BUKTI KORESPONDENSI

JURNAL INTERNASIONAL BEREPUTASI TERAKREDITASI Q2

Judul Artikel : Diversity and abundance of plankton community in Tawang and Prigi Bays, natural settlement habitats of Spiny Lobster larvae inEast Java, Indonesia
Jurnal : Biodiversitas
Penulis : ENDANG DEWI MASITHAH, MUHAMMAD GIANO FADHILAH, MUHAMAD AMIN , KURNIATI UMRAH NUR , LAILA MUSDALIFAH, SHIFANIA HANIFA SAMARA, YUDI CAHYOKO , ALIMUDDIN , SAHRUL ALIM , BAGUS DWI HARI SETYONO

No	Perihal	Tanggal	Halaman
1.	Bukti submit dan artikel yang disubmit	1 Februari 2023	2-17
2.	Bukti komentar reviewer (round 1)	3 Maret 2023	18-38
3.	Bukti review round 2	7 Maret 2023	39-52
4.	Bukti komentari reviewer (round 3)	11 Maret 2023	53-65
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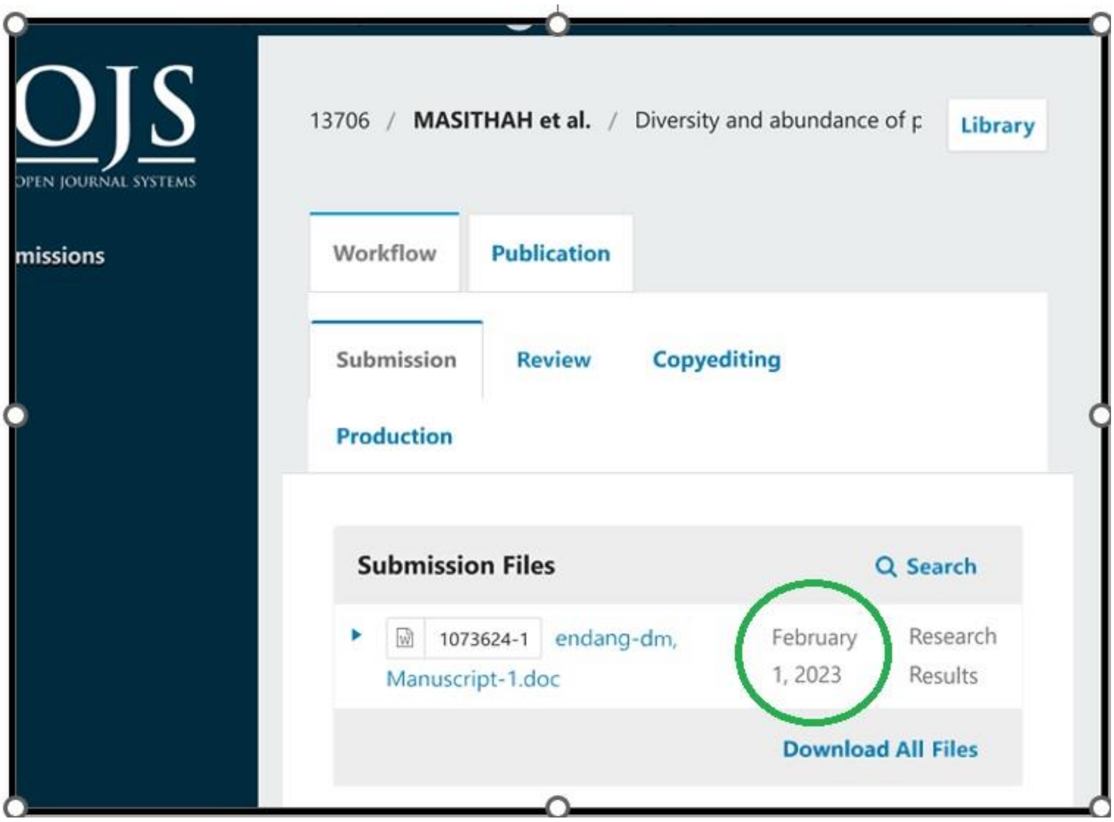

B. Editor mengkonfirmasi bahwa naskah telah diterima untuk proses review 1

[biodiv] Submission Acknowledgement
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Author(s) name:

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The manuscript is the first study to report diversity, and abundance of planktons in two most common natural settlement habitat of lobster larvae in east java Indonesia (Tawang Bay and Karanggongso Bay).

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Endang Dwi Masithah

Diversity and Abundance of Plankton Community in the Natural Settlement Habitats of Spiny Lobster Larvae

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Abstract. Tawang Bay and Karranggongso Bay have been well-known as settlement areas for lobster larvae in East Java Indonesia, which may suggest that the location are suitable environments including diet availability for lobster larvae. Therefore, the study aimed to investigate the abundance and diversity of plankton in the both locations to discover potential live diets for lobster larvae. Plankton samples were collected in both locations using a plankton net at four different depths: 0.3m, 2.5m, m, and 20m with three replicates. The result revealed that 17 plankton species were identified from the 0.30m depth, 13 species at a depth of 2.5m, 11 species at a depth of 5m, and 13 species at 20m at Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a 2.5m, 12 species at 5m, and 12 species at 20m. The diversity index and uniformity indices of plankton in both locations were considered at a moderate. While there were no dominant species at both locations, indicated by the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

Key words: diversity, diets, dominance, lobster, plankton, uniformity.

Abbreviations (if any): -

Running title: Plankton diversity in lobster natural habitat

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents as well as high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has been highly dependent on the wild catch because lobster aquaculture has not been well developed yet. One of the main issues faced in lobster aquaculture is larval production, which currently relies on the availability of seeds in nature. Many studies have been conducted to study various factors relating to larval production of larvae including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded to breed and producing larvae. Yet, the larvae can live only 7-14 days after hatching. It is hypothesized that the main challenge is in diet availability and suitability. According to Amin et al. (2022b), one way to start domesticating wild species is firstly by collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest that profiling certain animals' natural habitat may reveal their diets.

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors hold important information

for the lobster larvae, especially for diets (O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. In their natural settlement habitat, plankton might be a natural diet source for various types of fish seeds, including lobster seeds. Raza'i et al. (2018) added that the availability of plankton as a natural diet source has a significant impact on the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance might reveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed for lobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunung Kidul, Yogyakarta. The study results in general suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raise questions about whether lobster larvae are opportunistic feeders or specific feeders. To answer these questions more studies are required by collecting more information in more settlement areas of lobster.

Tawang Bay been well-known as one of the most settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, the objective of this research is to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlement habitat of lobster larvae at Karanggongso and Tawang Bays. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

MATERIALS AND METHODS

Study area

The collection of plankton samples was carried out in two common settlement areas of lobster larvae in East Java Indonesia (Tawang Bay) with a protocol as previously described by Amin et al. (2022c). The sampling location was performed at ordinate points: 8°15'57.4"S 111°17'46.0" E (L1), 8°15'54.3"S 111°17'48.2"E (L2) and 8°15'51.5"S 111°17'46.2"E (L3), (Figure 1). Plankton sampling was conducted at three different sampling points with four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. The water samples were filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

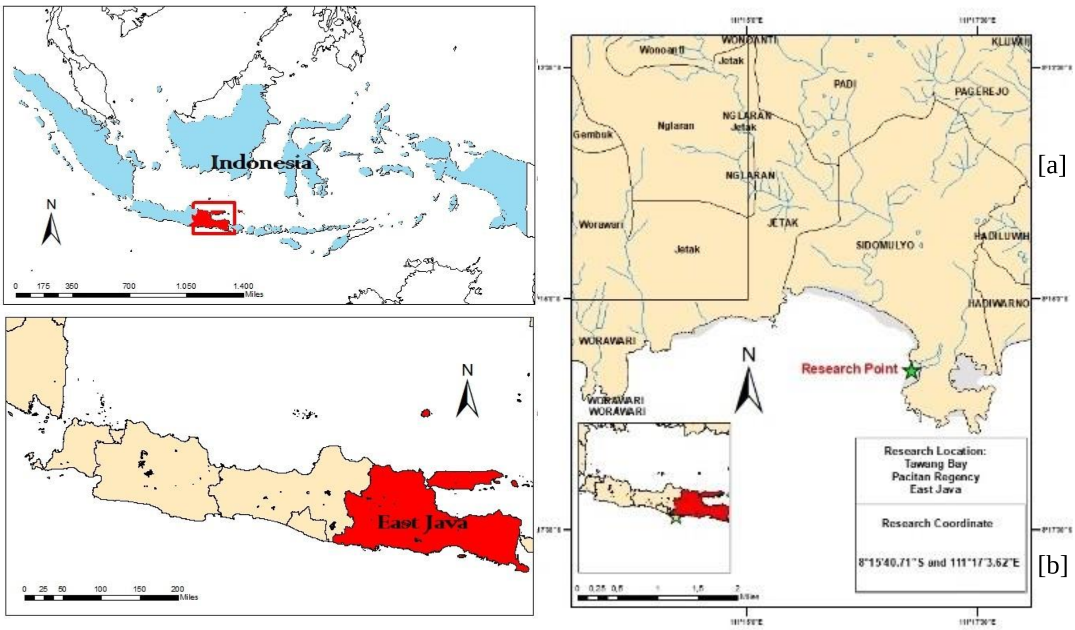

Figure 1 Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia.

Karanggongso Bay waters have temperatures ranging from 27-28 ^{o}C, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a NO_3 content of 0.01 mg/L, and a muddy substrate. Tawang Bay waters temperatures are slightly warmer than Karanggongso Bay, with water temperature ranging from 28.2-28.3 ^{o}C, with a significantly lower, DO content of 3.35

mg/L. moreover, Tawang Bay has a higher salinity of 35 ppt, a pH of 8, a NO_3 content of 0.01, a depth of 15 m, and a sandy substrate

Abundance and Identification of planktons

Firstly, plankton identity and their abundances were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting Cell and observed under a binocular microscope with a magnification of 1000x. Thereafter each plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012)::

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where “N” represents the abundance of plankton (plankter/L), “a” represents the number of SRC boxes, “b” is the area of one field of view (mm2), “c” denotes the number of individuals observed, and “d” indicates the number of boxes observed. “Vb” is the volume of water in the sample bottle (ml), “Vsrc” is the volume of water in the SRC (ml), and “Vs” represents the volume of water filtered in the Field (L).

Diversit, Uniformity and dominant indices

The diversity index value (H') was calculated using the following formula (Fachrul 2012):

$$H' = -\sum Pi\ln Pi, where\ Pi = \frac{ni}{N}$$

Where H' is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number.

The uniformity index (E') was calculated using the “Evennes Index” formula (Ulfah et al. 2019):

$$E' = \frac{H'}{\ln s}$$

where, E' is uniformity index, H': Shannon Wiener Diversity Index, S: Total number of species

The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

where, “d”: Simpson Dominance Index, Nmax: The most abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Plankton Abundance in Karanggongso Bay

Samples of water were obtained from Karanggongso Bay at three designated locations, each with four different levels of depth. A total of 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage was presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified and the top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and *Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the Bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species including *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer which were counted for 3.85% each, Table 1. Meanwhile, a total of 13 plankton species were found at the depth of 20 m. The top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta* sp. with 6.90%.

The rest species were presented in table 1.

Table 1. Planktons identified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different depths of the water column.

Depth	**Species**	**Cell density (Indiv/L)**
0.3 m (Surface)	*Cyclotella* sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
	Paracyclopina sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8
2.5 m	*Rizosolenia* sp.	8
	Penilia sp.	8
	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polychaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16

Euphausia sp.	8
Protoperidinium sp.	8
Sagitta sp.	16

Plankton Abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at depth of 0.0-0.3 m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp. with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). While the rest species were counted for 2.56% each and presented in **Table 2**. In addition, there were 11 species of plankton found in a water sample at a depth of 2.5 m in Tawang Bay. The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp. were counted at 4.00% each, **Table 2**.

Furthermore, a total of 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp. with an abundance of 9.52%. While the rest species including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00% respectively. While in the bottom waters of Tawang Bay (20 m depth), a total of 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). While the rest species were presented in table 2**.**

Table 2. Planktons identified from the natural habitat of spiny lobster in bottom water at Tawang Bay, East Java Indonesia

Depth	**Species**	**Density (Indiv/L)**
0.3 m (Surface)	*Synedra* sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
	Acartia sp.	40
	Microstella sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified *Fish larvae*	8
	Unclassified flatworms	8
2.5 m	Synedra sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
	Calanus sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
	Melosira sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16

5 m	*Dinophysis* sp.	8
	Microstella sp.	8
	Calanus sp.	48
	Oithona sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
20 m (bottom)	*Rhizoselenia* sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
	Microsetella sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified *flatworm*	8

Diversity indices

The diversity index values obtained in the waters of Karanggongso Bay, Trenggalek Regency East Java were 2.49 ± 0.07 at depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ± 0.10 at the 20 m water column which indicates that the Karanggongso Trenggalek waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay were 2.65 ± 0.03 at 0.0 – 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay have also moderate diversity, Figure 2

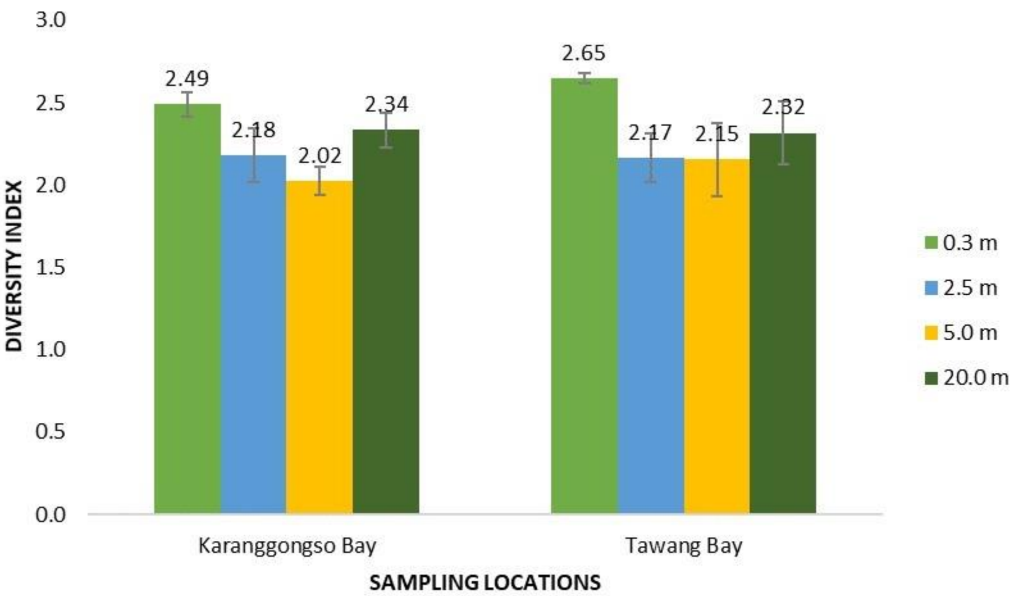

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East java Indonesia. Bars are the average values with a standard deviation of three replicates.

Domination Index

The dominance index is a value that indicates whether there are plankton species that dominate certain depths in the water column. Dominance index values obtained from the waters of Karanggongso Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean that no plankton species were dominant in the natural habitat of spiny lobster larvae (Karanggongso Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, based on the values obtained from the surface to the bottom of the waters shows that there are no species that dominate in Tawang Bay, Figure 4.

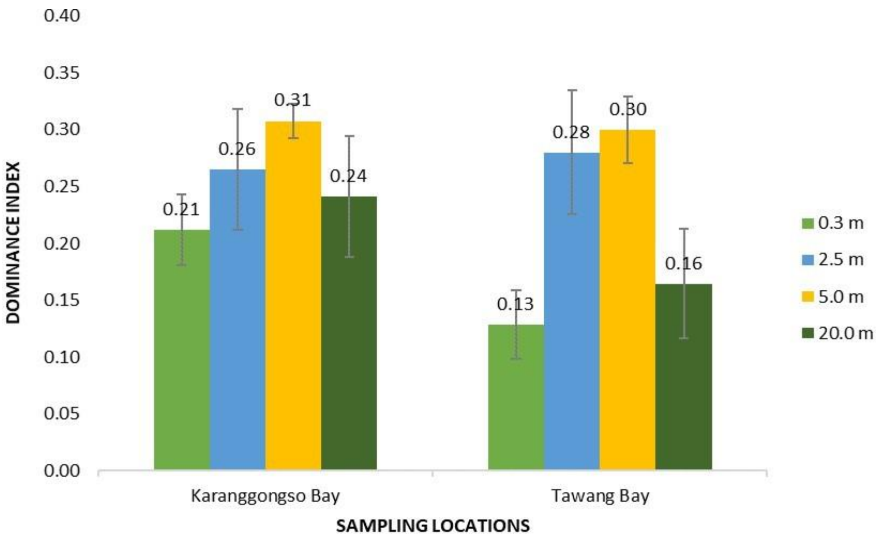

Figure 4. Domination indices of planktons identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Discussion

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability can be important information on the natural diets of lobster larvae (O'Rorke et al. 2014). Thus the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karangongso Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime . It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual or in another sense there are no species that have relatively more diversity than other species (Awwaluddin et al. 2017). As the diversity indices of plankton at Karanggongso Bay and Tawang Bay may which is at a moderate level may suggest that plankton communities is in relatively equal distribution of different species, with no one species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of planktons in both settlement areas were classified at a moderate level (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. The uniformity values found at each location, both Karanggongso Beach waters and Tawang Beach waters, are said to have moderate uniformity. The value of uniformity is categorized to be moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019)**.** The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020)**.** In addition, If the distribution of plankton in both waters is uniform, then a high degree of uniformity can be asserted **.** While the dominance indices were ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay. The result indicates that there were no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Karanggongso Bay and also Tawang Bay. Whether or not organisms dominate a waters can be seen from the value of the dominance index if the dominance index shows a value between 0.5 to 1 then in these waters there are organisms that dominate and if it shows a value less than 0.5 then in these waters it indicates the absence of organisms dominating (Berger and Parker 1970).

Potential Diet for Lobster Seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. The number of plankton species identified in the present study, in general, are higher than in previous study reported from other settlement habitats of lobster larvae in Awang Bay west Nusa Tenggara (Amin et al. 2022c) and Teluk Wedi Ombo, Yogyakarta (Trijoko and Pasaribu 2004)**.** The most abundant species identified from Karanggongso Bay were *Paracyclopina* sp., *Acartia* sp., *Pteropods* sp., and *Prorocentrum* sp. *Dinophysis* sp., *Saggita* sp., *Ceratium* sp., *Microstella* sp., *Dinophysis* sp., *Calanus* sp., *Synedra* sp., and *Oithona* sp. (7.69%). While most abundant species found in Tawang Bay were *Acartia* sp., *Ceratium* sp. *Prorocentrum* sp., *Microstella* sp., *Oncaea* sp., *Pteropods* sp., *Calanus* sp., *Synedra* sp., *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., *Macropthalmus* sp., *Sagita* sp., *Dinophysis* sp., and *Rhizoselenia* sp. of these identified plankton species, 10 species were found in both locations including *Acartia* sp., *Oithona* sp., *Paracyclopina* sp., *Pteropod*s sp., *Binophysis* sp., *Sagita* sp., *Microstellas* sp. *Calanus* sp., *Synedra* sp.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture including *Oithona* sp. for live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a), and shrimp larvae (Dinesh Kumar et al. 2017), and *Acartia* sp., as a live diet for seabass larvae, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae (Sarkisian et al. 2019). In fact, some studies also confirmed that these plankton species were identified in the stomach content of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022d; Khvorov et al. 2012). *Oithona* sp. has been described as a marine calanoid copepod which has high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30) which in fact are higher compared to a commercial live diet such as Artemia (Magouz et al. 2021b). Furthermore, *Acartia* sp. has been also documented to be a good live diet for aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). A. clausi has been described to have higher contents of proteins (63.12%) and lipids (16.65%) and is also richer in n − 3 fatty acids (33.94%) than Artemia nauplii and rotifers (Rajkumar, 2006). The plankton species has been also identified in the stomach content of spiny lobster larvae (Amin et al. 2022d). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. According to the results obtained, the plankton found at each station consists of Bachillariophiceae (*e.g. Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.,), and Copepoda (e.g. *Oithona* sp., *Acartia* sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). PUFA including EPA (eicosapentaenoic acid, 20:5 n-3) and DHA (docosahexaenoic acid 22:6 n-3) are the major fatty acids found in diatoms Bachillariopiceae (Pahl *et al*, 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera & Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long-chain fatty acids are an essential nutrient for spiny lobster (Koshio & Kanazawa, 1994; Liddy *et al*, 2004;Wang, 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods, it is also high in calcium content which is important for lobster during molting (Kirno et al, 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. This suggests that copepods are a preferred food for lobster larvae. Protein is constantly the predominant organic nutrient in the spiny lobster larvae as well as their preferred prey (Wang, 2013). This is consistent with prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston *et al*, 2004a; Johnston *et al*, 2004b, Johnston *et al*, 2006). Copepods contain high protein content, ranging from 28.9 - 84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang & Jeffs, 2014). The protein content of the copepods is in accordant with the amount of protein incorporated into artificial feeds for some of the crustaceans larvae including crab, shrimp, and clawed lobster species, which is ranging between 30% to 60% protein (Conklin *et al*, 1980 ; *Guillaume*, 1997 ; Holme *et al*, 2009). Moreover, copepods also high in lipid, ranging from 11.3%-12.4% (Wang & Jeffs, 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae, and utilize it to supply energy, especially during a food scarcity (Johnston *et al*, 2004; Liddy *et al* , 2003; Liddy *et al* , 2004; Ritar *et al*, 2003). Furthermore, late phase phyllosoma of spiny lobster probably target high lipid prey, as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs *et al*, 2001a; Jeffs *et al*, 2001b). The presence of copepods especially *Oithona* sp., *Acartia* sp., and *Calanus* sp in a high abundance value at the Karanggongso and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae, therefore, should be further studied by in vivo trials using aquatic animals especially for developing ornate spiny lobster hatcheries.

