). Gastrointestinal tract content analysis was performed based on the size category of the juvenile phase using the relative-fullness and presence-absence methods. The contents of the alimentary canal were placed on a Sedgewick-rafter slide, then sorted under a microscope to classify food organisms by type and identify them to the lowest possible taxonomy. Sedgewick-rafter is also aimed at determining the volumetric estimation of each food category. This technique is a modification of the method described by Joll & Phillips (1984), to Briones-Fourzán *et al*. (2003) and, Castañeda-Fernández-de-Lara *et al*. (2005) related to standard volume estimation measures.

Contents of The Digestive Tract Analysis

Percentage of gastric fullness was calculated visually and categorized based on a scale of 0% (0–5%), 10% (6–15%), 25% (16–35%), 50% (36–65%), 75% (66 – 90%), and 100% (91–100%) (Briones-Fourzán *et al*., 2003). Percentage of frequency of occurrence (%*F*) was calculated using the formula (Briones-Fourzán *et al*., 2003; Castañeda-Fernández-de-Lara *et al*., 2005):

$$\%F = \frac{Lbi}{\sum_{i=1}^{\sum n} Lbi} x100$$

Where Lbi = stomach contains the food type-i

The formula calculates the relative importance index (Index of Relative Important, IRI) for each type of organism (Pinkas *et al*., 1971):

$$IRI = (N + V)\ F$$

Where N = percent number of individual species organisms; V = volume percent of an organism species; F = percent frequency of occurrence of a species of organism.

The prey selection was analyzed using the Ivlev electivity index (Ivlev, 1961; Mashaii *et al*., 2011):

$$Ei = \frac{ri - pi}{ri + pi}$$

Where Ei = Ivlev electivity index of prey I; ri = percentage of target I contained in the stomach of the predator obtained from the number of individuals I/ total number of the individual mark in the stomach *100); pi = percentage of prey in its natural environment calculated only from prey eaten by predators.

Data analysis was carried out by comparing the IRI and Ei indices of early juvenile the Scalloped spiny lobster (*Panulirus homarus*) regarding month, depth and time of sampling using the ANOVA test with a significant level of 5%.

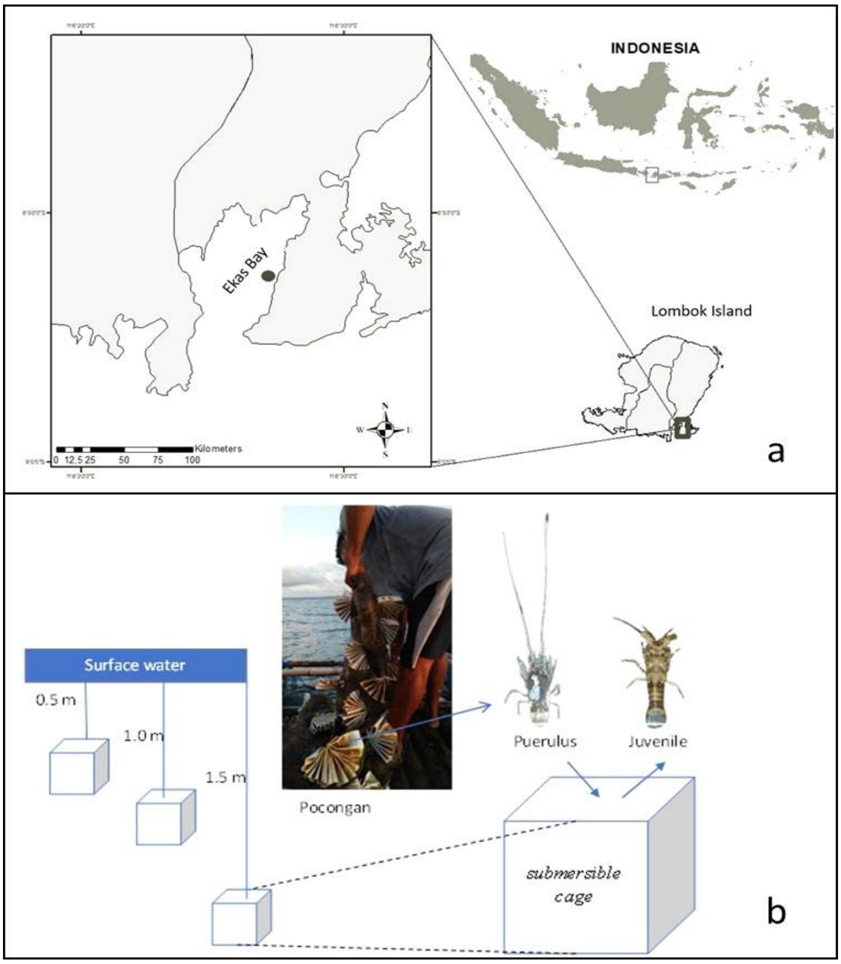


Figure. 1. Map of research locations on natural food preferences of Scalloped spiny lobsters (*Panulirus homarus*) in Ekas Bay, East Lombok (a), research design (b).

RESULTS AND DISCUSSION

Morphology, Weight, and Carapace Length of Juvenile *P. homarus*

The main distinguishing feature between puerulus and juveniles is the presence of pigmentation in the juvenile phase, which was previously transparent (Figure 2). Lobster species can be determined in the puerulus phase by looking at the antenna characteristics and body morphology. Puerulus *P. homarus* has a transparent body and brown eyes (Saputra *et al*., 2020). A transparent antenna has a pair of band pigments that differ half of the antenna's total length and develop in a pattern up to the entire length of the antenna. The pigment of the initial band is darker than the other bands. Antenna length ranges from 1.5 to 2 times body length. During the development of pigmentation, the abdomen has a mottled brown color without a white stripe (Priyambodo *et al*., 2015).

In addition to the transparent colour, the puerulus has an average carapace length (CL) range of 5.8 to 9.4 mm with an average of 4.49 ± 0.57 mm. Body weight is 0.1 to 0.29 g with an average of 0.20 ± 0.06 g (Dharani *et al*. 2009). Puerulus in Ekas Bay has a standard (CL) of 6.12 ± 0.01 mm with a weight of 0.27 ± 0.01 g and has the highest mean weight and

CL of 0.92 ± 0.13 g and 9.73 ± 0 .57 mm, respectively when entering the early juvenile phase in the puerulus placed at a depth of 0.5 m (Table 1). All juveniles collected were included in the algal category. Briones-Fourzán *et al*. (2003) described juvenile algal as the adolescent phase of lobsters in shallow and vegetated areas, living solitary lives and having limited foraging areas.

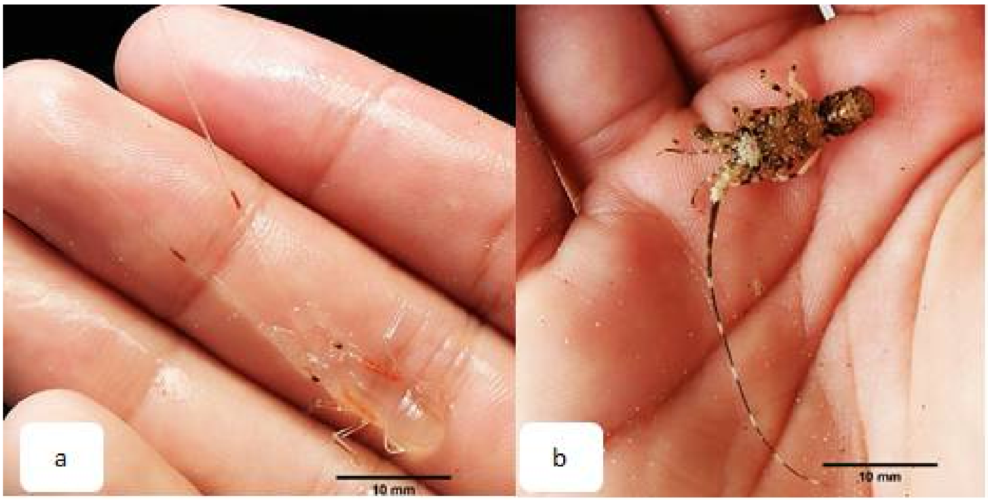


Figure 2. Puerulus (a) and early juvenile visual morphology (b) of the Scalloped spiny lobster (*Panulirus homarus*) in Ekas Bay, East Lombok.