In conclusion, a total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. It was also discovered that the diversity index of plankton was considered at a moderate level at

both locations, 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. Similarly, the uniformity index was classified at a moderate level at both locations (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. While the dominance index was ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay which indicates that there were no dominant species at both location. Among the identified plankton species, several members of *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied. Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia are considered potential live feed for lobster larvae, and thus should be further studied.

ACKNOWLEDGEMENTS

The authors thank all colleges at the Fish Nutrition Group, Department of Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga who have provided help and technical advice during the experiment.

REFERENCES

Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The Ecological Habitat of Spiny Lobster (*Panulirus* spp.): Case Study on Lobster Fishing Ground in Trenggalek, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodivers. J., 23(6). DOI: 10.13057/biodiv/d230615.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022c. Profiling the natural settlement habitat of spiny lobster, Panulirus spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodiversitas Journal of Biological Diversity, 23(6).

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022d. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquaculture Reports, 27: 101361. 10.1016/j.aqrep.2022.101361.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi Kelimpahan dan Struktur Komunitas Plankton pada Musim Timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia, 11(6): 33-56.

Badan Pusat Statistik Indonesia (BPS). 2020. Distribusi PDB Triwulanan Seri 2010 Atas Dasar Harga Berlaku (Persen).2020. Jakarta Pusat : Badan Pusat Statistik.

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture, 388: 153-158.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science, 168(3937): 1345-1347.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. Journal of Experimental Marine Biology and Ecology, 162(1): 35-49.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquaculture International, 25: 393-411.

Fachrul MF. 2012. Metode sampling bioekologi.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. Jurnal Riset Akuakultur, 14(3): 183-191.

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an eutrophic lake. Journal of applied microbiology, 125(6): 1626-1641.

Keulder FJ. 2005. *Puerulus and early juvenile recruitment of the rock lobster Jasus lalandii in relation to the environment at Lüderitz Bay, Namibia* Rhodes University].

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the Palinurid and Scyllarid Phyllosoma larvae in Oman Coastal Waters. Journal of Agricultural and Marine Sciences [JAMS], 17: 53-60.

LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Marine Ecology Progress Series, 401: 161-172.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ. Bull, 30: 7106-7116.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of Oithona nana (Cyclopoida, Copepoda), fed on different diets. Animals, 11(5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conference Series: Earth and Environmental Science.

O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Marine Biology, 161(3): 551-563.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261(2): 649-658.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan Kopepoda (Copepods) sebagai Stok Pakan Alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur, 2(1): 63-70.

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp.(Claus, 1866). IOP Conference Series: Earth and Environmental Science.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, Acartia tonsa. Aquaculture, 501: 272-278.

Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk Pakan Alami Larva Udang Karang (*Panulirus homarus* L.) Di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta.

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod Acartia tonsa as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin american journal of aquatic research, 45(1): 159-166.

2. Bukti komentar reviewer (round 1) (3 Maret 2023)

A. Reviewer A meminta mengembangkan metodologi

Notifications

[biodiv] Editor Decision

2023-03-03 05:18 AM

Endang Masithah, MUHAMMAD GIANO FADHILAH, muhamad Amin, KURNIATI UMRAH NUR, LAILA MUSDALIFAH, MAI DANG , ALIMUDDIN ALIMUDDIN, Yudi Cahyoko, Syifania H Samara:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Diversity and Abundance of Plankton Community in the Natural Settlement Habitats of Spiny Lobster Larvae".

Our decision is: Revisions Required

Reviewer A:

This manusript on a regional level has great importance. Do ensure the authors get the manusript proofread to further enhance the quality of their work. There are parts I have higlighted yellow to look into, but there are also other aspects that I may have overlooked but needs attention.

Methodology needs slight improvement, see comments.

Recommendation: Revisions Required

Reviewer B:

Recommendation: Accept Submission

B. Artikel yang telah diperbaiki
Permintaan pengembangan metodologi telah tersedia di bab Material and Method

Diversity and Abundance of Plankton Community in the Natural Settlement Habitats of Spiny Lobster Larvae

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Abstract. Tawang Bay and Karranggongso Bay have been well-known as settlement areas for lobster larvae in East Java Indonesia, which may suggest that the location are suitable environments including diet availability for lobster larvae. Therefore, the study aimed to investigate the abundance and diversity of plankton in the both locations to discover potential live diets for lobster larvae. Plankton samples were collected in both locations using a plankton net at four different depths: 0.3 m, 2.5m, m, and 20 m with three replicates. The results revealed that 17 plankton species were identified from the 0.30 m depth, 13 species at a depth of 2.5m, 11 species at a depth of 5m, and 13 species at 20m at Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a 2.5m, 12 species at 5m, and 12 species at 20m. The diversity index and uniformity indices of plankton in both locations were considered at a moderate. While there were no dominant species at both locations, indicated by the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

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Key words: diversity, diets, dominance, lobster, plankton, uniformity.

Abbreviations (if any): -

Running title: Plankton diversity in lobster natural habitat

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents as well as high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has been highly dependent on the wild catch because lobster aquaculture has not been well developed yet. One of the main issues faced in lobster aquaculture is larval production, which currently relies on the availability of seeds in nature. Many studies have been conducted to study various factors relating to larval production of larvae including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded to breed and producing larvae. Yet, the larvae can live only 7-14 days after hatching. It is hypothesized that the main challenge is in diet availability and suitability. According to Amin et al. (2022b), one way to start domesticating wild species is firstly by collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest that profiling certain animals' natural habitat may reveal their diets.

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Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors hold important information

for the lobster larvae, especially for diets (O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. In their natural settlement habitat, plankton might be a natural diet source for various types of fish seeds, including lobster seeds. Raza'i et al. (2018) added that the availability of plankton as a natural diet source has a significant impact on the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance might reveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed for lobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunung Kidul, Yogyakarta. The study results in general suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raised questions about whether lobster larvae are opportunistic feeders or specific feeders. To answer these questions more studies are required by collecting more information in more settlement areas of lobster.

Tawang Bay been well-known as one of the most settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, the objectives of this research is to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlement habitat of lobster larvae at Karanggongso and Tawang Bays. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

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MATERIALS AND METHODS

Study area

The collection of plankton samples was carried out in two common settlement areas of lobster larvae in East Java Indonesia (Tawang Bay) with a protocol as previously described by Amin et al. (2022c). The sampling location was performed at ordinate points: 8°15'57.4"S 111°17'46.0" E (L1), 8°15'54.3"S 111°17'48.2"E (L2) and 8°15'51.5"S 111°17'46.2"E (L3), (Figure 1). Plankton sampling was conducted at three different sampling points with four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. The water samples were filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

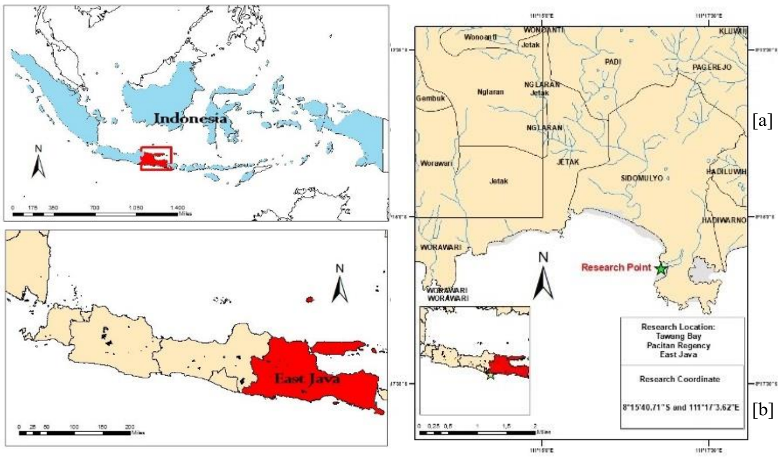

Figure 1 Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia.

Karanggongso Bay waters have temperatures ranging from 27-28 ºC, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a NO_3 content of 0.01 mg/L, and a muddy substrate. Tawang Bay waters temperatures are slightly warmer than Karanggongso Bay, with water temperature ranging from 28.2-28.3 ºC, with a significantly lower, DO content of 3.35

mg/L. moreover, Tawang Bay has a higher salinity of 35 ppt, a pH of 8, a NO_3 content of 0.01, a depth of 15 m, and a sandy substrate

Abundance and Identification of planktons

Firstly, plankton identity and their abundances were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting Cell and observed under a binocular microscope with a magnification of 1000x. Thereafter ~~each~~ plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012)::

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where "N" represents the abundance of plankton (plankter/L), "a" represents the number of SRC boxes, "b" is the area of one field of view (mm^2), "c" denotes the number of individuals observed, and "d" indicates the number of boxes observed. "Vb" is the volume of water in the sample bottle (ml), "Vsrc" is the volume of water in the SRC (ml), and "Vs" represents the volume of water filtered in the Field (L).

Diversity, Uniformity and dominant indices

The diversity index value (H') was calculated using the following formula (Fachrul 2012):

$$H' = -\sum Pi \ln Pi, \text{ where } Pi = \frac{ni}{N}$$

Where H' is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number.

The uniformity index (E') was calculated using the "Evennes Index" formula (Ulfah et al. 2019):

$$E' = \frac{H'}{\ln S}$$

where, E' is uniformity index, H': Shannon Wiener Diversity Index, S: Total number of species

The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

where, "d": Simpson Dominance Index, Nmax: The most abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Plankton Abundance in Karanggongso Bay

Samples of water were obtained from Karanggongso Bay at three designated locations, each with four different levels of depth. A total of 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage was presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified and the top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and *Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the Bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species ~~including~~ included *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer which were counted for 3.85% each, Table 1. Meanwhile, a total of 13 plankton species were found at the depth of 20 m. The top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta* sp. with 6.90%. The rest species were presented in table 1.

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Table 1. Planktons identified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different depths of the water column.

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Depth	Species	Cell density (Indiv/L)
0.3 m (Surface)	*Cyclotella* sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
	Paracyclopina sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8
2.5 m	*Rizosolenia* sp.	8
	Penilia sp.	8
	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polychaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16

Euphausia sp.	8
Protoperidinium sp.	8
Sagitta sp.	16

Plankton Abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at depth of 0.0-0.3 m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp. with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). While the rest species were counted for 2.56% each and presented in **Table 2**. In addition, there were 11 species of plankton found in a water sample at a depth of 2.5 m in Tawang Bay. The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp. were counted at 4.00% each, **Table 2**.

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Furthermore, a total of 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp. with an abundance of 9.52%. While the rest species including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00% respectively. While in the bottom waters of Tawang Bay (20 m depth), a total of 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). While the rest species were presented in table 2**.**

Table 2. Planktons identified from the natural habitat of spiny lobster in bottom water at Tawang Bay, East Java Indonesia

Depth	Species	Density (Indiv/L)
0.3 m (Surface)	*Synedra* sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
	Acartia sp.	40
	Microstella sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified *Fish larvae*	8
	Unclassified flatworms	8
2.5 m	Synedra sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
	Calanus sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
	Melosira sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16

5 m	*Dinophysis* sp.	8
	Microstella sp.	8
	Calanus sp.	48
	Oithona sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
20 m (bottom)	*Rhizoselenia* sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
	Microsetella sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified *flatworm*	8

Diversity indices

The diversity index values obtained in the waters of Karanggongso Bay, Trenggalek Regency East Java were 2.49 ± 0.07 at depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ± 0.10 at the 20 m water column which indicates that the Karanggongso Trenggalek waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay were 2.65 ± 0.03 at 0.0 – 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay have also moderate diversity, Figure 2

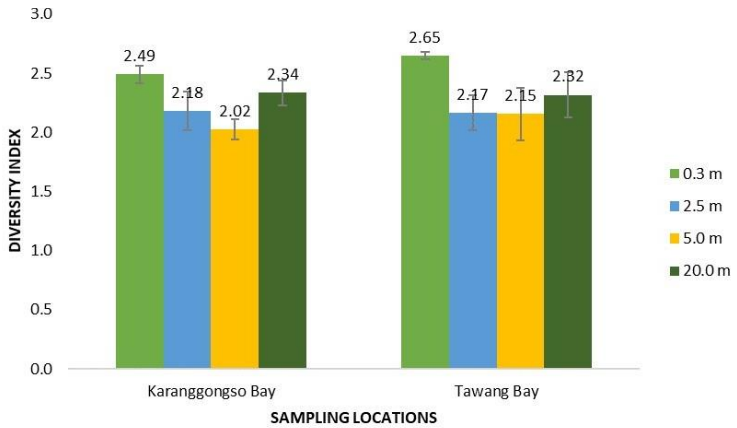

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East java Indonesia. Bars are the average values with a standard deviation of three replicates.

Domination Index

~~The dominance index is a value that indicates whether there are plankton species that dominate certain depths in the water column~~. Dominance index values obtained from the waters of Karanggongso Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean that no plankton species were dominant in the natural habitat of spiny lobster larvae (Karanggongso Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth

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of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, based on the values obtained from the surface to the bottom of the waters shows that there are no species that dominate in Tawang Bay (, Figure 4).

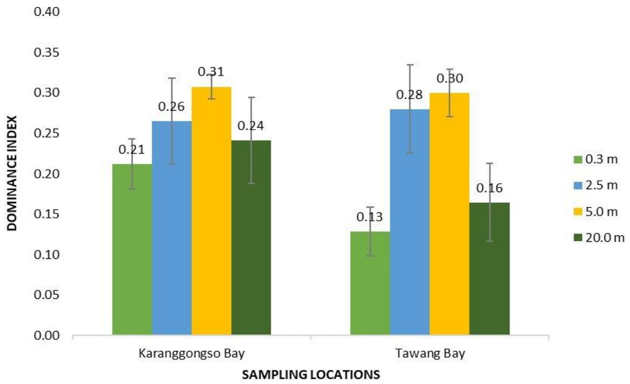

Figure 4. Domination indices of planktons identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Discussion

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability can be important information on the natural diets of lobster larvae (O'Rorke et al. 2014). Thus the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karangongso Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime . It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual or in another sense there are no species that have relatively more diversity than other species (Awwaluddin et al. 2017). As the diversity indices of plankton at Karanggongso Bay and Tawang Bay may which is at a moderate level may suggest that plankton communities is in relatively equal distribution of different species, with no one species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of planktons in both settlement areas were classified at a moderate level (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. The uniformity values found at each location, both Karanggongso Beach waters and Tawang Beach waters, are said to have moderate uniformity. The value of uniformity is categorized to be moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019)**.** The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020)**.** In addition, If if the distribution of plankton in both waters is uniform, then a high degree of uniformity can be asserted .

While the dominance indices were ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay. The result indicates that there were no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Karanggongso Bay and also Tawang Bay. Whether or not organisms dominate a waters can be seen from the value of the dominance index if the dominance index shows a value between 0.5 to 1 then in these waters there are organisms that dominate and if it shows a value less than 0.5 then in these waters it indicates the absence of organisms dominating (Berger and Parker 1970).

Potential Diet for Lobster Seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were

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discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. The number of plankton species identified in the present study, in general, are higher than in previous study reported from other settlement habitats of lobster larvae in Awang Bay west Nusa Tenggara (Amin et al. 2022c) and Teluk Wedi Ombo, Yogyakarta (Trijoko and Pasaribu 2004). The most abundant species identified from Karanggongso Bay were *Paracyclopina* sp., *Acartia* sp., *Pteropods* sp., and *Prorocentrum* sp. *Dinophysis* sp., *Saggita* sp., *Ceratium* sp., *Microstella* sp., *Dinophysis* sp., *Calanus* sp., *Synedra* sp., and *Oithona* sp. (7.69%). While most abundant species found in Tawang Bay were *Acartia* sp., *Ceratium* sp. *Prorocentrum* sp., *Microstella* sp., *Oncaea* sp., *Pteropods* sp., *Calanus* sp., *Synedra* sp., *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., *Macropthalmus* sp., *Sagita* sp., *Dinophysis* sp., and *Rhizoselenia* sp. of these identified plankton species, 10 species were found in both locations including *Acartia* sp., *Oithona* sp., *Paracyclopina* sp., *Pteropods* sp., *Binophysis* sp., *Sagita* sp., *Microstellas* sp. *Calanus* sp., *Synedra* sp.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture including *Oithona* sp. for live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a), and shrimp larvae (Dinesh Kumar et al. 2017), and *Acartia* sp., as a live diet for seabass larvae, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae (Sarkisian et al. 2019). In fact, some studies also confirmed that these plankton species were identified in the stomach content of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022d; Khvorov et al. 2012). *Oithona* sp. has been described as a marine calanoid copepod which has high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30) which in fact are higher compared to a commercial live diet such as Artemia (Magouz et al. 2021b). Furthermore, *Acartia* sp. has been also documented to be a good live diet for aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). A. clausi has been described to have higher contents of proteins (63.12%) and lipids (16.65%) and is also richer in n − 3 fatty acids (33.94%) than Artemia nauplii and rotifers (Rajkumar, 2006). The plankton species has been also identified in the stomach content of spiny lobster larvae (Amin et al. 2022d). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. According to the results obtained, the plankton found at each station consists of Bachillariophiceae (*e.g. Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.,), and Copepoda (e.g. *Oithona* sp., *Acartia* sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). PUFA including EPA (eicosapentaenoic acid, 20:5 n-3) and DHA (docosahexaenoic acid 22:6 n-3) are the major fatty acids found in diatoms Bachillariopiceae (Pahl *et al*, 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera & Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long-chain fatty acids are an essential nutrient for spiny lobster (Koshio & Kanazawa, 1994; Liddy *et al*, 2004;Wang, 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods, it is also high in calcium content which is important for lobster during molting (Kirno et al, 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. This suggests that copepods are a preferred food for lobster larvae. Protein is constantly the predominant organic nutrient in the spiny lobster larvae as well as their preferred prey (Wang, 2013). This is consistent with prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston *et al*, 2004a; Johnston *et al*, 2004b, Johnston *et al*, 2006). Copepods contain high protein content, ranging from 28.9 - 84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang & Jeffs, 2014). The protein content of the copepods is in accordant with the amount of protein incorporated into artificial feeds for some of the crustaceans larvae including crab, shrimp, and clawed lobster species, which is ranging between 30% to 60% protein (Conklin *et al*, 1980 ; *Guillaume*, 1997 ; Holme *et al*, 2009). Moreover, copepods also high in lipid, ranging from 11.3%-12.4% (Wang & Jeffs, 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae, and utilize it to supply energy, especially during a food scarcity (Johnston *et al*, 2004; Liddy *et al* , 2003; Liddy *et al* , 2004; Ritar *et al*, 2003). Furthermore, late phase phyllosoma of spiny lobster probably target high lipid prey, as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs *et al*, 2001a; Jeffs *et al*, 2001b). The presence of copepods especially *Oithona* sp., *Acartia* sp., and *Calanus* sp in a high abundance value at the Karanggongso and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae, therefore, should be further studied by in vivo trials using aquatic animals especially for developing ornate spiny lobster hatcheries.

In conclusion, a total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. It was also discovered that the diversity index of plankton was considered at a moderate level at

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both locations, 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. Similarly, the uniformity index was classified at a moderate level at both locations (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. While the dominance index was ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay which indicates that there were no dominant species at both location. Among the identified plankton species, several members of *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied. Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia are considered potential live feed for lobster larvae, and thus should be further studied.

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REFERENCES

Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The Ecological Habitat of Spiny Lobster (*Panulirus* spp.): Case Study on Lobster Fishing Ground in Trenggalek, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodivers. J., 23(6). DOI: 10.13057/biodiv/d230615.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022c. Profiling the natural settlement habitat of spiny lobster, Panulirus spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodiversitas Journal of Biological Diversity, 23(6).

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022d. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquaculture Reports, 27: 101361. 10.1016/j.aqrep.2022.101361.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi Kelimpahan dan Struktur Komunitas Plankton pada Musim Timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia, 11(6): 33-56.

Badan Pusat Statistik Indonesia (BPS). 2020. Distribusi PDB Triwulanan Seri 2010 Atas Dasar Harga Berlaku (Persen).2020. Jakarta Pusat : Badan Pusat Statistik.

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture, 388: 153-158.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science, 168(3937): 1345-1347.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. Journal of Experimental Marine Biology and Ecology, 162(1): 35-49.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquaculture International, 25: 393-411.

Fachrul MF. 2012. Metode sampling bioekologi.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. Jurnal Riset Akuakultur, 14(3): 183-191.

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an eutrophic lake. Journal of applied microbiology, 125(6): 1626-1641.

Keulder FJ. 2005. *Puerulus and early juvenile recruitment of the rock lobster Jasus lalandii in relation to the environment at Lüderitz Bay, Namibia* Rhodes University].

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the Palinurid and Scyllarid Phyllosoma larvae in Oman Coastal Waters. Journal of Agricultural and Marine Sciences [JAMS], 17: 53-60.

LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Marine Ecology Progress Series, 401: 161-172.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ. Bull, 30: 7106-7116.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of Oithona nana (Cyclopoida, Copepoda), fed on different diets. Animals, 11(5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conference Series: Earth and Environmental Science.