Table 1. Weight and carapace length of the Scalloped spiny lobster (*Panulirus homarus*) in Ekas Bay, East Lombok

Depth (m)	N	*Puerulus*		Early juvenile		Juvenile phase category
		Weight average (g)	CL Average (mm)	Weight average (g)	CL average (mm)	
0.5	20	0.27±0.01	6.12±0.01	0.92±0.13	9.73±0.57	Algal
1.0	20	0.27±0.01	6.12±0.01	0.74±0.11	9.24±0.53	Algal
1.5	20	0.27±0.01	6.12±0.01	0.74±0.10	9.21±0.48	Algal

*CL = carapace length

Feeding activity time for juvenile spiny lobster

A total of 60 initial juvenile lobsters were analyzed for their stomach contents. Per cent fullness of the stomach (25-50%) is more observed when taking samples at midnight (12.00 a.m. or 00.00) and in the morning (06.00 a.m). In comparison, the value of gastric fullness is 10% more before sunset (06.00 p.m.), indicating that juvenile *P. homarus* was actively looking for food at night (Figure 3). Lobsters show increased activity in areas where there is food at night, although in general, lobsters in foraging areas are observed in the morning and at night (Kropielnicka-Kruk *et al*., 2022). Lobsters are more active when there is no food or predators, less active when there are predators, and show moderate activity when food is present (Zenone *et al*., 2020).

The juvenile spiny lobster's main food

The overall prey obtained was grouped into four categories: copepods, demosponges, bivalves, and digested material (Figure 4). Leaving aside digested material, based on the total average of the Index of Relative Important (IRI) among all prey categories with identified taxa shows that early juveniles of *P. homarus* in Ekas Bay had a percentage of important natural food sources, namely crustaceans (copepods; 23.64%), molluscs (bivalves; 22.32%), and sponges (demosponges; 24.98%). The digestible material has a greater percentage (29.06%). In detail, referring to the phases of the moon, depth, and time, it shows that juvenile lobster food for the identified taxa each has the highest percentage in 6 conditions but at different times and depths (Figure 4). Statistical tests showed that the IRI of early juvenile lobsters differed according to the moon phases and did not differ for time and depth (ANOVA, ñ <0.05).

The growth of the early stages of spiny lobster is strongly influenced by the availability and abundance of feed and ideal environmental parameters (Haryono *et al*., 2021). Important feeds in different diets in the IRI concept were obtained by looking at the frequency and amount, regardless of nutrition and other factors (Hart *et al*., 2002). Briones-Fourzán *et al*. (2003) and, Castañeda-Fernández-de-Lara *et al*. (2005) reported juvenile *P. argus* and *P. interruptus* obtained its main prey in the form of crustaceans, whereas bivalves were found as the main food source of *P. homarus* on the southeastern coast of Iran (Mashaii *et al*., 2011). In contrast to the stomach contents of the *P. homarus* lobster, the *Jasus paulensis* has the most common prey item in the form of seaweed (brown algae), whose percentage is more than 40%, but has similarities with those found. Bivalves by 29%, hydroids (29%), sponges (24%), and only about 5-10% consisting of sea urchins, barnacles, and macroalgae Lobsters mostly consume sponges and sea urchins in deep waters. Sponges are seen as prey for both small and large lobsters (Blamey *et al*., 2019). Briones-Fourzán *et al*. (2003) explained that palinurid lobsters are omnivores and mainly consume crustaceans, molluscs (especially gastropods), fish and marine plants. Crabs, bivalves and gastropods are important in the diet of *P. homarus* (Mashaii *et al*., 2011)

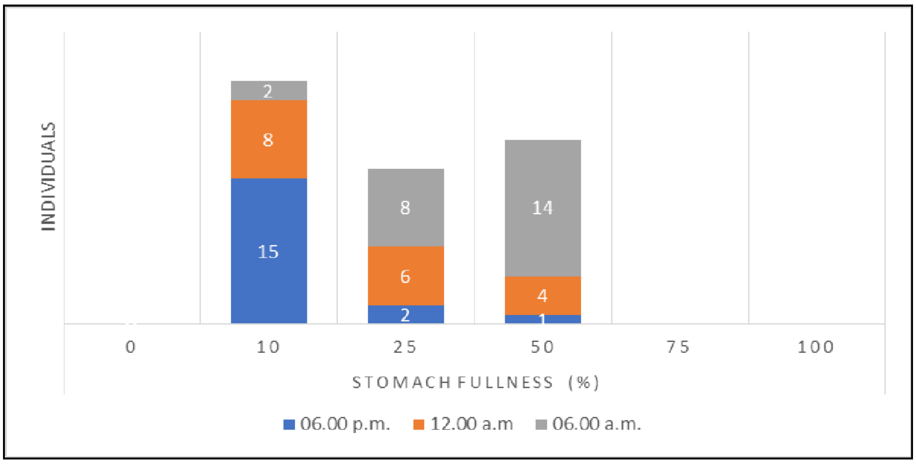
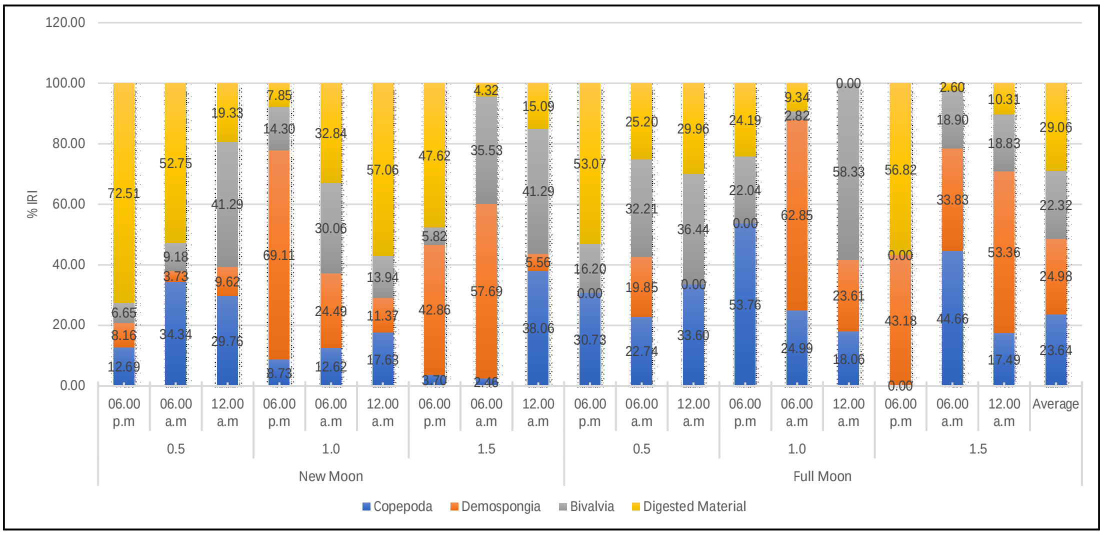


Figure 3. Percent stomach fullness of early juvenile Scalloped spiny lobsters (*Panulirus homarus*) in Ekas Bay, East Lombok, NTB, Indonesia.



Anova IRI, ñ <0.05), ñ (month) = 0.01; ñ (depth) = 0.365; ñ (times) = 0.604

Figure 4. Index of Relative Important (IRI) for early juveniles of Scalloped spiny lobster (*Panulirus homarus*) in Ekas bay, East Lombok, NTB, Indonesia.