O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Marine Biology, 161(3): 551-563.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261(2): 649-658.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan Kopepoda (Copepods) sebagai Stok Pakan Alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur, 2(1): 63-70.

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp.(Claus, 1866). IOP Conference Series: Earth and Environmental Science.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, Acartia tonsa. Aquaculture, 501: 272-278.

Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk Pakan Alami Larva Udang Karang (*Panulirus homarus* L.) Di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta.

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod Acartia tonsa as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin american journal of aquatic research, 45(1): 159-166.

C. Artikel yang telah diperbaiki (reviewer A)

Diversity and Abundance of Plankton Community in the Natural Settlement Habitats of Spiny Lobster Larvae

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Abstract. Tawang Bay and Karranggongso Bay have been well-known as settlement areas for lobster larvae in East Java Indonesia, which may suggest that the location are suitable environments including diet availability for lobster larvae. Therefore, the study aimed to investigate the abundance and diversity of plankton in the both locations to discover potential live diets for lobster larvae. Plankton samples were collected in both locations using a plankton net at four different depths: 0.3m, 2.5m, m, and 20m with three replicates. The result revealed that 17 plankton species were identified from the 0.30m depth, 13 species at a depth of 2.5m, 11 species at a depth of 5m, and 13 species at 20m at Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a 2.5m, 12 species at 5m, and 12 species at 20m. The diversity index and uniformity indices of plankton in both locations were considered at a moderate. While there were no dominant species at both locations, indicated by the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

Key words: diversity, diets, dominance, lobster, plankton, uniformity.

Abbreviations (if any): -

Running title: Plankton diversity in lobster natural habitat

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents as well as high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has been highly dependent on the wild catch because lobster aquaculture has not been well developed yet. One of the main issues faced in lobster aquaculture is larval production, which currently relies on the availability of seeds in nature. Many studies have been conducted to study various factors relating to larval production of larvae including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded to breed and producing larvae. Yet, the larvae can live only 7-14 days after hatching. It is hypothesized that the main challenge is in diet availability and suitability. According to Amin et al. (2022b), one way to start domesticating wild species is firstly by collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest that profiling certain animals' natural habitat may reveal their diets.

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors hold important information

for the lobster larvae, especially for diets (O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. In their natural settlement habitat, plankton might be a natural diet source for various types of fish seeds, including lobster seeds. Raza'i et al. (2018) added that the availability of plankton as a natural diet source has a significant impact on the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance might reveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed for lobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunung Kidul, Yogyakarta. The study results in general suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raise questions about whether lobster larvae are opportunistic feeders or specific feeders. To answer these questions more studies are required by collecting more information in more settlement areas of lobster.

Tawang Bay been well-known as one of the most settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, the objective of this research is to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlement habitat of lobster larvae at Karanggongso and Tawang Bays. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

MATERIALS AND METHODS

Study area

The collection of plankton samples was carried out in two common settlement areas of lobster larvae in East Java Indonesia (Tawang Bay) with a protocol as previously described by Amin et al. (2022c). The sampling location was performed at ordinate points: 8°15'57.4"S 111°17'46.0" E (L1), 8°15'54.3"S 111°17'48.2"E (L2) and 8°15'51.5"S 111°17'46.2"E (L3), (Figure 1). Plankton sampling was conducted at three different sampling points with four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. The water samples were filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

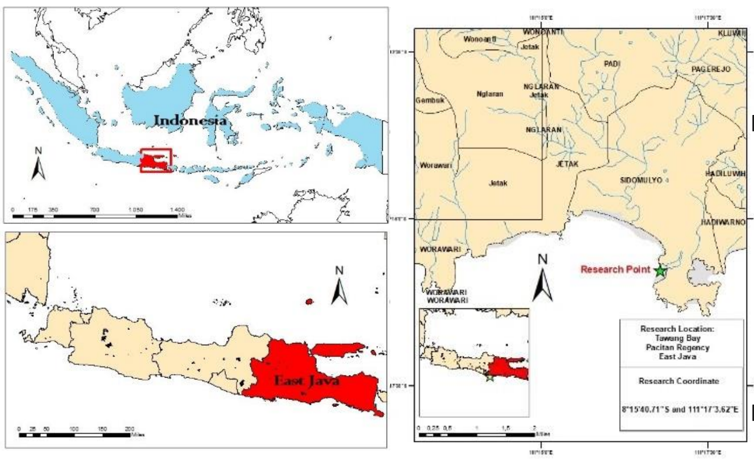

Figure 1 Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia.

Karanggongso Bay waters have temperatures ranging from 27-28 ºC, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a NO_3 content of 0.01 mg/L, and a muddy substrate. Tawang Bay waters temperatures are slightly warmer than Karanggongso Bay, with water temperature ranging from 28.2-28.3 ºC, with a significantly lower, DO content of 3.35

mg/L. moreover, Tawang Bay has a higher salinity of 35 ppt, a pH of 8, a NO_3 content of 0.01, a depth of 15 m, and a sandy substrate

Abundance and Identification of planktons

Firstly, plankton identity and their abundances were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting Cell and observed under a binocular microscope with a magnification of 1000x. Thereafter each plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012)::

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where “N” represents the abundance of plankton (plankter/L), “a” represents the number of SRC boxes, “b” is the area of one field of view (mm2), “c” denotes the number of individuals observed, and “d” indicates the number of boxes observed. “Vb” is the volume of water in the sample bottle (ml), “Vsrc” is the volume of water in the SRC (ml), and “Vs” represents the volume of water filtered in the Field (L).

Diversit, Uniformity and dominant indices

The diversity index value (H') was calculated using the following formula (Fachrul 2012):

$$H' = -\sum Pi \ln Pi, \text{ where } Pi = \frac{ni}{N}$$

Where H' is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number.

The uniformity index (E') was calculated using the “Evennes Index” formula (Ulfah et al. 2019):

$$E' = \frac{H'}{\ln S}$$

where, E' is uniformity index, H': Shannon Wiener Diversity Index, S: Total number of species

The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

where, “d”: Simpson Dominance Index, Nmax: The most abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Plankton Abundance in Karanggongso Bay

Samples of water were obtained from Karanggongso Bay at three designated locations, each with four different levels of depth. A total of 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage was presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified and the top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and *Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the Bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species including *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer which were counted for 3.85% each, Table 1. Meanwhile, a total of 13 plankton species were found at the depth of 20 m. The top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta* sp. with 6.90%. The rest species were presented in table 1.

Table 1. Planktons identified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different depths of the water column.

Depth	Species	Cell density (Indiv/L)
0.3 m (Surface)	*Cyclotella* sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
	Paracyclopina sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8
2.5 m	*Rizosolenia* sp.	8
	Penilia sp.	8
	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polychaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16

Euphausia sp.	8
Protoperidinium sp.	8
Sagitta sp.	16

Plankton Abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at depth of 0.0-0.3 m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp. with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). While the rest species were counted for 2.56% each and presented in **Table 2**. In addition, there were 11 species of plankton found in a water sample at a depth of 2.5 m in Tawang Bay. The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp. were counted at 4.00% each, **Table 2**.

Furthermore, a total of 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp. with an abundance of 9.52%. While the rest species including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00% respectively. While in the bottom waters of Tawang Bay (20 m depth), a total of 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). While the rest species were presented in table 2**.**

Table 2. Planktons identified from the natural habitat of spiny lobster in bottom water at Tawang Bay, East Java Indonesia

Depth	Species	Density (Indiv/L)
	Synedra sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
0.3 m	*Acartia* sp.	40
(Surface)	*Microstella* sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified *Fish larvae*	8
	Unclassified flatworms	8
	Synedra sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
2.5 m	*Calanus* sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
	Melosira sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16

5 m	*Dinophysis* sp.	8
	Microstella sp.	8
	Calanus sp.	48
	Oithona sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
20 m (bottom)	*Rhizoselenia* sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
	Microsetella sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified *flatworm*	8

Diversity indices

The diversity index values obtained in the waters of Karanggongso Bay, Trenggalek Regency East Java were 2.49 ± 0.07 at depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ± 0.10 at the 20 m water column which indicates that the Karanggongso Trenggalek waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay were 2.65 ± 0.03 at 0.0 – 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay have also moderate diversity, Figure 2

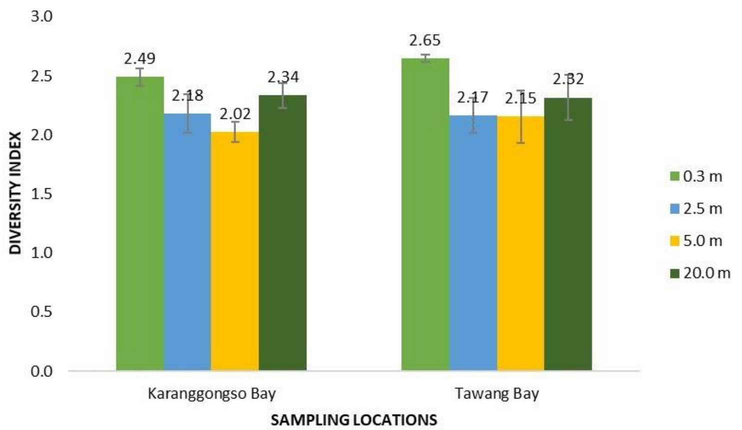

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East java Indonesia. Bars are the average values with a standard deviation of three replicates.

Domination Index

The dominance index is a value that indicates whether there are plankton species that dominate certain depths in the water column. Dominance index values obtained from the waters of Karanggongso Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean that no plankton species were dominant in the natural habitat of spiny lobster larvae (Karanggongso Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, based on the values obtained from the surface to the bottom of the waters shows that there are no species that dominate in Tawang Bay, Figure 4.

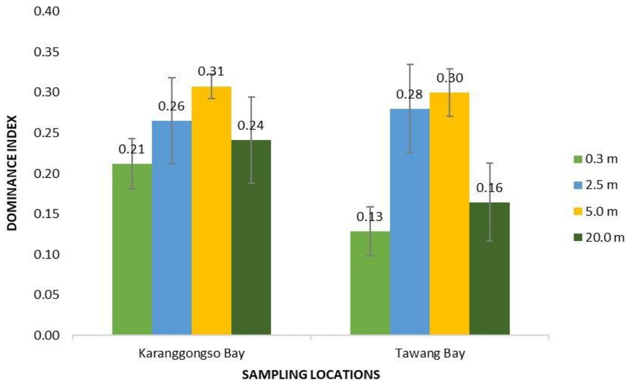

Figure 4. Domination indices of planktons identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Discussion

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability can be important information on the natural diets of lobster larvae (O'Rorke et al. 2014). Thus the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karangongso Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime . It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual or in another sense there are no species that have relatively more diversity than other species (Awwaluddin et al. 2017). As the diversity indices of plankton at Karanggongso Bay and Tawang Bay may which is at a moderate level may suggest that plankton communities is in relatively equal distribution of different species, with no one species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of planktons in both settlement areas were classified at a moderate level (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. The uniformity values found at each location, both Karanggongso Beach waters and Tawang Beach waters, are said to have moderate uniformity. The value of uniformity is categorized to be moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019**).** The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020**).** In addition, If the distribution of plankton in both waters is uniform, then a high degree of uniformity can be asserted **.** While the dominance indices were ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay. The result indicates that there were no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Karanggongso Bay and also Tawang Bay. Whether or not organisms dominate a waters can be seen from the value of the dominance index if the dominance index shows a value between 0.5 to 1 then in these waters there are organisms that dominate and if it shows a value less than 0.5 then in these waters it indicates the absence of organisms dominating (Berger and Parker 1970).

Potential Diet for Lobster Seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. The number of plankton species identified in the present study, in general, are higher than in previous study reported from other settlement habitats of lobster larvae in Awang Bay west Nusa Tenggara (Amin et al. 2022c) and Teluk Wedi Ombo, Yogyakarta (Trijoko and Pasaribu 2004)**.** The most abundant species identified from Karanggongso Bay were *Paracyclopina* sp., *Acartia* sp., *Pteropods* sp., and *Prorocentrum* sp. *Dinophysis* sp., *Saggita* sp., *Ceratium* sp., *Microstella* sp., *Dinophysis* sp., *Calanus* sp., *Synedra* sp., and *Oithona* sp. (7.69%). While most abundant species found in Tawang Bay were *Acartia* sp., *Ceratium* sp. *Prorocentrum* sp., *Microstella* sp., *Oncaea* sp., *Pteropods* sp., *Calanus* sp., *Synedra* sp., *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., *Macropthalmus* sp., *Sagita* sp., *Dinophysis* sp., and *Rhizoselenia* sp. of these identified plankton species, 10 species were found in both locations including *Acartia* sp., *Oithona* sp., *Paracyclopina* sp., *Pteropods* sp., *Binophysis* sp., *Sagita* sp., *Microstellas* sp. *Calanus* sp., *Synedra* sp.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture including *Oithona* sp. for live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a), and shrimp larvae (Dinesh Kumar et al. 2017), and *Acartia* sp., as a live diet for seabass larvae, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae (Sarkisian et al. 2019). In fact, some studies also confirmed that these plankton species were identified in the stomach content of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022d; Khvorov et al. 2012). *Oithona* sp. has been described as a marine calanoid copepod which has high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30) which in fact are higher compared to a commercial live diet such as Artemia (Magouz et al. 2021b). Furthermore, *Acartia* sp. has been also documented to be a good live diet for aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). A. clausi has been described to have higher contents of proteins (63.12%) and lipids (16.65%) and is also richer in n − 3 fatty acids (33.94%) than Artemia nauplii and rotifers (Rajkumar, 2006). The plankton species has been also identified in the stomach content of spiny lobster larvae (Amin et al. 2022d). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. According to the results obtained, the plankton found at each station consists of Bachillariophiceae (*e.g. Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.,), and Copepoda (e.g. *Oithona* sp., *Acartia* sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). PUFA including EPA (eicosapentaenoic acid, 20:5 n-3) and DHA (docosahexaenoic acid 22:6 n-3) are the major fatty acids found in diatoms Bachillariopiceae (Pahl *et al*, 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera & Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long-chain fatty acids are an essential nutrient for spiny lobster (Koshio & Kanazawa, 1994; Liddy *et al,* 2004;Wang, 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods, it is also high in calcium content which is important for lobster during molting (Kirno et al, 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. This suggests that copepods are a preferred food for lobster larvae. Protein is constantly the predominant organic nutrient in the spiny lobster larvae as well as their preferred prey (Wang, 2013). This is consistent with prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston *et al*, 2004a; Johnston *et al*, 2004b, Johnston *et al*, 2006). Copepods contain high protein content, ranging from 28.9 - 84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang & Jeffs, 2014). The protein content of the copepods is in accordant with the amount of protein incorporated into artificial feeds for some of the crustaceans larvae including crab, shrimp, and clawed lobster species, which is ranging between 30% to 60% protein (Conklin *et al*, 1980 ; *Guillaume*, 1997 ; Holme *et al*, 2009). Moreover, copepods also high in lipid, ranging from 11.3%-12.4% (Wang & Jeffs, 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae, and utilize it to supply energy, especially during a food scarcity (Johnston *et al*, 2004; Liddy *et al* , 2003; Liddy *et al* , 2004; Ritar *et al*, 2003). Furthermore, late phase phyllosoma of spiny lobster probably target high lipid prey, as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs *et al*, 2001a; Jeffs *et al*, 2001b). The presence of copepods especially *Oithona* sp., *Acartia* sp., and *Calanus* sp in a high abundance value at the Karanggongso and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae, therefore, should be further studied by in vivo trials using aquatic animals especially for developing ornate spiny lobster hatcheries.

In conclusion, a total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. It was also discovered that the diversity index of plankton was considered at a moderate level at

both locations, 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. Similarly, the uniformity index was classified at a moderate level at both locations (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. While the dominance index was ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay which indicates that there were no dominant species at both location. Among the identified plankton species, several members of *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied. Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia are considered potential live feed for lobster larvae, and thus should be further studied.

ACKNOWLEDGEMENTS

The authors thank all colleges at the Fish Nutrition Group, Department of Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga who have provided help and technical advice during the experiment.

REFERENCES

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Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The Ecological Habitat of Spiny Lobster (*Panulirus* spp.): Case Study on Lobster Fishing Ground in Trenggalek, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodivers. J., 23(6). DOI: 10.13057/biodiv/d230615.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022c. Profiling the natural settlement habitat of spiny lobster, Panulirus spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodiversitas Journal of Biological Diversity, 23(6).

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022d. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquaculture Reports, 27: 101361. 10.1016/j.aqrep.2022.101361.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi Kelimpahan dan Struktur Komunitas Plankton pada Musim Timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia, 11(6): 33-56.

Badan Pusat Statistik Indonesia (BPS). 2020. Distribusi PDB Triwulanan Seri 2010 Atas Dasar Harga Berlaku (Persen).2020. Jakarta Pusat : Badan Pusat Statistik.

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture, 388: 153-158.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science, 168(3937): 1345- 1347.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. Journal of Experimental Marine Biology and Ecology, 162(1): 35-49.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquaculture International, 25: 393-411.

Fachrul MF. 2012. Metode sampling bioekologi.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. Jurnal Riset Akuakultur, 14(3): 183-191.

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an eutrophic lake. Journal of applied microbiology, 125(6): 1626-1641.

Keulder FJ. 2005. *Puerulus and early juvenile recruitment of the rock lobster Jasus lalandii in relation to the environment at Lüderitz Bay, Namibia* Rhodes University].

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the Palinurid and Scyllarid Phyllosoma larvae in Oman Coastal Waters. Journal of Agricultural and Marine Sciences [JAMS], 17: 53-60.

LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Marine Ecology Progress Series, 401: 161-172.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ. Bull, 30: 7106-7116.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of Oithona nana (Cyclopoida, Copepoda), fed on different diets. Animals, 11(5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conference Series: Earth and Environmental Science.

O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Marine Biology, 161(3): 551-563.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261(2): 649-658.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan Kopepoda (Copepods) sebagai Stok Pakan Alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur, 2(1): 63-70.

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp.(Claus, 1866). IOP Conference Series: Earth and Environmental Science.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, Acartia tonsa. Aquaculture, 501: 272-278.

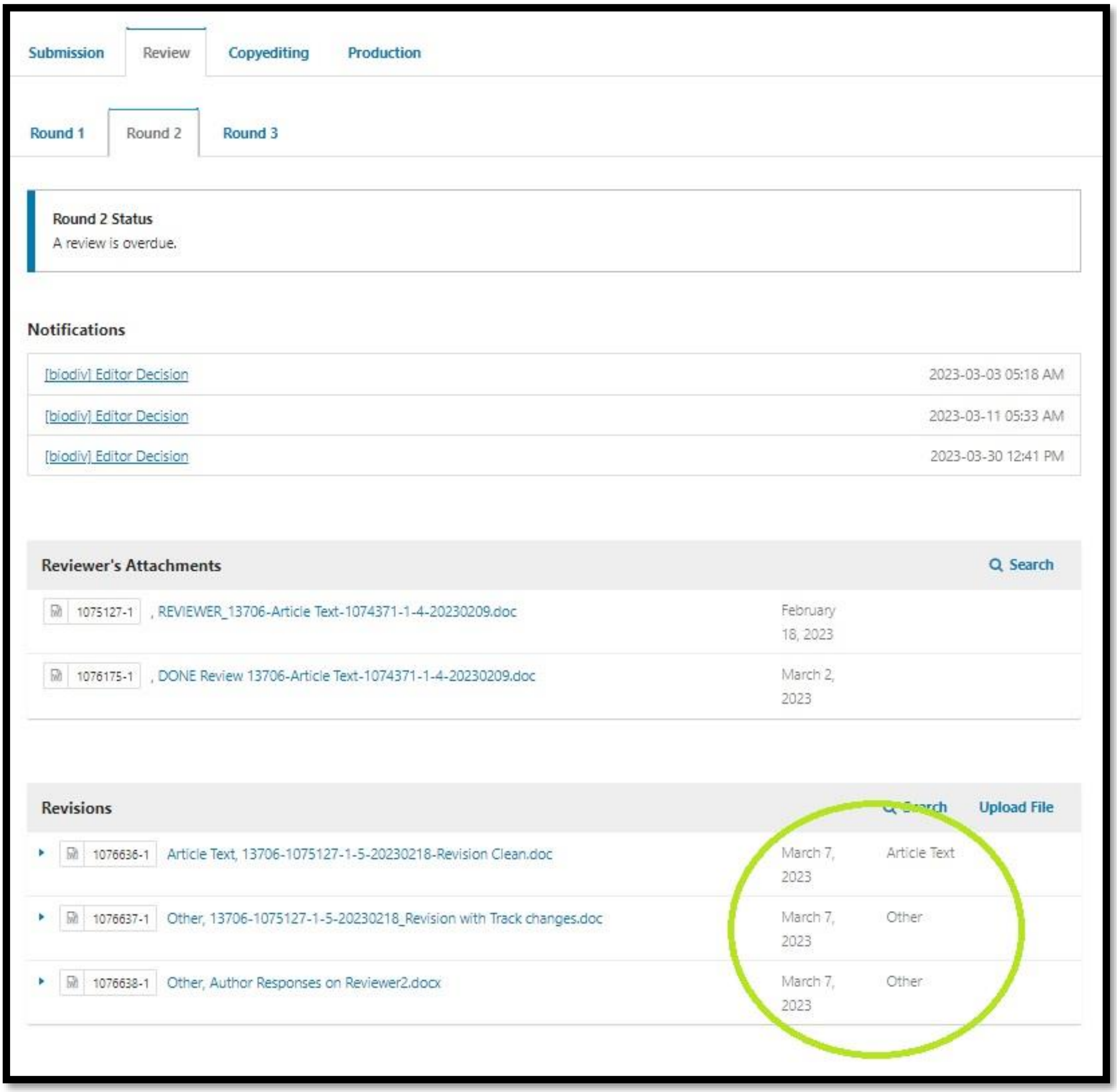
Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk Pakan Alami Larva Udang Karang (*Panulirus homarus* L.) Di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta.

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod Acartia tonsa as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin american journal of aquatic research, 45(1): 159-166.

3. Bukti review round 2 (7 Maret 2023)

A. Komentar reviewer A (rounde 2): isi tertuang di point B



B. Permintaan reviewer A dan respon author (rounde 2)

1. Line 1-3: highlight the two bays here? Otherwise it is too broad.

Authors' Response: Title has been revised by adding two bays and presented in line 1-2 in the amended manuscript.

ABSTRACT

2. Line 17: Are there multiple species? Or just one kind present in these areas.

Authors' Response: yes, the habitat provide more than one spiny lobster species.

3. Line-23: A missing value here
   Authors' Response: Value has been added, and presented in line 23 in the amended manuscript
4. Authors should mention also then the objective of this paper is to identify the speciespresent at different depths in these two different bays.
   Authors' Response: Objective has been added, ad presented in line 21-23 in the amendedmanuscript.
5. Line: 31: Values?
   Authors' Response: values have been added and presented in line 25-29 in the amendedmanuscript.
6. Highlight the two locations in the methodology
   Authors' Response: More information on the two selected locations have been added in methodology, and presented in line 74-77 in the amended manuscript.
7. Plural of plankton is still plankton

   Authors' Response: "planktons" has been replaced with "plankton" and presented in line 139 inthe amended manuscript.
8. Line 224: Why if and not since?
   Authors' Response: if has been replaced with "since"
9. "Artemia" Are you refering to the species or the noun?
   Authors' Response: "Artemia" has been replaced with "Artemia sp." and presented in line264 in the amended manuscript.
10. Scientific names at the beginning at the sentence should be spelt full
    Authors' Response: Full scientific name has been added, and presented in line 269
11. Have a holistic conclusion on what these results implicate with the ecology of Karanggongso and Tawang Bay or for the larvae of these lobsters, or human benefits?
    Authors' Response: Conclusion has been rewritten and the higher uniformity indexed comparedto dominance index indicated that the was no dominant species in each study locations, this information is stated in line 291-294

C. Artikel yang sudah diperbaiki (rounde 2)

Diversity and Abundance of Plankton Community in Tawang Bay and Karanggongso Bay, the Natural Settlement Habitats of Spiny Lobster Larvae

Abstract. Tawang Bay and Karranggongso Bay have been well-known as settlement areas for lobster larvae *Panulirus* spp. in East Java Indonesia, which may suggest that the location are suitable environments including diet availability for lobster larvae. Therefore, the study aimed to investigate the types, abundance and diversity of plankton in the both locations to discover potential live diets for lobster larvae. Plankton samples were collected in both locations using a plankton net at four different depths: 0.3 m, 2.5m, 5 mand 20 m with three replicates. The objectives of this study are to explore the diversity, abundance, uniformity and dominance indices of plankton in the natural settlement ground of lobster larvae at Karanggongso and Tawang Bay.The results revealed that 17 plankton species were identified from the 0.30 m depth, 13 species at a depth of 2.5m, 11 species at a depth of 5m, and 13 species at 20m at Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a 2.5m, 12 species at 5m, and 12 species at 20m. The diversity indices observed in Karanggongso and Tawang bay ranged from 2.02-2.49 and 2.17-2.65, respectively, which fall within the moderate range. Similarly, the uniformity indices observed at both locations were also moderate, with values ranging from 0.38-0.45 at Karanggongso bay and 0.41-0.46 at Tawang bay. ~~While there were no dominant species at both locations,~~ indicated by the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

~~The diversity index and uniformity indices of plankton in both locations were considered at a moderate. While there were no dominant species at both locations, indicated by the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.~~

Key words: diversity, diets, dominance, lobster, plankton, uniformity.

Abbreviations (if any): -

Running title: Plankton diversity in lobster natural habitat

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents as well as high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has been highly dependent on the wild catch because lobster aquaculture has not been well developed yet. One of the main issues faced in lobster aquaculture is larval production, which currently relies on the availability of seeds in nature. Many studies have been conducted to study various factors relating to larval production of larvae including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded to breed and producing larvae. Yet, the larvae can live only 7-14 days after hatching. It is hypothesized that the main challenge is in diet availability and suitability. According to Amin et al. (2022b), one way to start domesticating wild species is firstly by

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collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest that profiling certain animals' natural habitat may reveal their diets.

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors hold important information for the lobster larvae, especially for diets (O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. In their natural settlement habitat, plankton might be a natural diet source for various types of fish seeds, including lobster seeds. Raza'i et al. (2018) added that the availability of plankton as a natural diet source has a significant impact on the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance might reveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed for lobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunung Kidul, Yogyakarta. The study results in general suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raised questions about whether lobster larvae are opportunistic feeders or specific feeders. To answer these questions more studies are required by collecting more information in more settlement areas of lobster.

Tawang Bay been well-known as one of the most settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed ,to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, the objectives of this research is to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlement habitat of lobster larvae at Karanggongso and Tawang Bays. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

MATERIALS AND METHODS

Study area

The collection of plankton samples was carried out in two common settlement areas of lobster larvae in East Java Indonesia (Tawang Bay) with a protocol as previously described by Amin et al. (2022c). The sampling location was performed at ordinate points: 8°15'57.4"S 111°17'46.0" E (L1), 8°15'54.3"S 111°17'48.2"E (L2) and 8°15'51.5"S 111°17'46.2"E (L3), (Figure 1). Plankton sampling was conducted at three different sampling points with four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. The water samples were filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

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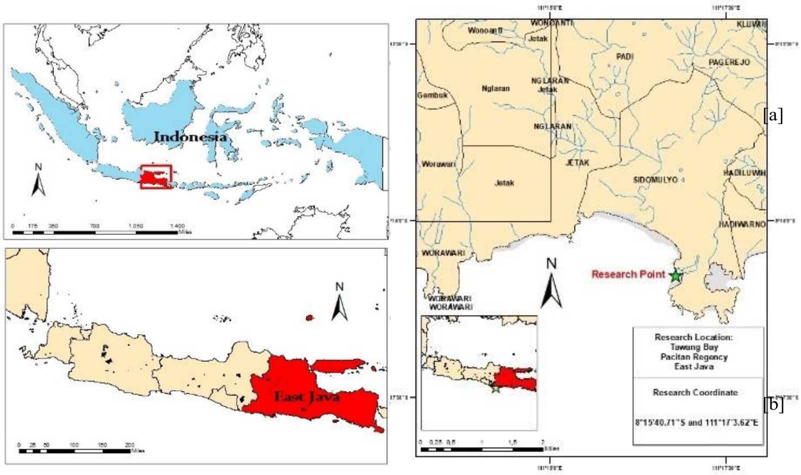

Figure 1 Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia.

Karanggongso Bay waters have temperatures ranging from 27-28 ^oC, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a NO_3 content of 0.01 mg/L, and a muddy substrate. Tawang Bay waters temperatures are slightly warmer than Karanggongso Bay, with water temperature ranging from 28.2-28.3 ^oC, with a significantly lower, DO content of 3.35 mg/L. moreover, Tawang Bay has a higher salinity of 35 ppt, a pH of 8, a NO_3 content of 0.01, a depth of 15 m, and a sandy substrate.

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Abundance and Identification of planktons

Firstly, plankton identity and their abundances were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting Cell and observed under a binocular microscope with a magnification of 1000x. Thereafter ~~each~~ plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012):

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where "N" represents the abundance of plankton (plankter/L), "a" represents the number of SRC boxes, "b" is the area of one field of view (mm^2), "c" denotes the number of individuals observed, and "d" indicates the number of boxes observed. "Vb" is the volume of water in the sample bottle (ml), "Vsrc" is the volume of water in the SRC (ml), and "Vs" represents the volume of water filtered in the Field (L).

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Diversity, Uniformity and dominant indices

The diversity index value (H') was calculated using the following formula (Fachrul 2012):

$$H' = -\sum Pi ln Pi, where\ Pi = \frac{ni}{N}$$

Where H' is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number.

The uniformity index (E') was calculated using the "Evennes Index" formula (Ulfah et al. 2019):

$$E' = \frac{H'}{Lns}$$

where, E' is uniformity index, H': Shannon Wiener Diversity Index, S: Total number of species

The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

where, "d": Simpson Dominance Index, Nmax: The most abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Results

Plankton Abundance in Karanggongso Bay

Water Samples samples of water were obtained collected two locations, from Karanggongso Bay at three designated locations and Tawang Bay at, each with four different l evels of depths (0.3m, 2.5m, 5m, and 20m). The two bays were located at southern part of East Java Province and both areas are facing to the Indian Ocean, Figure 1. The results showed t hat A a total of 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage was presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified and the top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and *Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the Bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species i ncluding i ncluded *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer which were counted for 3.85% each, Table 1. Meanwhile, a total of 13 plankton species were found at the depth of 20 m. The top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta*sp. with 6.90%. The rest species were presented in table 1.

Table 1. Planktons identified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different depths of the water column.

Depth	Species	Cell density (Indiv/L)
0.3 m (Surface)	*Cyclotella* sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
	Paracyclopina sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8
2.5 m	*Rizosolenia* sp.	8
	Penilia sp.	8

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Commented [mA12R11]: More information on the two selected locations have been added in line124-127

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	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polychaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16
	Euphausia sp.	8
	Protoperidinium sp.	8
	Sagitta sp.	16

Plankton Abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at depth of 0.0-0.3 m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp. with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). While the rest of the species were counted for 2.56% each and presented in **Table 2**. In addition, there were 11 species of plankton found in a water sample at a depth of 2.5 m in Tawang Bay. The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp. were counted at 4.00% each, **Table 2**.

Furthermore, a total of 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp. with an abundance of 9.52%. While the rest of the species including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00% respectively. While in the bottom waters of Tawang Bay (20 m depth), a total of 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). While the rest species were presented in table 2**.**

Table 2. Planktons identified from the natural habitat of spiny lobster in bottom water at Tawang Bay, East Java Indonesia

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Depth	Species	Density (Indiv/L)
0.3 m (Surface)	*Synedra* sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
	Acartia sp.	40
	Microstella sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified *Fish larvae*	8
	Unclassified flatworms	8
2.5 m	Synedra sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
	Calanus sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
5 m	*Melosira* sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16
	Dinophysis sp.	8
	Microstella sp.	8
	Calanus sp.	48
	Oithona sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
20 m (bottom)	*Rhizoselenia* sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
	Microsetella sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified *flatworm*	8

Diversity indices

The diversity index values obtained in the waters of Karanggongso Bay, Trenggalek Regency East Java were 2.49 ± 0.07 at depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ±

0.10 at the 20 m water column which indicates that the Karanggongso Trenggalek waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay were 2.65 ± 0.03 at 0.0 – 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay have also moderate diversity, Figure 2

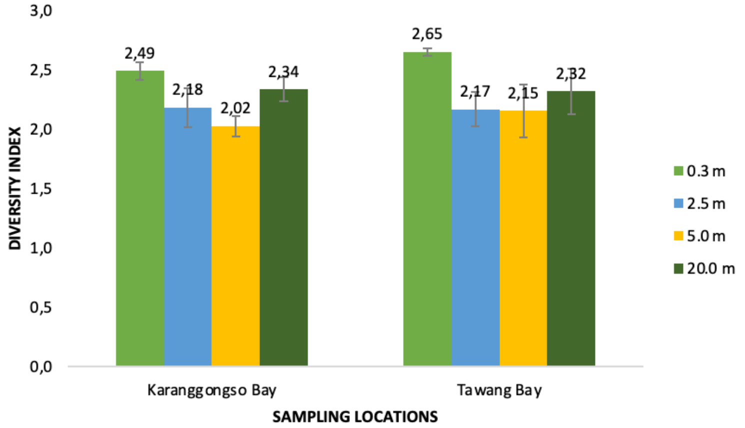

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East java Indonesia. Bars are the average values with a standard deviation of three replicates.

Uniformity indices

The uniformity index values obtained in the water column of Karanggongso Bay were 0.45 ± 0.01 at 0.0-0.3 m depth (surface water column), 0.39 ± 0.06 at a depth of 2.5 m, 0.38 ± 0.01at a depth of 5 m and 0.43 ± 0.04 at the 25m depth or bottom of the water column. These index values indicated that the uniformity of plankton in Karanggongso Bay was at a moderate level. While the uniformity values obtained in Tawang Bay were 0.46 ± 0.01 at 0.0-0.3 m depth, 0.41 ± 0.05 at a depth of 2.5 m, 0.42 ± 0.07 at a depth of 5 m, and 0.46 ± 0.05 at 25 m depth or bottom of the water column. Similarly, uniformity indices of plankton in Tawang Bay were considered also at a moderate level, **Figure 3**.

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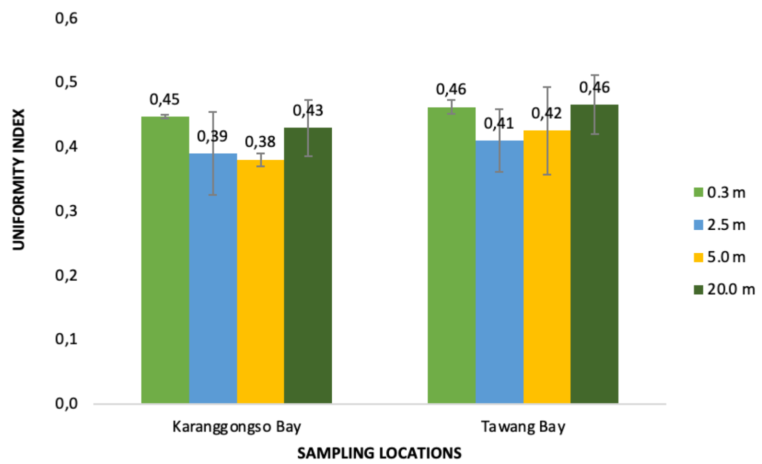

Figure 3. Uniformity indices of planktons identified in Karanggongso Bay and Tawang Bay, East Java Indonesia. Bars are the average values with a standard deviation of three replicates.

Domination Index

~~The dominance index is a value that indicates whether there are plankton species that dominate certain depths in the water column.~~ Dominance index values obtained from the waters of Karanggongso Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean that no plankton species were dominant in the natural habitat of spiny lobster larvae (Karanggongso Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, based on the values obtained from the surface to the bottom of the waters shows that there are no species that dominate in Tawang Bay (, Figure 4).

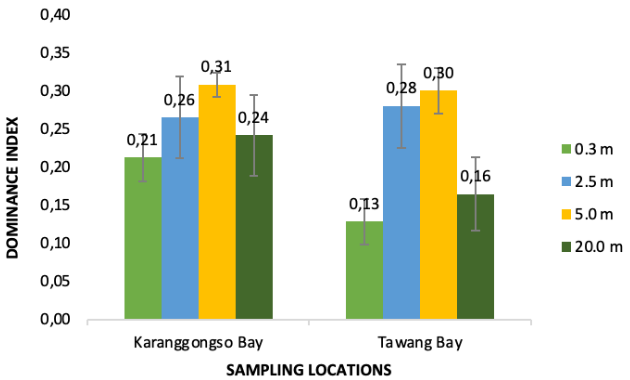

Figure 4. Domination indices of planktons identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

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Discussion

Environmental conditions including physical, chemical, and biological factors in natural habitats highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability can be important information on the natural diets of lobster larvae (O'Rorke et al. 2014). Thus the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karangongso Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime . It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual or in another sense there are no species that have relatively more diversity than other species (Awwaluddin et al. 2017). As the diversity indices of plankton at Karanggongso Bay and Tawang Bay may which is at a moderate level may suggest that plankton communities is in relatively equal distribution of different species, with no one species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of planktons in both settlement areas were classified at a moderate level (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. The uniformity values found at each location, both Karanggongso Beach waters and Tawang Beach waters, are said to have moderate uniformity. The value of uniformity is categorized to be moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019)**.** The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020)**.** In addition, ~~If~~ since~~if~~ the distribution of plankton in both waters is uniform, then a high degree of uniformity can be

asserted~~-~~**.** While the dominance indices were ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay. The result indicates that there were no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Karanggongso Bay and also Tawang Bay. The dominance index value indicates whether organisms are dominant in a water environment. A value between 0.5 to 1 on the dominance index shows the presence of dominant organisms in the water. On the other hand, a value less than 0.5 indicates that there are no dominant organisms present in the water ~~Whether or not organisms dominate a waters can be seen from the value of the dominance index if the dominance index shows a value between 0.5 to 1 then in these waters there are organisms that dominate and if it shows a value less than 0.5 then in these waters it indicates the absence of organisms dominating~~ (Berger and Parker 1970).

Potential Diet for Lobster Seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. The number of plankton species identified in the present study, in general, are higher than in previous study reported from other settlement habitats of lobster larvae in Awang Bay west Nusa Tenggara (Amin et al. 2022c) and Teluk Wedi Ombo, Yogyakarta (Trijoko and Pasaribu 2004)**.** The most abundant species identified from Karanggongso bay are mainly from Phylum Arthropoda including *Paracyclopina* sp, *Oithona* sp, *Acartia* sp, and *Calanus* sp. Other prominent species included *Prorocentrum* sp, *Dinophysis* sp, and *Ceratium* sp, are belonged to phylum Dinoflagellata, ~~most abundant species identified from Karanggongso Bay were *Paracyclopina* sp., *Acartia* sp~~., ~~*Pteropods* sp., and *Prorocentrum* sp. *Dinophysis* sp., *Saggita* sp., *Ceratium* sp., *Microstella* sp., *Dinophysis* sp., *Calanus* sp., *Synedra* sp., and *Oithona* sp. (7.69%).~~ While most abundant species found in Tawang Bay were also dominated by phylum Arthropoda, including *Acartia* sp..,*Oithona* sp.,*Oncaea* sp., *Calanus* sp., *Paracyclopina*.,and *Macropthalmus* sp. Plankton species in this area also dominated by phylum Dinoflagellata such as *Ceratium* sp. *Prorocentrum* sp., and *Dinophysis* sp. ~~*Microstella* sp., *Oncaea* sp., *Pteropods* sp., *Calanus* sp., *Synedra* sp., *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., *Macropthalmus* sp., *Sagita* sp., *Dinophysis* sp., and *Rhizoselenia* sp. O~~of these identified plankton species, 10 species were found in both locations including *Acartia* sp., *Oithona* sp., *Paracyclopina* sp., *Pteropods* sp., *Binophysis* sp., *Sagita* sp., *Microstellas* sp. *Calanus* sp., *Synedra* sp. These findings suggest that the planktonic community in both bays is dominated by species belonging to the phylum Arthropoda and Dinoflagellata, which are known to be important components of the marine food web.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture including *Oithona* sp. for live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a), and shrimp larvae (Dinesh Kumar et al. 2017), and *Acartia* sp., as a live diet for seabass larvae, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae (Sarkisian et al. 2019). In

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Formatted: Font: English (Indonesia) fact, some studies also confirmed that these plankton species were identified in the stomach content of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022d; Khvorov et al. 2012). *Oithona* sp. has been described as a marine calanoid copepod which has high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30) which in fact are higher compared to a commercial live diet such as *Artemia* sp. (Magouz et al. 2021b). Furthermore, *Acartia* sp. has been also documented to be a good live diet for aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). *Acartia* . *clausi* has been described to have higher contents of proteins (63.12%) and lipids (16.65%) and is also richer in n − 3 fatty acids (33.94%) than Artemia nauplii and rotifers (Rajkumar, 2006). The plankton species has been also identified in the stomach content of spiny lobster larvae (Amin et al. 2022d). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. According to the results obtained, the plankton found at each station consists of Bachillariophiceae (*e.g. Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.,), and Copepoda (e.g. *Oithona* sp., *Acartia* sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). PUFA including EPA (eicosapentaenoic acid, 20:5 n-3) and DHA (docosahexaenoic acid 22:6 n-3) are the major fatty acids found in diatoms Bachillaripiceae (Pahl *et al*, 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera & Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long-chain fatty acids are an essential nutrient for spiny lobster (Koshio & Kanazawa, 1994; Liddy *et al*, 2004;Wang, 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods, it is also high in calcium content which is important for lobster during molting (Kirno et al, 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. This suggests that copepods are a preferred food for lobster larvae. Protein is constantly the predominant organic nutrient in the spiny lobster larvae as well as their preferred prey (Wang, 2013). This is consistent with prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston *et al*, 2004a; Johnston *et al*, 2004b, Johnston *et al*, 2006). Copepods contain high protein content, ranging from 28.9 - 84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang & Jeffs, 2014). The protein content of the copepods is in accordant with the amount of protein incorporated into artificial feeds for some of the crustaceans larvae including crab, shrimp, and clawed lobster species, which is ranging between 30% to 60% protein (Conklin *et al*, 1980 ; *Guillaume*, 1997 ; Holme *et al*, 2009). Moreover, copepods also high in lipid, ranging from 11.3%-12.4% (Wang & Jeffs, 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae, and utilize it to supply energy, especially during a food scarcity (Johnston *et al*, 2004; Liddy *et al* , 2003; Liddy *et al* , 2004; Ritar *et al*, 2003). Furthermore, late phase phyllosoma of spiny lobster probably target high lipid prey, as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs *et al*, 2001a; Jeffs *et al*, 2001b). The presence of copepods especially *Oithona* sp., *Acartia* sp., and *Calanus* sp in a high abundance value at the Karanggongso and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae, therefore, should be further studied by in vivo trials using aquatic animals especially for developing ornate spiny lobster hatcheries.