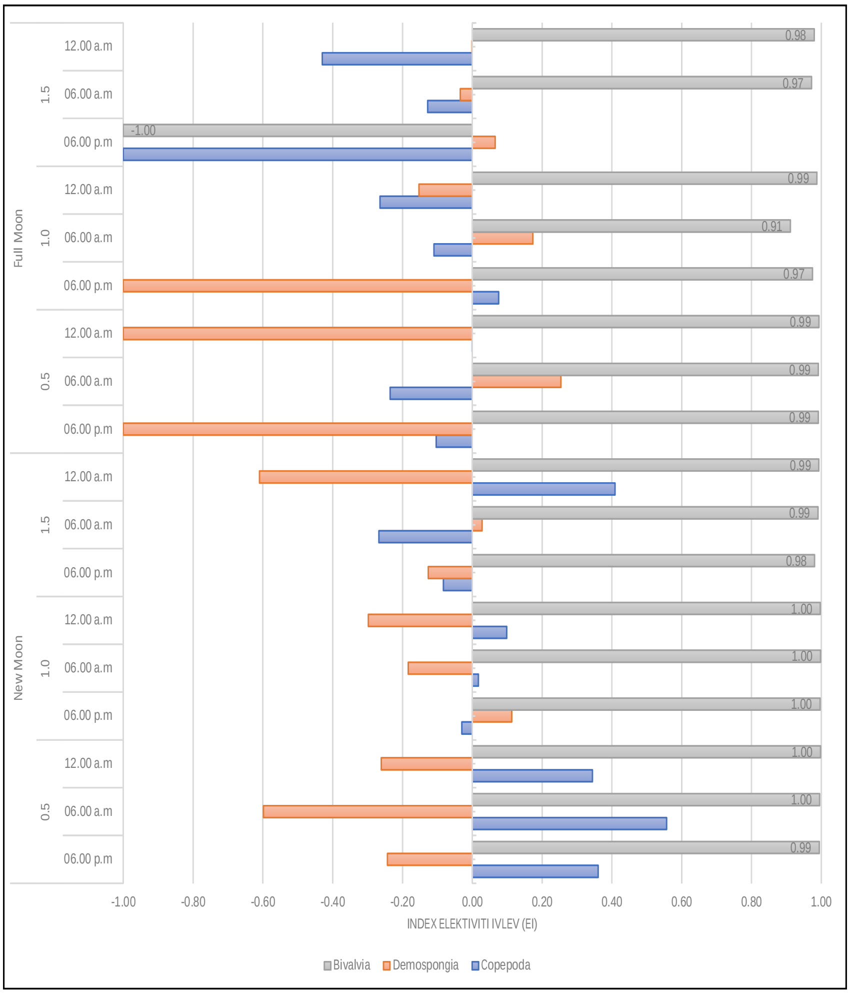
Plankton is the prey found in post-larval stage sand lobsters caught in three locations: Prigi Bay, Tawang Bay, and Gerupuk Bay. Analysis of the digestive tract shows that lobsters consume several plankton species with the type *Synedra* sp. and *Rhizolenia* sp. are plankton generally found in all lobster samples used (Amin *et al*., 2022a). Natural food analysis of wild-caught *P. ornatus* lobsters using eDNA barcoding showed 17 species identified at the post-puerulus stage, with the dominant species from the crustacean group, namely *Audacallichirus mirim* (28.60%), *Oithona* sp. (19.36%), and the juvenile stage which was dominated 80.88% by *Oithona* sp. (Amin *et al*., 2022b). Food preferences depend highly on location and season (Castañeda-Fernández-de-Lara *et al*., 2005; Pavlova & Dvoretsky, 2022).

Juvenile spiny lobsters' favorite food

The electivity index (Ei) of prey varies between taxa categories. Selection of prey based on the value of Ei showed no difference between the moon's phases, time of day and depth (ANOVA, $p<0.05$). Interestingly, although copepods (crustaceans) and demosponge (Porifera) had higher IRIs, bivalves (molluscs) had more positive Ei values between different times and months than copepod taxa. In contrast, demosponge tended to show negative Ei values (Figure 5). Negative values indicate avoidance or prey items are difficult or even inaccessible, while positive values indicate active selection of prey. Values 0 indicates the proportion of prey consumed in proportion to its abundance in the environment (Borme *et al*., 2022; Strauss, 1979; Waddington *et al*., 2008). Furthermore, a negative value indicates that the proportion of prey eaten or observed in the digestive tract is usually lower than the number of prey in their natural environment (Macário *et al*., 2021).

CONCLUSIONS

Early juvenile food organisms (algal category) Scalloped spiny lobster (*Panulirus homarus*) in Ekas Bay, East Lombok, consists of three identified taxa, with demosponges as their main food. Bivalvia is the type of food most preferred by juvenile lobsters. Lobsters eat at night. Based on the results obtained in this study, it is recommended to provide food in the form of bivalves for the development of Scalloped spiny lobster cultivation from the puerulus phase to early-stage juvenile lobsters. The best feeding time is recommended when the sun begins to set with optimal seed placement at a depth of 0.5 m.



Anova Ei, ñ <0.05), ñ (month) = 0.247; ñ (depth) = 0.811; ñ (times) = 0.601

Figure 5. The selectivity index of juvenile sand lobsters (Panulirus homarus) based on moon phase, depth and time of day in Ekas Bay, East Lombok, NTB.

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