In conclusion, t he number of plankton species found in both locations was more abundant in the surface water (0-0.3m) compared to the deeper water column. A total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20 m (bottom) of Karanggongso Bay. Similarly, 17 plankton species were discovered from the water surface of Tawang Bay: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. Based on the diversity, uniformity, and dominance indices, both locations had moderate plankton diversity, and no specific species was dominant over the others. Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia such as *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studieda total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20m (bottom) of Karanggongso Bay. While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. It was also discovered that the diversity index of plankton was considered at a moderate level at both locations, 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. Similarly, the uniformity index was classified at a moderate level at both locations (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. While the dominance index was ranging from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay which indicates that there were no dominant species at both location. Among the identified plankton species, several members of *Oithona* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied. Among the identified plankton species, several members of

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~~Bachillariophiceae, Copepoda, and Hexanauplia are considered potential live feed for lobster larvae, and thus should be further studied.~~

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ACKNOWLEDGEMENTS

The authors thank all colleges at the Fish Nutrition Group, Department of Aquaculture, Faculty of Fisheries and Marine, Universitas Airlangga who have provided help and technical advice during the experiment.

REFERENCES

Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The Ecological Habitat of Spiny Lobster (*Panulirus* spp.): Case Study on Lobster Fishing Ground in Trenggalek, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodivers. J., 23(6). DOI: 10.13057/biodiv/d230615.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022c. Profiling the natural settlement habitat of spiny lobster, Panulirus spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodiversitas Journal of Biological Diversity, 23(6).

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022d. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquaculture Reports, 27: 101361. 10.1016/j.aqrep.2022.101361.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi Kelimpahan dan Struktur Komunitas Plankton pada Musim Timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia, 11(6): 33-56.

Badan Pusat Statistik Indonesia (BPS). 2020. Distribusi PDB Triwulanan Seri 2010 Atas Dasar Harga Berlaku (Persen).2020. Jakarta Pusat : Badan Pusat Statistik.

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture, 388: 153-158.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science, 168(3937): 1345-1347.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. Journal of Experimental Marine Biology and Ecology, 162(1): 35-49.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquaculture International, 25: 393-411.

Fachrul MF. 2012. Metode sampling bioekologi.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. Jurnal Riset Akuakultur, 14(3): 183-191.

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an eutrophic lake. Journal of applied microbiology, 125(6): 1626-1641.

Keulder FJ. 2005. *Puerulus and early juvenile recruitment of the rock lobster Jasus lalandii in relation to the environment at Lüderitz Bay, Namibia* Rhodes University].

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the Palinurid and Scyllarid Phyllosoma larvae in Oman Coastal Waters. Journal of Agricultural and Marine Sciences [JAMS], 17: 53-60.

LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Marine Ecology Progress Series, 401: 161-172.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ. Bull, 30: 7106-7116.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of Oithona nana (Cyclopoida, Copepoda), fed on different diets. Animals, 11(5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conference Series: Earth and Environmental Science.

O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Marine Biology, 161(3): 551-563.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261(2): 649-658.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan Kopepoda (Copepods) sebagai Stok Pakan Alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur, 2(1): 63-70.

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp.(Claus, 1866). IOP Conference Series: Earth and Environmental Science.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, Acartia tonsa. Aquaculture, 501: 272-278.

Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk Pakan Alami Larva Udang Karang (*Panulirus homarus* L.) Di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta.

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod Acartia tonsa as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin american journal of aquatic research, 45(1): 159-166.

4. Bukti komentari reviewer (round 3) (11 Maret 2023)

A. Bukti reviewer A meminta melakukan revisi rounde 3. Detail permintaan reviewer terdapat pada draft artikel di point C

Round 3 Status
Submission accepted.

Notifications

[biodiv] Editor Decision	2023-03-03 05:18 AM
[biodiv] Editor Decision	2023-03-11 05:33 AM
[biodiv] Editor Decision	2023-03-30 12:41 PM

Reviewer's Attachments — Search

1077001-1	, 13706-Article Text-1076667-1-4-20230307 xo.doc	March 11, 2023

Revisions — Search — Upload File

1077068-1	Article Text, 13706-1077001-1-5-20230311-R2-Clean.doc	March 11, 2023	Article Text
1077069-1	Article Text, 13706-1077001-1-5-20230311-R2-Track changes.doc	March 11, 2023	Article Text

B. Bukti author memenuhi saran yang diberikan reviewer A rounde 3

Reviewer suggestion:

1. Revise the title
2. Rephrase the abstract
3. Revise the introduction, method, and discussion according to the reviewer's suggestion. See the manuscript

Answers:

1. We revised the title according to the reviewer's suggestion
2. We revised the abstract
3. We revised the introduction, method, and discussion according to the reviewer's suggestion. See the new manuscript

C. Artikel yang telah diperbaiki sesuai arahan reviewer A (rounde 3)

Diversity and Abundance of Plankton Community in Tawang ~~Bay~~ and Karanggongso Bays, ~~the~~ Natural Settlement Habitats of Spiny Lobster Larvae in East Java Indonesia

Abstract. Tawang Bay and Karranggongso Bay have been well-known as settlement areas for spiny lobster larvae, *Panulirus* spp., in East Java, Indonesia. Therefore, these locations, ~~which~~ may suggest ~~that the location are~~ suitable environments, including diet availability for lobster larvae. Furtherm~~Theref~~ore, the present study aimed to investigate the types~~,~~ and, abundance ~~and diversity~~ of plankton in ~~the~~ both locations to discover potential live diets for lobster larvae. ~~Plankton samples were collected in both locations using a plankton net at four different depths: 0.3 m, 2.5m, 5 m, and 20 m with three replicates. The objectives of t~~This study also ~~are to~~ explored plankton's diversity, uniformity, and dominance indices~~the diversity, abundance, uniformity, and dominance indices of plankton~~ in ~~the natural settlement ground of lobster larvae at~~ both locations~~Karanggongso and Tawang Bay~~. Plankton samples were collected using a plankton net at four ~~different~~ depths: 0.3 m, 2.5 m, 5 m, and 20 m. The results revealed that 17 plankton species were identified from ~~the~~ 0.30 m depth, 13 ~~species at a 2.5mdepth of 2.5m, 11 species at a 5mdepth of 5m, and 13 species~~at 2.5 m, 11 at 5 m, and 13 at 20 m ~~at~~depth at Karanggongso Bay. ~~While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a 2.5m, 12 species at 5m, and 12 species at 20m.~~ In addition, 17 plankton species were discovered ~~in~~at 0.3 m depth, 11 ~~species at 2.5m, 12 species at 5m, and 12 species~~at 2.5 m, 12 at 5 m, and 12 at 20 m at Tawang Bay. Among the most abundant species were *Acartia* sp., *Calanus* sp., *Paracyclopina* sp., and *Oithona* sp. The diversity indices observed in Karanggongso and Tawang bay ranged from 2.02-2.49 and 2.17-2.65, respectively, ~~which fall~~ within the moderate range. Similarly, the uniformity indices observed at both locations were ~~also~~ moderate, ~~with values~~ ranging from 0.38-0.45 at Karanggongso bay and 0.41-0.46 at Tawang bay. ~~While t~~There were no dominant species at both locations, ~~as indicated by,~~ as the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., *Calanus* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

Key words: diversity, diets, dominance, lobster, plankton, uniformity.

Abbreviations (if any): -

Running title: Plankton diversity in ~~lobster natural~~natural lobster habitat

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents ~~as well as~~, and high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has ~~been highly dependent on the wild catch because lobster aquaculture has not been well developed yet~~depended highly on the wild catch because lobster aquaculture has not yet been well developed. One of the main issues faced in lobster aquaculture is larval production, which currently relies on the availability of ~~seeds in nature~~natural seeds. Many studies have been conducted to study various factors relating to larva~~l production of larvae~~e's larval production, including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded ~~to~~

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Commented [mA2R1]: Value has been added

~~breedi~~n breeding and producing larvae. Yet, the larvae can live only 7-14 days after hatching. ~~It~~ Therefore, it is hypothesized that the main challenge is ~~i n~~ diet availability and suitability. According to Amin et al. (2022b), ~~one way to start domesticating wild species is firstly by collecting information on their natural habitat as much as possible~~first, one way to start domesticating wild species is by collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest ~~t hat profiling certain animals' natural habitat~~profiling certain animals' natural habitats may reveal their diets.

Environmental conditions, including physical, chemical, and biological factors in natural habitats, highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are ~~still~~ very limited. Meanwhile, many studies conclude that biological factors have~~old~~ important information for the lobster larvae, especially for diets (~~O'Rorke~~ O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. ~~In~~ For example, plankton might be a natural diet source for various fish seeds, including lobster seeds, in their natural settlement habitat~~t heir natural settlement habitat, plankton might be a natural diet source for various types of fish seeds, including lobster seeds~~. Raza'i et al. (2018) added that the availability of plankton as a natural diet source ~~has a significant impact on~~significantly impacts the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance might reveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed for lobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunung Kidul, Yogyakarta. Generally, t~~T~~hi s~~e~~ study's results~~ in general~~ suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raised questions about whether lobster larvae are opportunistic ~~feeders~~ or specific feeders. Therefore, to answer these questions, more studies are required by collecting more information in more settlement areas of lobster.

Tawang Bay ~~has been~~i s well-known as one of the most settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, th~~e objectives of this research i~~i s research aims to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlement habitat of lobster larvae at Karanggongso and Tawang Bays. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

MATERIALS AND METHODS

Study area

~~The collection of plankton samples was carried out~~Plankton samples were collected in two common settlement areas of lobster larvae in East Java, Indonesia (Tawang Bay), with a protocol as previously described by Amin et al. (2022c). The sampling location was performed at ordinate points: 8°15'57.4"S 111°17'46.0" E (L1), 8°15'54.3"S 111°17'48.2"E (L2), and 8°15'51.5"S 111°17'46.2"E (L3), (Figure 1). Plankton sampling was conducted at three different sampling points with four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. ~~The~~ First, the water samples were filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering, and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

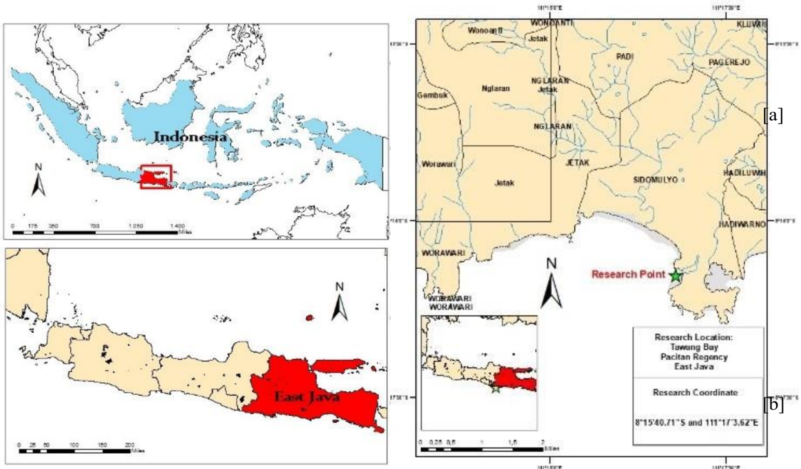

Figure 1 Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia.

Karanggongso Bay waters have temperatures ranging from 27-28 ºC, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a NO_3 content of 0.01 mg/L, and a muddy substrate. On the other hand, Tawang Bay waters temperatures are slightly warmer than Karanggongso Bay, with water temperature ranging from 28.2-28.3 ºC, with a significantly lower, DO content of 3.35 mg/L. moreover, Tawang Bay has a higher salinity of 35 ppt, a pH of 8, a NO_3 content of 0.01, a depth of 15 m, and a sandy substrate.

Abundance and Identification of planktons

Firstly, plankton identity and their abundances were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting Cell and observed under a binocular microscope with a magnification of 1000x. Thereafter Afterward, plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012):

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where "N" represents the abundance of plankton (plankter/L), "a" represents the number of SRC boxes, "b" is the area of one field of view (mm^2), "c" denotes the number of individuals observed, and "d" indicates the number of boxes observed. "Vb" is the volume of water in the sample bottle (ml), "Vsrc" is the volume of water in the SRC (ml), and "Vs" represents the volume of water filtered in the Field (L).

Diversity, ~~Uniformity~~ uniformity, and dominant indices

The diversity index value (H') was calculated using the following formula (Fachrul 2012):

$$H' = -\sum PilnPi, where\ Pi = \frac{ni}{N}$$

Where H' is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number.

The uniformity index (E') was calculated using the "Evennes Index" formula (Ulfah et al. 2019):

$$E' = \frac{H'}{Lns}$$

where~~,~~ E' is t~~ ~~he uniformity index, H' is~~:~~ t~~ ~~he Shannon Wiener ~~Diversity~~ diversity ~~Indexi~~ ndex, S is: ~~t~~ he ~~Total~~ t otal number of species

The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

~~where,~~ where, ~~"~~"d"~~:~~ ": Simpson Dominance Index, Nmax: The most abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Results

Plankton Abundance in Karanggongso Bay

Water samples were collected from ~~two locations,~~ Karanggongso Bay and Tawang Bay at four ~~different~~ depths (0.3 m, 2.5 m, 5 m, and 20 m). The two bays were located ~~at~~ in the Southern part of East Java Province, and both areas ~~are facing~~ face ~~to~~ the Indian Ocean, Figure 1. The results showed that ~~a total of~~ 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage ~~was~~ are presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified. Again, t~~ and t~~he top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and *Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the Bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species included *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer, which were counted for 3.85% each~~,~~ (Table 1). Meanwhile, ~~a total of~~ 13 plankton species were found at ~~the~~ a depth of 20 m. ~~The~~ Again, the top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta* sp. with 6.90%. The rest species ~~were~~ are presented in table 1.

Table 1. Plankton ~~identified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different depths of the water column~~ was identified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different water column depths.

Depth	Species	Cell density (Indiv/L)
	Cyclotella sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
0.3 m (Surface)	*Paracyclopina* sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8

2.5 m	*Rizosolenia* sp.	8
	Penilia sp.	8
	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polychaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16
	Euphausia sp.	8
	Protoperidinium sp.	8
	Sagitta sp.	16

Plankton Abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at a depth of 0.0-0.3 m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp., with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). ~~While~~ At the same time, the rest of the species were counted for 2.56% each and presented in **Table 2**. In addition, ~~t here were 11 species of plankton~~11 species of plankton were found in a water sample at a depth of 2.5 m in Tawang Bay. The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species, including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp., were counted at 4.00% each, **Table 2**.

Furthermore, ~~a total of~~ 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp. with an abundance of 9.52%. While the rest of the species, including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00%, respectively. While in the bottom waters of Tawang Bay (20 m depth), ~~a total of~~ 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). ~~While~~ At the same time, the rest species ~~were~~ are presented in table 2**.**

Table 2. Planktons identified from the natural habitat of spiny lobster in bottom water at Tawang Bay, East Java Indonesia

Depth	**Species**	**Density (Indiv/L)**
	Synedra sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
0.3 m (Surface)	*Acartia* sp.	40
	Microstella sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified *Fish larvae*	8
	Unclassified flatworms	8
	Synedra sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
2.5 m	*Calanus* sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
	Melosira sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16
	Dinophysis sp.	8
	Microstella sp.	8
	Calanus sp.	48
5 m	*Oithona* sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
	Rhizoselenia sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
20 m (bottom)	*Microsetella* sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified *flatworm*	8

Diversity indices

The diversity index values obtained in the waters of Karanggongso Bay, Trenggalek Regency East Java, were 2.49 ± 0.07 at a depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ± 0.10 at the 20 m water column. Those ~~which~~ indicate~~s~~ that the Karanggongso Trenggalek waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay were 2.65 ± 0.03 at 0.0 – 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay ~~have also~~also have moderate diversity, Figure 2

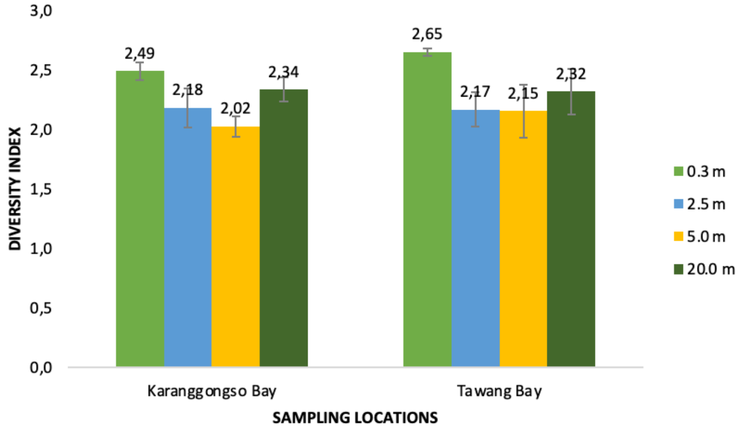

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East ~~java~~Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Uniformity indices

The uniformity index values obtained in the water column of Karanggongso Bay were 0.45 ± 0.01 at 0.0-0.3 m depth (surface water column), 0.39 ± 0.06 at a depth of 2.5 m, 0.38 ± 0.01at a depth of 5 m and 0.43 ± 0.04 at the 25m depth or bottom of the water column. These index values indicated that the uniformity of plankton in Karanggongso Bay was ~~at a moderate level~~moderate. ~~While~~ At the same time, the uniformity values obtained in Tawang Bay were 0.46 ± 0.01 at 0.0-0.3 m depth, 0.41 ± 0.05 at a depth of 2.5 m, 0.42 ± 0.07 at a depth of 5 m, and 0.46 ± 0.05 at 25 m depth or bottom of the water column. Similarly, uniformity indices of plankton in Tawang Bay were ~~considered also~~also considered at a moderate level, **Figure 3**.

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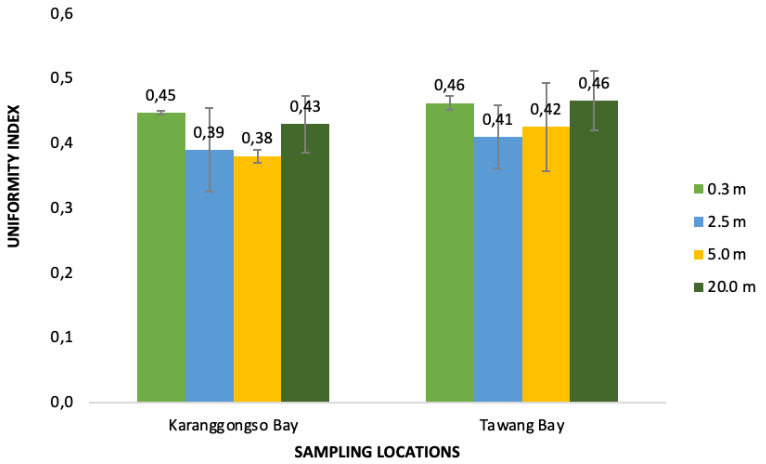

Figure 3. Uniformity indices of planktons identified in Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Domination Index

Dominance index values obtained from the waters of Karanggongso Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean ~~that~~ no plankton species were dominant in the natural habitat of spiny lobster larvae (Karanggongso Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, ~~based on the values obtained from the surface to the bottom of the waters shows that there are no species that~~the values obtained from the surface to the bottom of the waters show that no species dominate in Tawang Bay (Figure 4).

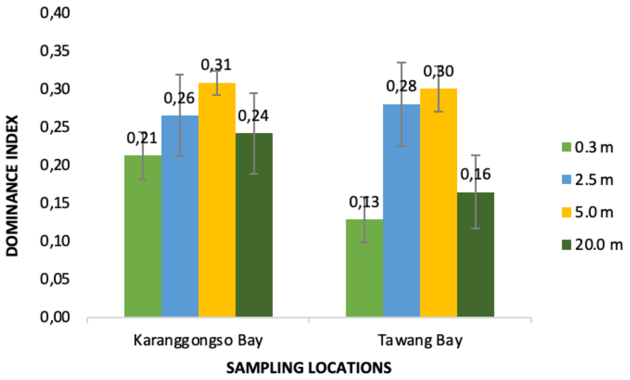

Figure 4. Domination indices of planktons identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Discussion

Environmental conditions, including physical, chemical, and biological factors in natural habitats, highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022c; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability ~~can~~ would be important information on the natural diets of lobster larvae (~~O'Rorke~~ O'Rorke et al. 2014). Thus the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karanggongso Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths, which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime . It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual~~ or in another sense there are no species that~~. In another sense, no species have relatively more diversity than other species (Awwaluddin et al. 2017). ~~As the diversity indices of plankton at Karanggongso Bay and Tawang Bay may which is are at a moderate level may suggest that plankton communities is are in relatively equal distribution of different species, with no one~~Therefore, the diversity indices of plankton at Karanggongso Bay and Tawang Bay, which are at a moderate level may suggest that plankton communities are in relatively equal distribution of different species, with no species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of planktons in both settlement areas were classified at a moderate level (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay). The uniformity values found at each location, ~~both~~ Karanggongso Beach water~~s~~ and Tawang Beach water~~s~~, are categorized~~said to have as~~ moderate uniformity. The ~~value of uniformity is categorized to be~~uniformity value is categorized as moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019)**.** The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020)**.** In addition, since the distribution of plankton in both water~~s~~ samples is uniform, ~~then~~ a high degree of uniformity can be asserted**.** While the dominance indices ~~were ranging~~ranged from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay. The result indicates~~ that there were~~ no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Karanggongso Bay and ~~also~~ Tawang Bay. The dominance index value indicates whether organisms are dominant in a water environment. A value between 0.5 to 1 on the dominance index shows the presence of dominant organisms in the water. On the other hand, a value less than 0.5 indicates ~~that there are no dominant organisms~~no dominant organisms are present in the water (Berger and Parker, 1970).

Potential Diet for Lobster Seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 ~~species at a depth of 5 m, and 13 species~~at a depth of 5 m, and 13 at 20m (bottom) of Karanggongso Bay. ~~While~~At the same time, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. ~~The number of plankton species identified in the present study, in general,~~In general, the number of plankton species identified in the present study ~~are~~ is higher than in previous stud~~y reported from other settlement habitats of lobster larvae~~ies reported from other lobster larvae settlement habitats in Awang Bay west Nusa Tenggara (Amin et al. 2022c) and Teluk Wedi Ombo, Yogyakarta (Trijoko and Pasaribu 2004)**.** The most abundant species identified from Karanggongso bay are mainly from Phylum Arthropoda, including *Paracyclopina* sp, *Oithona* sp, *Acartia* sp, and *Calanus* sp. Other prominent species included *Prorocentrum* sp., *Dinophysis* sp., and *Ceratium* sp., which ~~are~~ belonged to the phylum Dinoflagellata. While ~~most abundant species found in Tawang Bay were also dominated by phylum Arthropoda, including *Acartia* sp., *Oithona* sp., *Oncaea* sp., *Calanus* sp., *Paracyclopina*~~phylum Arthropoda, including *Acartia sp., Oithona sp., Oncaea sp., Calanus sp., Paracyclopina*, and *Macropthalmus* sp., also dominated the most abundant species found in Tawang Bay. ~~, and *Macropthalmus* sp~~. Plankton species in this area are also dominated by phylum Dinoflagellata such as *Ceratium* sp., *Prorocentrum* sp., and *Dinophysis* sp. Of these identified plankton species, ~~10~~ ten species were found in both locations, including *Acartia* sp., *Oithona* sp., *Paracyclopina* sp., *Pteropods* sp., *Binophysis* sp., *Sagita* sp., *Microstellas* sp. *Calanus* sp., *Synedra* sp. These findings suggest that the planktonic community in both bays is dominated by species belonging to the phylum Arthropoda and Dinoflagellata, which are known to be important components of the marine food web.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture, including *Oithona* sp., for a live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a) and shrimp larvae (Dinesh Kumar et al. 2017). Therefore, ~~and~~ *Acartia* sp. could possess ~~as~~ a live diet for seabass larvae, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae (Sarkisian et al. 2019). ~~In fact, s~~Some studies also confirmed that these plankton species were identified in the content

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stomach content of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022d; Khvorov et al. 2012). Furthermore, *Oithona* sp. has been described as a marine calanoid copepod which withhas high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30), which i n fact are higher compared tot han a commercial live diet such as *Artemia* sp. (Magouz et al. 2021b). Furthermore, *Acartia* sp. has been alsoalso been documented to be a good live diet for aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). *Acartia clausi* has been described to have higher contents of proteins (63.12%) and lipids (16.65%) and is also richer in n − 3 fatty acids (33.94%) than Artemia nauplii and rotifers (Rajkumar, 2006). The plankton species has have been also identified in the stomach content of spiny lobster larvaealso been identified in spiny lobster larvae's stomach content (Amin et al. 2022d). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. According to the results obtained, the plankton found at each station consistsThe plankton results found at each station consist of Bachillariophiceae (*e.g.*, *Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.), and Copepoda (e.g., *Oithona* sp., *Acartia* sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). The PUFA PUFA is the major fatty acid in Bachillariopiceae diatoms (Pahl et al. 2010), including EPA (eicosapentaenoic acid, 20:5 n-3) and DHA (docosahexaenoic acid 22:6 n-3). Therefore, PUFA are i s the major fatty acids found in diatoms Bachillariopiceae diatoms (Pahl *et al*, 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera & Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long-chain fatty acids are an essential nutrient for spiny lobster (Koshio & Kanazawa, 1994; Liddy et al., 2004; Wang, 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods, ; it is also high in calcium content which is important for lobster during molting (Kirno et al., 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. Thati s suggests t hat copepods are a preferred food for lobster larvae. Protein is constantly the predominant organic nutrient in the spiny lobster larvae as well asnd their preferred prey (Wang, 2013). This is consistent withwith prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston et al., 2004a; Johnston et al., 2004b, Johnston et al., 2006). Copepods contain high protein content, ranging from 28.9 - 84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang & Jeffs, 2014). The protein content of the copepods i s in accordant withfollows the amount of protein incorporated into artificial feeds for some of the crustaceans larvae, including crab, shrimp, and clawed lobster species, which i s rangingranges between 30% to 60% protein (Conklin et al., 1980 ; Guillaume, 1997 ; Holme et al., 2009). Moreover, copepods are also high in lipids, ranging from 11.3%-12.4% (Wang & Jeffs, 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae, and utilized i t to supply energy, especially during a food scarcity (Johnston et al., 2004; Liddy et al., 2003; Liddy et al., 2004; Ritar et al., 2003). Furthermore, l ate l ate-phase phyllosoma of spiny lobster probably targets high lipid prey, as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs et al., 2001a; Jeffs et al., 2001b). The presence of copepods, especially *Oithona* sp., *Acartia* sp., and *Calanus* sp., in a high abundance value at the Karanggongso and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae, therefore, should be further studied by in vivo trials using aquatic animals especially for developing ornate spiny lobster hatcheries. Therefore, in vivo trials using aquatic animals especially for developing ornate lobster hatcheries, should be further studied.

In conclusion, t he number of plankton species found in both locations was more abundant in the surface water (0-0.3 m) compared to the deeper water column. A total of a total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20 m (bottom) of Karanggongso Bay. Similarly, While, 17 plankton species were discovered on from the water surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. Based on the diversity, uniformity, and dominance indices, at both locations had, plankton species which are available at both location were moderate plankton quite varietydiversity, and no specific species was dominant over the others. , which suggest there were no dominant species in both locations. Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia, such as *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., and *Acartia* sp., are considered potential live feed for lobster larvae, and thus should be further studied.

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AUTHORS' CONTRIBUTIONS

1. Endang Dwi Masitah : funding acquisition, data analysis, writing draft, supervision
2. Muhamad Amin : Experimental design, data collection, data analysis, writing the draft
3. Anis Fitria: data collection, data analysis, writing draft.
4. Andi Baso Manguntungi : Experimental design, data collection, data analysis, writing draft, data validation, submission.
5. Shafwan Amrullah : Experimental design, data collection, data analysis, writing draft, data validation, submission.
6. Laila Musdalifah: Experimental design, data collection, data analysis, writing the draft
7. Sahrul Alim : Experimental design, data collection, data analysis, writing draft, data validation, submission.

REFERENCES

Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The Ecological Habitat of Spiny Lobster (*Panulirus* spp.): Case Study on Lobster Fishing Ground in Trenggalek, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodivers. J., 23(6). DOI: 10.13057/biodiv/d230615.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022c. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodiversitas Journal of Biological Diversity, 23(6).

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022d. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus, and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquaculture Reports, 27: 101361. 10.1016/j.aqrep.2022.101361.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi Kelimpahan dan Struktur Komunitas Plankton pada Musim Timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia, 11(6): 33-56.

Badan Pusat Statistik Indonesia (BPS). 2020. Distribusi PDB Triwulanan Seri 2010 Atas Dasar Harga Berlaku (Persen).2020. Jakarta Pusat : Badan Pusat Statistik.

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture, 388: 153-158.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science, 168(3937): 1345- 1347.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. Journal of Experimental Marine Biology and Ecology, 162(1): 35-49.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquaculture International, 25: 393-411.

Fachrul MF. 2012. Metode sampling bioekologi.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. Jurnal Riset Akuakultur, 14(3): 183-191.

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an eutrophic lake. Journal of applied microbiology, 125(6): 1626-1641.

Keulder FJ. 2005. *Puerulus and early juvenile recruitment of the rock lobster Jasus lalandii in relation to the environment at Lüderitz Bay, Namibia* Rhodes University].

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the Palinurid and Scyllarid Phyllosoma larvae in Oman Coastal Waters. Journal of Agricultural and Marine Sciences [JAMS], 17: 53-60.

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LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Marine Ecology Progress Series, 401: 161-172.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ. Bull, 30: 7106-7116.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of Oithona nana (Cyclopoida, Copepoda), fed on different diets. Animals, 11(5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conference Series: Earth and Environmental Science.

~~O'Rorke~~ O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Marine Biology, 161(3): 551-563.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261(2): 649-658.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan Kopepoda (Copepods) sebagai Stok Pakan Alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur, 2(1): 63-70.

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp.(Claus, 1866). IOP Conference Series: Earth and Environmental Science.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, Acartia tonsa. Aquaculture, 501: 272-278.

Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk Pakan Alami Larva Udang Karang (*Panulirus homarus* L.) Di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta.

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod *Acartia tonsa* as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin american journal of aquatic research, 45(1): 159-166.

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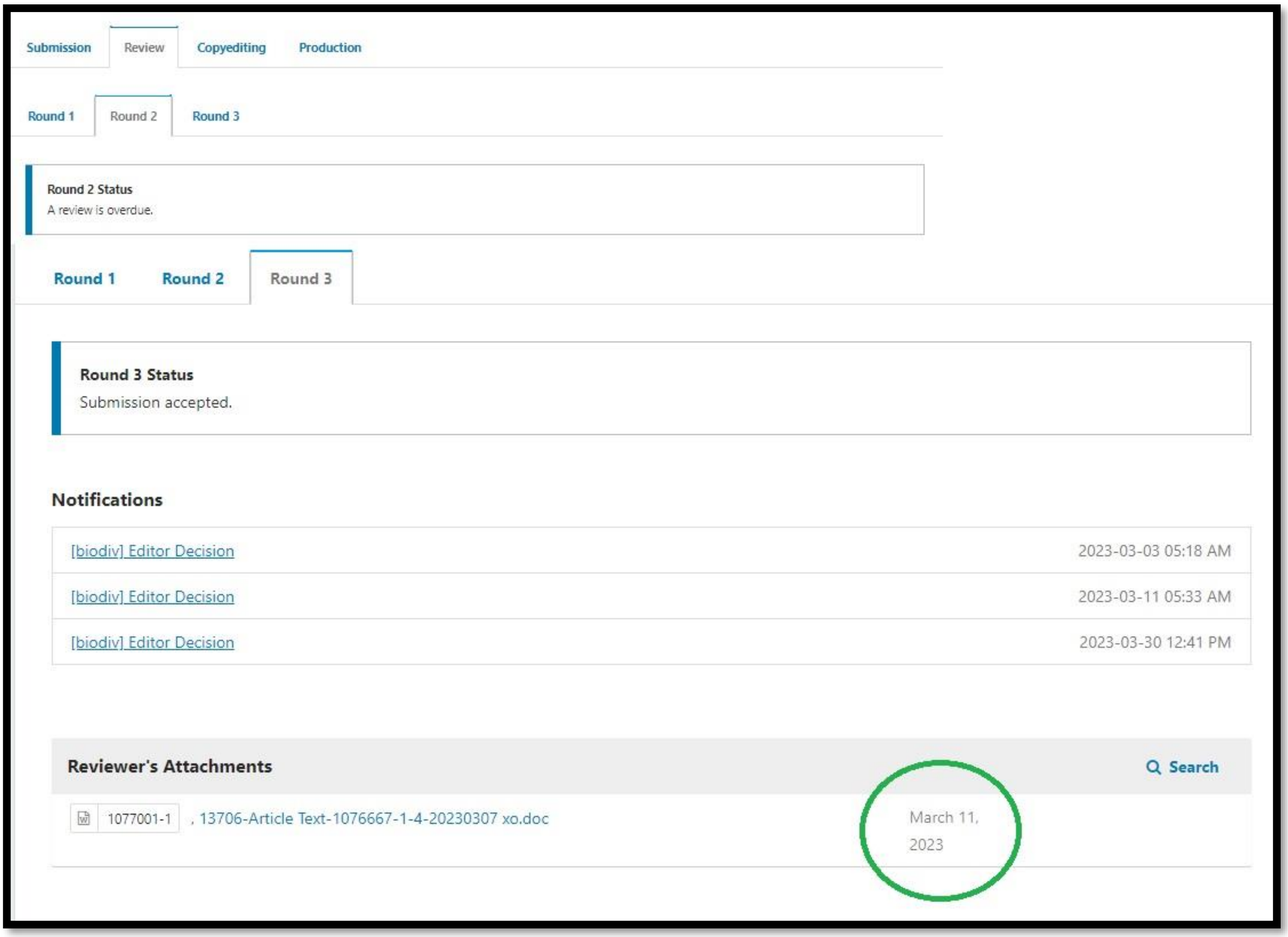
5. Bukti respon kepada reviewer rounde 3, dan artikel yang diresubmit (11 Maret 2023)

A. Author mengirim Kembali artikel yang sudah direvisi



B. Bukti artikel yang diperbaiki rounde 3

Diversity and Abundance of Plankton Community in Tawang ~~Bay~~ and Karanggongso Bays, ~~the~~ Natural Settlement Habitats of Spiny Lobster Larvae in East Java Indonesia

Abstract. Tawang and Kar~~r~~anggongso Bays have been well-known as settlement areas for spiny lobster larvae, *Panulirus* spp., in East Java, Indonesia. These locations may suggest ~~. Therefore, these locations~~, ~~which may suggest that the location are~~ suitable environments including diet availability for lobster larvae. Theref~~Furtherm~~~~Theref~~ore, the present study aimed to investigate type~~s~~ and, abundance ~~and diversity~~ of plankton in ~~the~~ both locations to discover potential live diets for lobster larvae. ~~Plankton samples were collected in both locations using a plankton net at four different depths: 0.3 m, 2.5m, 5~~ m ~~, and 20 m with three replicates. The objectives of t~~This study also ~~are to~~ explored plankton's ~~plankton's~~ diversity, uniformity, and dominance indices ~~the diversity, abundance, uniformity and dominance indices of plankton~~ in ~~the natural settlement ground of lobster larvae at~~ both locations~~Karanggongso and Tawang Bay~~. Plankton samples in each location was collected using a plankton net at four ~~different~~ depths: 0.3 m, 2.5 m, 5 m, and 20 m with three replicates. The results revealed that 17 plankton species were identified from ~~the~~ 0.30 m depth, 13 ~~species at a 2.5mdepth of 2.5m, 11 species at a 5mdepth of 5m, and 13 species~~at 2.5 m, 11 at 5 m, and 13 at 20 m ~~at~~depth at Karanggongso Bay. ~~While, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a 2.5m, 12 species at 5m, and 12 species at 20m.~~ In addition, 17 plankton species were discovered ~~in~~at 0.3 m depth, 11 ~~species at 2.5m, 12 species at 5m, and 12 species~~at 2.5 m, 12 at 5 m, and 12 at 20 m at Tawang Bay. Among the most abundant species were *Acartia* sp., *Calanus* sp., *Paracyclopina* sp., and *Oithona* sp. The diversity indices observed in Karanggongso and Tawang bay ranged from 2.02-2.49 and 2.17-2.65, respectively, ~~which fall~~ within the moderate range. Similarly, the uniformity indices observed at both locations were ~~also~~ moderate, ~~with values~~ ranging from 0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay. ~~While t~~There were no dominant species at both locations~~s, as indicated by~~, as the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

Key words: diversity, diets, dominance, lobster, plankton, uniformity.

Abbreviations (if any): -

Running title: Plankton diversity in ~~lobster natural~~natural lobster habitat

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents ~~as well as~~, and high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has ~~been highly dependent on the wild catch because lobster aquaculture has not been well developed yet~~depended highly on the wild catch because lobster aquaculture has not yet been well developed. One of the main issues faced in lobster

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aquaculture is larval production, which currently relies on the availability of ~~seeds in nature~~natural seeds. Many studies have been conducted to study various factors relating to ~~larval production of larvae~~e's larval production, including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded ~~to breed~~in breeding and producing larvae. Yet, the larvae can live only 7-14 days after hatching. ~~It~~ Therefore, it is hypothesized that the main challenge is ~~in~~ diet availability and suitability. According to Amin et al. (2022b), ~~one way to start domesticating wild species is firstly by collecting information on their natural habitat as much as possible~~first, one way to start domesticating wild species is by collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest ~~that profiling certain animals' natural habitat~~profiling certain animals' natural habitats may reveal their diets.

Environmental conditions, including physical, chemical, and biological factors in natural habitats, highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022b; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are ~~still~~ very limited. Meanwhile, many studies conclude that biological factors have~~old~~ important information for the lobster larvae, especially for diets (O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. ~~In~~ For example, plankton might be a natural diet source for various fish seeds, including lobster seeds, in their natural settlement habitat~~t heir natural settlement habitat, plankton might be a natural diet source for various types of fish seeds, including lobster seeds~~. Raza'i et al. (2018) added that the availability of plankton as a natural diet source ~~has a significant impact on~~significantly impacts the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance might reveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed for lobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunung Kidul, Yogyakarta. Generally, t~~T~~his~~e~~ study's results ~~in general~~ suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raised questions about whether lobster larvae are opportunistic ~~feeders~~ or specific feeders. Therefore, to answer these questions, more studies are required by collecting more information in more settlement areas of lobster.

Karanggongso bay and Tawang Bay ~~has been~~ ~~is~~have been well-known as one of the most settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, th~~e objectives of this research~~ ~~i~~is research aims to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlement habitat of lobster larvae at Karanggongso and Tawang Bays. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

MATERIALS AND METHODS

Study area

~~The collection of plankton samples was carried out~~Plankton samples were collected in two common settlement areas of lobster larvae in East Java, Indonesia (Karanggongso Bay and Tawang Bay), with a protocol as previously described by Amin et al. (2022b). At Karanggongso Bay, ~~The~~ sampling ~~location~~ was performed at three different ordinate points~~at ordinate points~~ as repetitions: 8°18'13.8"S 111°44'28.4"E (R1), 8°18'16.3"S 111°44'21.6"E (R2), and 8°18'23.0"S 111°44'26.8"E (R3). While at Tawang Bay, the sampling pointes were 8°15'57.4"S 111°17'46.0"E (R1), 8°15'54.3"S 111°17'48.2"E (R2), and 8°15'51.5"S 111°17'46.2"E (R3) ~~8°15'57.4"S 111°17'46.0" E (L1), 8°15'54.3"S 111°17'48.2"E (L2) and 8°15'51.5"S 111°17'46.2"E (L3),~~ (Figure 1). Plankton sampling in each sampling point was collected at ~~Plankton sampling was conducted at three different sampling points with~~ four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. First, ~~T~~the water samples collected from three sampling points with the same depth were mixed and filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering, and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

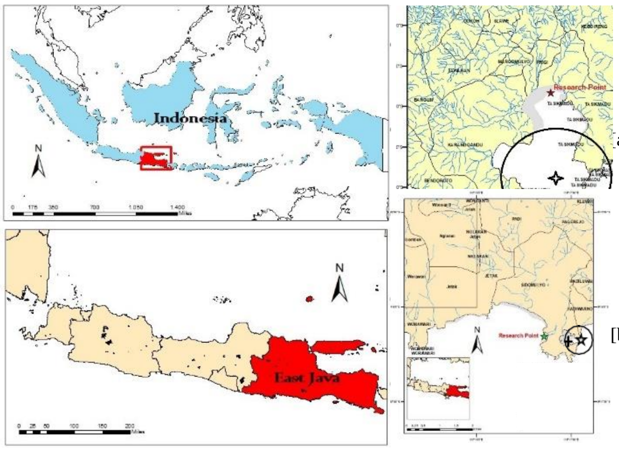

Figure 1 Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia.

Karanggongso Bay water~~s have~~ had temperatures ranging from 27-28~~-~~ºC, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a NO_3 content of 0.01 mg/L, and a muddy substrate. On the other hand, Tawang Bay water~~s~~ temperatures ~~are~~ were slightly warmer than Karanggongso Bay, with water temperature ranging from 28.2-28.3 ºC, with a significantly lower~~,~~ DO content of 3.35 mg/L. moreover, Tawang Bay has a higher salinity of 35 ppt, a pH of 8, a NO_3 content of 0.01, a depth of 15 m, and a sandy substrate.

Abundance and Identification of plankton

Firstly, plankton identity and ~~their~~ abundances were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting (SRC) Cell and observed under a binocular microscope with a magnification of 1000x. ~~Thereafter~~ Afterward, plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012):

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where "N" represents the abundance of plankton (plankter/L), "a" represents the number of SRC boxes, "b" is the area of one field of view (mm^2), "c" denotes the number of individuals observed, and "d" indicates the number of boxes observed. "Vb" is the volume of water in the sample bottle (ml), "Vsrc" is the volume of water in the SRC (ml), and "Vs" represents the volume of water filtered in the Field (L).

Diversity, ~~Uniformity~~uniformity, and dominant indices

The diversity index value (H') was calculated using the following formula (Fachrul 2012):

$$H' = -\sum PilnPi, where\ Pi = \frac{ni}{N} H' - -\sum PilnPi, where\ Pi - \frac{ni}{N}$$

Where H' is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number.

The uniformity index (E') was calculated using the "Evennes Index" formula (Ulfah et al. 2019):

$$E' = \frac{H'}{lns}$$

where~~,~~ E' is the uniformity index, H' is~~:~~ the Shannon Wiener ~~Diversity~~ diversity ~~Index~~ index, S is~~:~~

t he ~~Total~~ t otal number of species

The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

~~where,~~where, ~~“~~"d~~”:~~ ": Simpson Dominance Index, Nmax: The most abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Results

Plankton Abundance in Karanggongso Bay

Water samples were collected from ~~two locations,~~ Karanggongso Bay and Tawang Bay at four ~~different~~ depths (0.3 m, 2.5 m, 5 m, and 20 m). The two bays were located ~~at~~ i n the Southern part of East Java Province, and both areas ~~are facing~~face ~~to~~ the Indian Ocean, Figure 1. The results showed that ~~a total of~~ 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage ~~was~~ are presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified. Again, t ~~and t~~he top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and *Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the Bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species included *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer, which were counted for 3.85% each~~,~~ (Table 1). Meanwhile, ~~a total of~~ 13 plankton species were found at ~~the~~ a depth of 20 m. ~~The~~ Again, the top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta* sp. with 6.90%. The rest species ~~were~~ are presented in table 1.

Table 1. Plankton species ~~i dentified from two natural settlement habitats of spiny lobster larvae (Karanggongso Bay and Trenggalek Regency, East Java Indonesia) at four different depths of the water column~~~~was~~ identified from ~~t wo natural settlement habitats of spiny lobster larvae~~ (Karanggongso Bay ~~and Trenggalek Regency, East Java Indonesia)~~ at four different depth of water column ~~depths~~.

Depth	Species	Cell density (Indiv/L)
0.3 m (Surface)	*Cyclotella* sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
	Paracyclopina sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8
2.5 m	*Rizosolenia* sp.	8

	Penilia sp.	8
	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polychaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16
	Euphausia sp.	8
	Protoperidinium sp.	8
	Sagitta sp.	16

Plankton Abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at a depth of 0.0-0.3 m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp., with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). ~~While~~ At the same time, the rest of the species were counted for 2.56% each and presented in **Table 2**. In addition, ~~t here were 11 species of plankton~~11 species of plankton were found in a water sample at a depth of 2.5 m in Tawang Bay. The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species, including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp., were counted at 4.00% each, **Table 2**.

Furthermore, ~~a total of~~ 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp. with an abundance of 9.52%. While the rest of the species, including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00%, respectively. While in the bottom waters of Tawang Bay (20 m depth), ~~a total of~~ 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). ~~While~~ At the same time, the rest species ~~were~~ are presented in table 2**.**

Table 2. Plankton species identified from t~~he natural habitat of spiny lobster in bottom water at~~ Tawang Bay, at four different depth of water column.~~East Java Indonesia~~

Depth	Species	Density (Indiv/L)
0.3 m (Surface)	*Synedra* sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
	Acartia sp.	40
	Microstella sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified *Fish larvae*	8
	Unclassified flatworms	8
2.5 m	Synedra sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
	Calanus sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
5 m	*Melosira* sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16
	Dinophysis sp.	8
	Microstella sp.	8
	Calanus sp.	48
	Oithona sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
20 m (bottom)	*Rhizoselenia* sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
	Microsetella sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified *flatworm*	8

Diversity indices

The diversity index values obtained in the waters of Karanggongso Bay, Trenggalek Regency East Java, were 2.49 ± 0.07 at a depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ± 0.10 at the 20 m water column. Those ~~which~~ indicate~~s~~ that the Karanggongso Trenggalek waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay were 2.65 ± 0.03 at 0.0 – 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay ~~have also~~also have moderate diversity, Figure 2

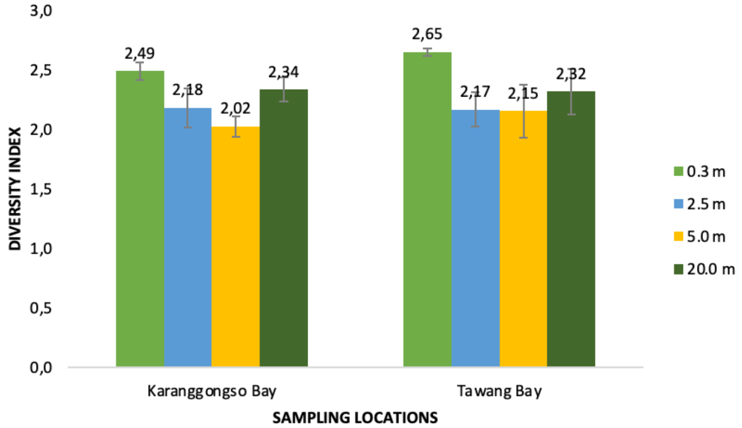

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East ~~java~~Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Uniformity indices

The uniformity index values obtained in the water column of Karanggongso Bay were 0.45 ± 0.01 at 0.0-0.3 m depth (surface water column), 0.39 ± 0.06 at a depth of 2.5 m, 0.38 ± 0.01at a depth of 5 m and 0.43 ± 0.04 at the 25m depth or bottom of the water column. These index values indicated that the uniformity of plankton in Karanggongso Bay was ~~at a moderate level~~moderate. ~~While~~ At the same time, the uniformity values obtained in Tawang Bay were 0.46 ± 0.01 at 0.0-0.3 m depth, 0.41 ± 0.05 at a depth of 2.5 m, 0.42 ± 0.07 at a depth of 5 m, and 0.46 ± 0.05 at 25 m depth or bottom of the water column. Similarly, uniformity indices of plankton in Tawang Bay were ~~considered also~~also considered at a moderate level, **Figure 3**.

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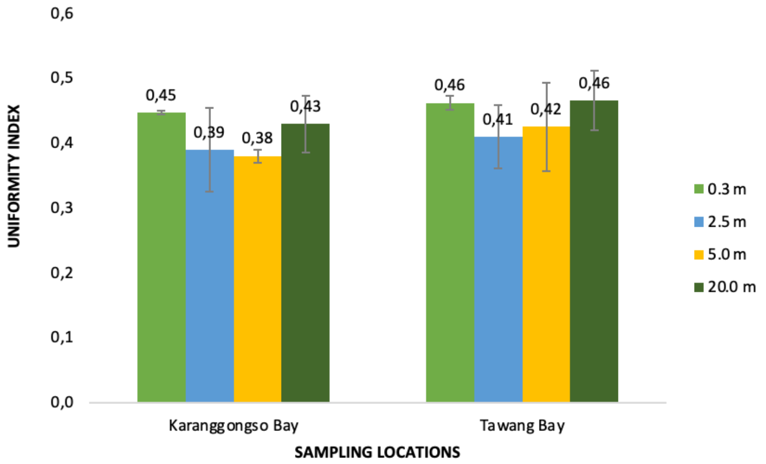

Figure 3. Uniformity indices of plankton identified in Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Domination Index

Dominance index values obtained from the waters of Karanggongso Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean ~~that~~ no plankton species were dominant in the natural habitat of spiny lobster larvae (Karanggongso Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, ~~based on the values obtained from the surface to the bottom of the waters shows that there are no species that~~the values obtained from the surface to the bottom of the waters show that no species dominate in Tawang Bay (Figure 4).

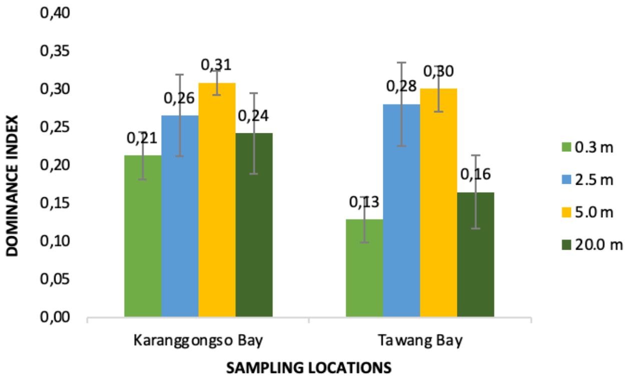

Figure 4. Domination indices of plankton identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates.

Discussion

Environmental conditions, including physical, chemical, and biological factors in natural habitats, highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022b; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability ~~can~~ would be important information on the natural diets of lobster larvae (O'Rorke et al. 2014). Thus the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karangongso Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths, which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime . It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual~~ or in another sense there are no species that~~. In another sense, no species have relatively more diversity than other species (Awwaluddin et al. 2017). ~~As the diversity indices of plankton at Karanggongso Bay and Tawang Bay may which is are at a moderate level may suggest that plankton communities is are in relatively equal distribution of different species, with no one~~Therefore, the diversity indices of plankton at Karanggongso Bay and Tawang Bay, which are at a moderate level may suggest that plankton communities are in relatively equal distribution of different species, with no species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of plankton in both settlement areas were classified at a moderate level (0.38-0.45 at Karanggongso Bay and 0.41-0.46 at Tawang Bay). The uniformity values found at each location, ~~both~~ Karanggongso Beach water~~s~~ and Tawang Beach water~~s~~, are categorized~~said to have as~~ moderate uniformity. The ~~value of uniformity is categorized to be~~uniformity value is categorized as moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019)**.** The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020)**.** In addition, since the distribution of plankton in both water~~s~~ samples is uniform, ~~then~~ a high degree of uniformity can be asserted**.** While the dominance indices ~~were ranging~~ranged from 0.21 – 0.31 at Karanggongso Bay and 0.13-0.30 in Tawang Bay. The result indicates~~ that there were~~ no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Karanggongso Bay and ~~also~~ Tawang Bay. The dominance index value indicates whether organisms are dominant in a water environment. A value between 0.5 to 1 on the dominance index shows the presence of dominant organisms in the water. On the other hand, a value less than 0.5 indicates ~~that there are no dominant organisms~~no dominant organisms are present in the water (Berger and Parker 1970).

Potential Diet for Lobster Seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 ~~species at a depth of 5 m, and 13 species~~at a depth of 5 m, and 13 at 20m (bottom) of Karanggongso Bay. ~~While~~At the same time,~~,~~ 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. ~~The number of plankton species identified in the present study, in general,~~In general, the number of plankton species identified in the present study ~~are~~ is higher than in previous stud~~y reported from other settlement habitats of lobster larvae~~ies reported from other lobster larvae settlement habitats in Awang Bay west Nusa Tenggara (Amin et al. 2022b) and Teluk Wedi Ombo, Yogyakarta (Trijoko and Pasaribu 2004)**.** The most abundant species identified from Karanggongso bay are mainly from Phylum Arthropoda, including *Paracyclopina* sp, *Oithona* sp, *Acartia* sp, and *Calanus* sp. Other prominent species included *Prorocentrum* sp., *Dinophysis* sp., and *Ceratium* sp.,, which ~~are~~ belonged to ~~t~~he phylum Dinoflagellata., While ~~most abundant species found in Tawang Bay were also dominated by phylum Arthropoda, including *Acartia* sp., *Oithona* sp., *Oncaea* sp., *Calanus* sp., *Paracyclopina*~~phylum Arthropoda, including *Acartia sp.*, *Oithona sp.*, *Oncaea sp.*, *Calanus sp.*, *Paracyclopina*, and *Macropthalmus* sp., also dominated the most abundant species found in Tawang Bay.~~,and *Macropthalmus* sp~~. Plankton species in this area are also dominated by phylum Dinoflagellata such as *Ceratium* sp.,. *Prorocentrum* sp., and *Dinophysis* sp. Of these identified plankton species, ~~10 t~~ e11n species were found in both locations, including *Acartia* sp., *Ceratium* sp., *Dynophysis* sp., *Euphausia* sp., *Microstella* sp., ***Oithona*** **sp.**, ***Paracyclopina*** **sp.**, ***Pteropods*** **sp.**, *Rizosolenia* sp., ~~*Binophysis* sp.,~~ ***Sagita*** **sp.**,~~ *Microstellas* sp. *Calanus* sp.,~~ ***Synedra*** sp.. These findings suggest that the planktonic community in both bays is dominated by species belonging to the phylum Arthropoda and Dinoflagellata, which are known to be important components of the marine food web.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture, including *Oithona* sp., for a live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a)~~,~~ and shrimp larvae (Dinesh Kumar et al. 2017). Therefore, ~~and~~ *Acartia* sp., could possess ~~as~~ a live diet for seabass larvae,, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae

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(Sarkisian et al. 2019). ~~In fact, s~~Some studies also confirmed that these plankton species were identified in the content stomach ~~content~~ of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022c; Khvorov et al. 2012). Furthermore, *Oithona* sp. has been described as a marine calanoid copepod ~~which~~ with~~has~~ high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30), which ~~i n fact~~ are higher ~~compared to~~t han a commercial live diet such as *Artemia* sp. (Magouz et al. 2021b). Furthermore, *Acartia* sp. has ~~been also~~also been documented to be a good live diet for aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). *Acartia clausi* has been described to have higher contents of proteins (63.12%) and lipids (16.65%) and is also richer in n − 3 fatty acids (33.94%) than Artemia nauplii and rotifers (Rajkumar, 2006). The plankton species ~~has~~ have ~~been also identified in the stomach content of spiny lobster larvae~~also been identified in spiny lobster larvae's stomach content (Amin et al. 2022b; Amin et al. 2022c). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. ~~According to the results obtained, the plankton found at each station consists~~The plankton results found at each station consist of Bachillariophiceae (*e.g.*, *Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.~~),~~ and Copepoda (e.g., *Oithona* sp., *Acartia* sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). The ~~PUFA~~ PUFA is the major fatty acid in Bachillariopiceae diatoms (Pahl et al. 2010), including EPA (eicosapentaenoic acid, 20:5 n-3) and DHA (docosahexaenoic acid 22:6 n-3). Therefore, PUFA ~~are~~ i s the major fatty acid~~s found~~ in ~~diatoms~~ Bachillariopiceae diatoms (Pahl *et al*, 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera & Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long-chain fatty acids are an essential nutrient for spiny lobster (Koshio & Kanazawa, 1994; Liddy et al.~~,~~ 2004; Wang, 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods~~,~~; it is also high in calcium content which is important for lobster during molting (Kirno et al.~~,~~ 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. Thati~~s~~ suggests ~~t hat~~ copepods are a preferred food for lobster larvae. Protein is ~~constantly~~ the predominant organic nutrient in the spiny lobster larvae a~~s well as~~nd their preferred prey (Wang, 2013). This is consistent with~~with~~ prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston et al.~~,~~ 2004a; Johnston et al.~~,~~ 2004b, Johnston et al.~~,~~ 2006). Copepods contain high protein content, ranging from 28.9 - 84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang & Jeffs, 2014). The protein content of the copepods ~~i s in accordant with~~follows the amount of protein incorporated into artificial feeds for some of the crustaceans larvae, including crab, shrimp, and clawed lobster species, which ~~i s ranging~~ranges between 30% to 60% protein (Conklin et al.~~,~~ 1980 ; Guillaume, 1997~~,~~; Holme et al.~~,~~ 2009). Moreover, copepods are also high in lipids, ranging from 11.3%-12.4% (Wang & Jeffs, 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae~~,~~ and utilized ~~i t~~ to supply energy, especially during a food scarcity (Johnston et al.~~,~~ 2004; Liddy et al. ~~,~~ 2003; Liddy et al. ~~,~~ 2004; Ritar et al.~~,~~ 2003). Furthermore, ~~l ate~~ l ate-phase phyllosoma of spiny lobster probably targets high lipid prey~~,~~ as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs et al.~~,~~ 2001a; Jeffs et al.~~,~~ 2001b). The presence of copepods, especially *Oithona* sp., *Acartia* sp., and *Calanus* sp., in a high abundance value at the Karanggongso and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae, ~~therefore, should be further studied by in vivo trials using aquatic animals especially for developing ornate spiny lobster hatcheries~~. Therefore, in vivo trials using aquatic animals especially for developing ornate lobster hatcheries, should be further studied.

In conclusion, t he number of plankton species found in both locations was more abundant in the surface water (0-0.3 m) compared to the deeper water column. A total of ~~a total of~~ 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20 m (bottom) of Karanggongso Bay. Similarly~~, While~~, 17 plankton species were discovered ~~on~~ from the water surface of Tawang Bay~~ waters~~: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. Based on the diversity, uniformity, and dominance indices~~, at~~ both locations had~~,~~ ~~plankton species which are available at both location were~~ moderate plankton ~~quite variety~~diversity, and no specific species was dominant over the others. ~~, which suggest there were no dominant species in both locations.~~ Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia, such as *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., and *Acartia* sp., are considered potential live feed for lobster larvae, and thus should be further studied.

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3. Muhamad Amin : Experimental design, data collection, data analysis, writing draft, validation, supervision, submission.
4. Kurniati Umrah Nur: data collection, data analysis, writing draft, validation.
5. Laila Musdalifah: Experimental design, data collection, data analysis, writing the draft.
6. Shifania Hanifa Samara: Data collection, data analysis, writing draft, data validation.
7. Yudi Cahyoko: Experimental design, data collection, data analysis, writing draft, data validation, submission.
8. Alimuddin: Experimental design, data collection, data analysis, writing the draft.
9. Sahrul Alim: Experimental design, data collection, data analysis, writing the draft.
10. Bagus Dwi Hari Setyono: Experimental design, data collection, data analysis, writing draft, data validation

REFERENCES

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Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The Ecological Habitat of Spiny Lobster (*Panulirus* spp.): Case Study on Lobster Fishing Ground in Trenggalek, East Java, Indonesia. IOP Conference Series: Earth and Environmental Science.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodivers. J., 23(6). DOI: 10.13057/biodiv/d230615.

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022c. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquaculture Reports, 27: 101361.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi Kelimpahan dan Struktur Komunitas Plankton pada Musim Timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia, 11(6): 33-56.

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture, 388: 153-158.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science, 168(3937): 1345-1347.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. Journal of Experimental Marine Biology and Ecology, 162(1): 35-49.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquaculture International, 25: 393-411.

Fachrul MF. 2012. Metode sampling bioekologi.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. Jurnal Riset Akuakultur, 14(3): 183-191.

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an eutrophic lake. Journal of applied microbiology, 125(6): 1626-1641.

Keulder FJ. 2005. *Puerulus and early juvenile recruitment of the rock lobster Jasus lalandii in relation to the environment at Lüderitz Bay, Namibia* Rhodes University].

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the Palinurid and Scyllarid Phyllosoma larvae in Oman Coastal Waters. Journal of Agricultural and Marine Sciences [JAMS], 17: 53-60.

LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Marine Ecology Progress Series, 401: 161-172.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ. Bull, 30: 7106-7116.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of *Oithona nana* (Cyclopoida, Copepoda), fed on different diets. Animals, 11(5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conference Series: Earth and Environmental Science.

O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Marine Biology, 161(3): 551-563.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture, 261(2): 649-658.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan Kopepoda (Copepods) sebagai Stok Pakan Alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur, 2(1): 63-70.

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp. (Claus, 1866). IOP Conference Series: Earth and Environmental Science.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, Acartia tonsa. Aquaculture, 501: 272-278.

Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk Pakan Alami Larva Udang Karang (*Panulirus homarus* L.) Di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta.

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conference Series: Earth and Environmental Science.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod *Acartia tonsa* as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin american journal of aquatic research, 45(1): 159-166.

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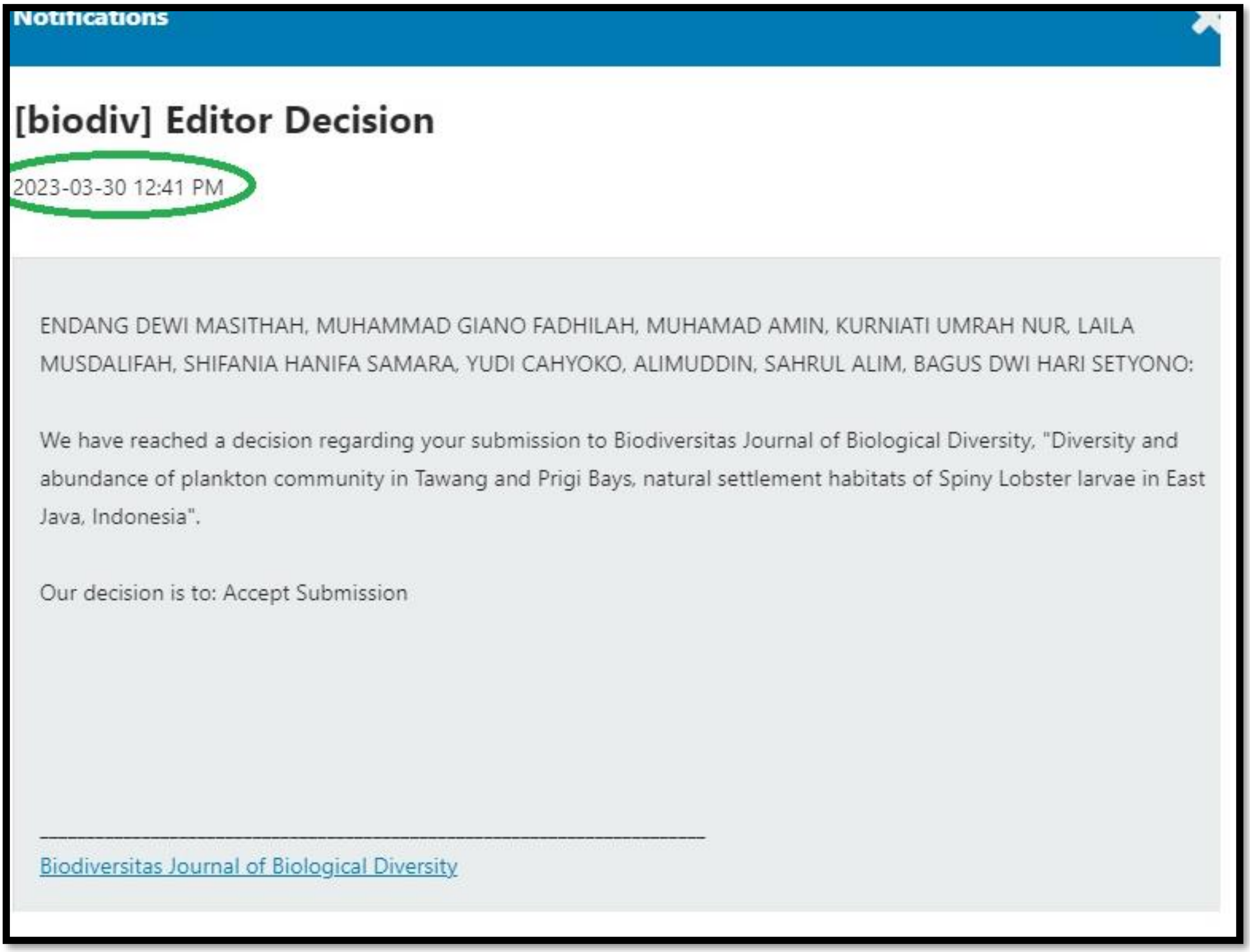

Notifications

[biodiv] Editor Decision

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ENDANG DEWI MASITHAH, MUHAMMAD GIANO FADHILAH, MUHAMAD AMIN, KURNIATI UMRAH NUR, LAILA MUSDALIFAH, SHIFANIA HANIFA SAMARA, YUDI CAHYOKO, ALIMUDDIN, SAHRUL ALIM, BAGUS DWI HARI SETYONO:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Diversity and abundance of plankton community in Tawang and Prigi Bays, natural settlement habitats of Spiny Lobster larvae in East Java, Indonesia".

Our decision is to: Accept Submission

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Biodiversitas Journal of Biological Diversity

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Section
Articles

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Diversity and abundance of plankton community in Prigi and TawangBays, natural settlement habitats of Spiny Lobster larvae in East Java,Indonesia

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Abstract. *Masithah ED, Fadhilah MG, Amin M, Nur KU, Musdalifah L, Samara SH, Cahyoko Y, Alimuddin, Alim S, Setyono BDH. 2023. Diversity and abundance of plankton community in Prigi and Tawang Bays, natural settlement habitats of Spiny Lobster larvae in East Java, Indonesia. Biodiversitas 24: 1642-1649.* Prigi and Tawang Bays have been well-known as settlement areas for spiny lobster larvae, *Panulirus* spp., in East Java, Indonesia. These locations may suggest suitable environments including diet availability for lobster larvae. Therefore, the present study aimed to investigate the type and abundance of plankton in both locations to discover potential live diets for lobster larvae. This study also explored plankton's diversity, uniformity, and dominance indices in both locations. Plankton samples in each location were collected using a plankton net at four depths: 0.3 m, 2.5 m, 5 m, and 20 m with three replicates. The results revealed that 17 plankton species were identified from 0.30 m depth, 13 at 2.5 m, 11 at 5 m, and 13 at 20 m depth at Prigi Bay. Inaddition, 17 plankton species were discovered at 0.3 m depth, 11 at 2.5 m, 12 at 5 m, and 12 at 20 m at Tawang Bay. Among the most abundant species were *Acartia* sp., *Calanus* sp., *Paracyclopina* sp., and *Oithona* sp. The diversity indices observed in Karanggongso of Prigi Bay and Tawang Bay ranged from 2.02-2.49 and 2.17-2.65, respectively, within the moderate range. Similarly, the uniformity indices observed at both locations were moderate, ranging from 0.38-0.45 at Prigi Bay and 0.41-0.46 at Tawang Bay. There were no dominant species at both locations, as the dominance index values ranged from 0.13-0.30. Among the identified plankton species, *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., and *Acartia* sp. are considered potential live feed for lobster larvae, and thus should be further studied.

Keywords: Diets, diversity, dominance, lobster, plankton, uniformity

INTRODUCTION

Lobster is an important fishery commodity in Indonesia due to its high price, high nutritional contents, and high market demands. According to the Indonesian Central Bureau of Statistics, the total export value of lobsters in 2020 reached USD 8.1 million (BPS 2020). The high export value and continuously increasing marketing demands at national or global markets indicate that lobster is a high-potential fisheries commodity. However, the lobster supply has depended highly on the wild catch because lobster aquaculture has not yet been well developed. One of the main issues faced in lobster aquaculture is larval production, which currently relies on the availability of natural seeds. Many studies have been conducted to study various factors relating to larval production, including spawning-inducing technology and rearing condition, yet the success rates are very low. Several authors have succeeded in breeding and producing larvae. Yet, the larvae can live only 7-14 days after hatching. Therefore, it is hypothesized that the main challenge is diet availability and suitability. According to Amin et al. (2022b), first, one way to start domesticating wild species is by collecting information on their natural habitat as much as possible. Similarly, Kashinskaya et al. (2018) suggest profiling certain animals' natural habitats may reveal their diets.

Environmental conditions, including physical, chemical, and biological factors in natural habitats, highly determine the recruitment rates of lobster larvae (Keulder 2005). Several authors have previously reported the physical and chemical characteristics of the natural settlement areas of lobster larvae (Amin et al. 2022b; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies investigating biological aspects of settlement habitat in the natural environment of lobster larvae are very limited. Meanwhile, many studies conclude that biological factors have important information for the lobster larvae, especially for diets (O'Rorke et al. 2014). Accordingly, biological aspects such as natural dietary aspects and lobster predation processes that occur in nature during larval and post-larval stages could be critical information that must be considered for hatchery production. For example, plankton might be a natural diet source for various aquatic species (Amin et al. 2022d),including lobster seeds, in their natural settlement habitat. Raza'i et al. (2018) added that the availability of planktonas a natural diet source significantly impacts the dependence and growth of marine organisms such as fish, crabs, shrimp, and lobsters.

Profiling plankton diversity and abundance mightreveal potential diets for lobster larvae. A similar approach has been done in some studies. For instance, Ihsan et al. (2019) conducted research on plankton as a natural feed forlobster larvae and post-larvae in natural habitats in Teluk Awang, Central Lombok. Trijoko and Pasaribu (2003) conducted another study in Wedi Ombo Bay, Gunungkidul, Yogyakarta. Generally, this study's results suggest that each location has a different structure and abundance, although some species were the same between the area. All these results raised questions about whether lobster larvae are opportunistic or specific feeders. Therefore, to answer these questions, more studies are required by collecting more information in more settlement areas of lobster.

Prigi Bay and Tawang Bay have been well-known as the top two settlement areas for lobster larvae in East Java Indonesia (Amin et al. 2022a); therefore, it is assumed to have important suitable diet availability for lobster larvae. However, studies on the biological aspects of both locations areas are still very limited. Thus, this research aims to investigate the plankton diversity, abundance, uniformity, and dominance indices in the natural settlementhabitat of lobster larvae at Prigi Bay and Tawang Bay. The study results are expected to enrich the information on potential diets for lobster larvae for hatchery development.

MATERIALS AND METHODS

Study area

Plankton samples were collected in two common settlement areas of lobster larvae in East Java, Indonesia (Prigi Bay and Tawang Bay), with a protocol as previously described by Amin et al. (2022b). At Karanggongso of Prigi Bay, sampling was performed at three different ordinate points as repetitions: 8°18'13.8"S 111°44'28.4"E (R1), 8°18'16.3"S 111°44'21.6"E (R2), and 8°18'23.0"S 111°44'26.8"E (R3). While at Tawang Bay, the sampling points were 8°15'57.4"S 111°17'46.0" E (R1), 8°15'54.3"S 111°17'48.2"E (R2), and 8°15'51.5"S 111°17'46.2"E (R3) (Figure 1). Plankton sampling in each sampling point was collected at four different depths: 0-0.3 m, 2.5 m, 5 m, and 20 m. First, the water samples collected from three sampling points with the same depth were mixed and filtered using a plankton net and placed in sterile bottles. The filtered sample was then immediately given Lugol which acts as a plankton preservative, up to 1% of the total filtering, and wrapped in Styrofoam. The samples were then examined in the Microbiology Laboratory, Faculty of Fisheries and Marine Science at Airlangga University.

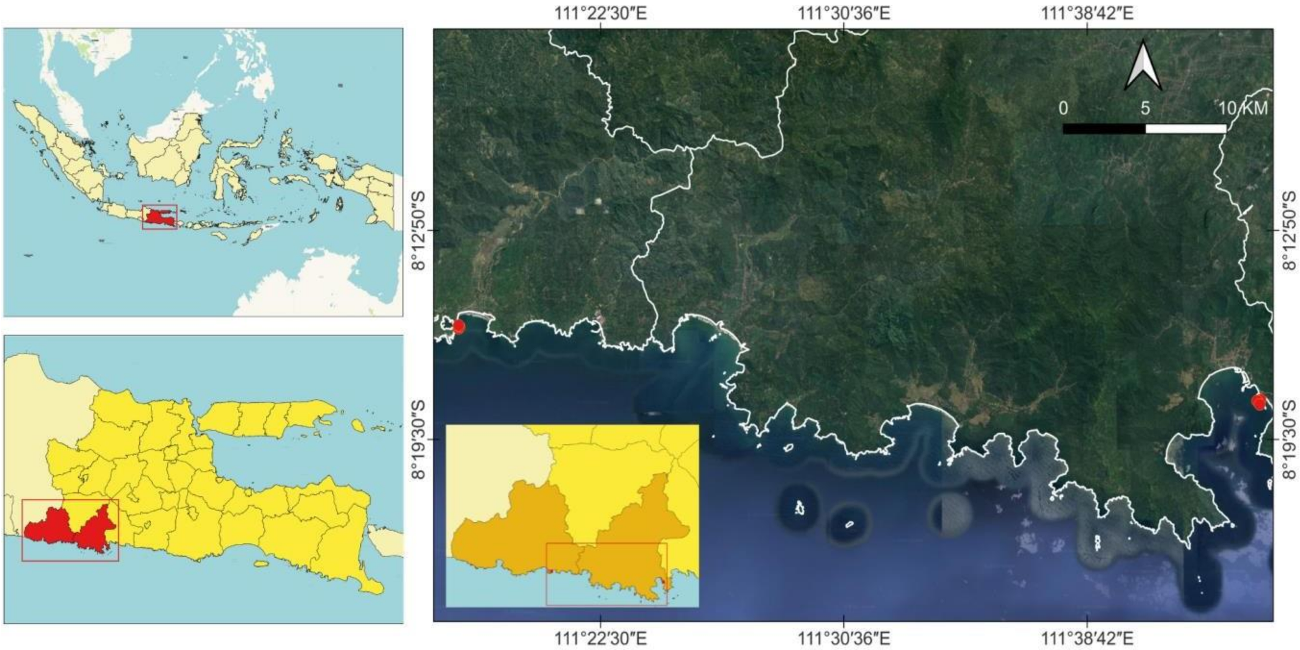

Figure 1. Two sampling locations in Prigi Bay, Trenggalek District, and Tawang Bay, Pacitan District, East Java, Indonesia

Prigi Bay water had temperatures ranging from 27- 28ºC, a DO content of 7.48 mg/L, a salinity of 26 ppt, a pH of 7-8, a nitrate (NO_3) content of 0.01 mg/L, and a muddy substrate. On the other hand, Tawang Bay water temperatures were slightly warmer than Prigi Bay, with water temperature ranging from 28.2-28.3ºC, with a lower DO concentration (3.35 mg/L). Moreover, Tawang Bay hasa higher salinity (35 ppt), a pH of 8, a NO_3 concentration of 0.01 mg/L, a depth of 20 m, and a sandy substrate.

Abundance and identification of plankton

Firstly, plankton identity and abundance were analyzed using a protocol of LeGresley and McDermott (2010). In brief, plankton samples were placed on a Sedgewick Rafter Counting (SRC) Cell and observed under a binocular microscope with a magnification of 1,000x. Afterward, plankton found in each sample was counted, photographed, and identified according to an identification book guide by Mazzocchi et al. (2012). Then, the abundance index was calculated according to the following formula (Fachrul 2012):

$$N = \frac{a}{b} \times \frac{c}{d} \times \frac{Vb}{Vsrc} \times \frac{1}{Vs}$$

Where: "N" represents the abundance of plankton (plankter/L), "a" represents the number of SRC boxes, "b" is the area of one field of view (mm^2), "c" denotes the number of individuals observed, and "d" indicates the number of boxes observed. "Vb" is the volume of water in the sample bottle (ml), "Vsrc" is the volume of water in the SRC (ml), and "Vs" represents the volume of water filtered in the Field (L).

Diversity, uniformity, and dominant indices

The diversity index value (*H'*) was calculated using the following formula (Fachrul 2012):

$$H' = -\sum Pi ln Pi, where\ Pi = \frac{ni}{N}$$

Where: *H'* is Shannon Wiener Diversity Index, pi is the number of individuals of the i-th species, ni is the number of species, and N is the total individual number. The uniformity index (*E'*) was calculated using the "Evennes Index" formula (Ulfah et al. 2019):

$$E' = \frac{H'}{Lns}$$

Where: E' is the uniformity index, *H'* is the Shannon-Wiener diversity index, *S* is the total number of species The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

$$d = \frac{Nmax}{N}$$

Where: "d": Simpson Dominance Index, Nmax: Themost abundant number of individual species, dan N = Total individual number.

RESULTS AND DISCUSSION

Plankton abundance in Prigi Bay

Water samples were collected from Prigi Bay and Tawang Bay at four depths (0.3 m, 2.5 m, 5 m, and 20 m). The two bays were located in the Southern part of East Java Province, and both areas face the Indian Ocean, Figure 1. The results showed that 17 plankton species were identified from the surface water (0.0-0.3 m). The top six most abundant species were *Paracyclopina* sp. with 21.21%, followed by *Acartia* sp. (18.18%), *Pteropods* sp. (9.09%,) *Prorocentrum* sp. (6.06%), *Dinophysis* sp. (6.06%), and *Saggita* sp. (2.13%). Other species and their percentage are presented in Table 1. In addition, at a 2.5 m depth, 13 plankton species were identified. Again, the top 6 most abundant species were *Acartia* sp. (26.47%), followed by *Paracyclopina* sp. (23.53%), *Ceratium* sp. (8.82%), *Microstella* sp. (8.82%), *Dinophysis* sp. (5.8%), and*Oncaea* sp. (5.88%). The rest species with their abundance were presented in Table 1.

Furthermore, at 5 m depth, the bay is home to 11 plankton species. The top 4 most abundant species were *Acartia* sp. (30.77%), followed by *Paracyclopina* sp. (23.08%), *Sagitta* sp. (11.54%), and *Oithona* sp. (7.69%). While the other 7 species included *Synedra* sp., *Oikopleura* sp., *Coscinodiscus* sp., *Ceratirum* sp., *Pteropods* sp., *Microstella* sp., and unclassified Lucifer, which were counted for 3.85% each (Table 1). Meanwhile, 13 plankton species were found at a depth of 20 m. Again, the top 6 most abundant species were *Acartia* sp. accounted for 24.14%), followed by *Paracyclopina* sp. with 13.79%, *Pteropods* sp. (10.34%), *Dinophysis* sp. (10.34%), *Ceratium* sp. with 6.90%, and *Sagitta* sp. with 6.90%. The rest species are presented in table 1.

Plankton abundance in Tawang Bay

A total of 17 plankton species were identified from the water sample at a depth of 0.0-0.3m (surface water) of Tawang Bay. The top 9 most abundant species were *Acartia* sp., with an abundance of 12.82%, followed by *Ceratium* sp. (10.26%), *Prorocentrum* sp. (10.26%), *Microstella* sp. (10.26%), *Oncaea* sp. (10.26%) *Pteropods* sp. (7.69%), *Calanus* sp., (7.69%), *Synedra* sp. (5.13%), and *Oithona* sp. (5.13%). At the same time, the rest of the species were counted for 2.56% each and presented in Table 2. In addition, 11 species of plankton were found in a water sample at a depth of 2.5 m in Tawang Bay.

The top 6 most abundant species were *Calanus* sp. (28.00%), followed by *Prorocentrum* sp. (12.00%), *Paracyclopina* sp. (12.00%), *Microstella* sp. (12.00%), *Oncaea* sp. (8.00%), and *Oithona* sp. with an abundance of 8.00%. While the rest plankton species, including *Synedra* sp., *Ceratium* sp., *Pteropods* sp., *Macropthalmus* sp., and *Sagita* sp., were counted at 4.00% each, Table 2.

Table 1. Plankton species identified from Prigi Bay at four depths of water column

Depth	Species	Density (ind./L)
0.3 m (surface)	*Cyclotella* sp.	8
	Penilia sp	8
	Noctiluca sp.	8
	Prorocentrum sp.	16
	Dinophysis sp.	16
	Ceratium sp.	8
	Ceratium sp.	8
	Pteropods sp.	24
	Paracyclopina sp.	56
	Acartia sp.	48
	Microstella sp.	8
	Euphausia sp.	8
	Lucifer sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	16
	Nermatea sp.	8
	Actinulla larvae	8
2.5 m	*Rizosolenia* sp.	8
	Penilia sp.	8
	Ceratium sp.	24
	Dinophysis sp.	16
	Paracyclopina sp.	64
	Acartia sp.	72
	Microstella sp.	24
	Oncaea sp.	16
	Codonelopsis sp.	8
	Oipheureidea sp.	8
	Sagitta sp.	8
	Actinula sp.	8
	Polycnaete	8
5.0 m	*Oikopleura* sp.	8
	Synedra sp.	8
	Coscinodiscus sp.	8
	Ceratium sp.	*8*
	Pteropods sp.	8
	Paracyclopina sp.	48
	Acartia sp.	64
	Microstella sp.	8
	Oithona sp.	16
	Lucifer sp.	8
	Sagita sp.	24
20.0 m (Bottom)	Synedra sp.	8
	Penilia sp.	8
	Noctiluca sp.	8
	Dinophysis sp.	24
	Ceratium sp.	16
	Pteropods sp.	24
	Acartia sp.	56
	Paracyclopina sp.	32
	Oithona sp.	8
	Microstella sp.	16
	Euphausia sp.	8
	Protoperidinium sp.	8
	Sagitta sp.	16

Table 2. Plankton species identified from Tawang Bay at four depths of water column

Depth	Species	Density (ind./L)
0.3 m (surface)	*Synedra* sp.	16
	Oscillatoria sp.	8
	Spirulina sp.	8
	Ceratium sp.	32
	Prorocentrum sp.	32
	Pteropods sp.	24
	Acartia sp.	40
	Microstella sp.	32
	Calanus sp.	24
	Oithona sp	16
	Oncaea sp.	32
	Euphausia sp.	8
	Macrophthalamus sp.	8
	Clytemnestra sp.	8
	Cypris sp.	8
	Unclassified Fish larvae	8
	Unclassified flatworms	8
2.5 m	*Synedra* sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Pteropods sp.	8
	Paracyclopina sp	24
	Calanus sp.	56
	Oithona sp.	16
	Microstella sp.	24
	Oncaea sp.	16
	Macrophthalamus sp.	8
	Sagitta sp.	8
5 m	*Melosira* sp.	8
	Synedra sp.	8
	Bivalve larvae	8
	Prorocentrum sp.	16
	Dinophysis sp.	8
	Microstella sp.	8
	Calanus sp.	48
	Oithona sp.	24
	Naupli Copepoda	16
	Temora sp.	8
	Oncaea sp.	8
	Sagitta sp.	8
20 m (bottom)	*Rhizoselenia* sp.	8
	Pleurosigma sp.	8
	Prorocentrum sp.	24
	Ceratium sp.	8
	Dinophysis sp.	8
	Microsetella sp.	4
	Calanus sp.	6
	Acartia sp.	24
	Oithona sp.	24
	Oncaea sp.	16
	Caridean sp.	8
	Unclassified flatworm	8

Furthermore, 12 plankton species were identified from the water sample at 5 m depth. The top 4 most common species were *Calanus* sp. with an abundance of 28.57%, *Oithona* sp. with an abundance of 14.29%, *Copepoda nauplii* with an abundance of 9.52%, *Prorocentrum* sp.with an abundance of 9.52%. While the rest of the species, including *Melosira* sp., *Synedra* sp., *Dinophysis* sp., *Microstella* sp., *Temora* sp., *Oncaea* sp., and *Sagita* sp., with an abundance of 5.00%, respectively. While in the bottom waters of Tawang Bay (20 m depth), 12 plankton species were identified. The top 9 most abundant species were *Prorocentrum* sp. with an abundance of 16.44%, *Acartia* sp. with an abundance of 16.44%, *Oithona* sp. with an abundance of 16.44%, *Oncaea* sp. with an abundance of 10.96%, *Dinophysis* sp. with an abundance of 5.48%, *Rhizoselenia* sp. with an abundance of 5.48%, *Pleurosigma* sp. with an abundance of the abundance of 5.48%, *Ceratium* sp. with 5.48%, *Caridean* sp. (5.48%). At the same time, the rest species are presented in table 2.

Diversity indices

The diversity index values obtained in the waters of Prigi Bay, Trenggalek District, were 2.49 ± 0.07 at a depth of 0.0-0.3 m depth of water column, 2.18 ± 0.16 at a depth of 2.5 m, 2.02 ± 0.08 at a depth of 5 m, and 2.34 ± 0.10 at the 20 m water column. Those indicate that the Prigi Bay waters have moderate diversity. While the diversity index values obtained in the waters of Tawang Bay, Pacitan District were 2.65 ± 0.03 at 0.0 - 0.3 m depth, 2.17 ± 0.15 at the 2.5 m depth, 2.15 ± 0.22 at a 5 m depth, and 2.32 ± 0.19 at a depth of 20 m which indicates that the waters of Tawang Bay also have moderate diversity, Figure 2.

Uniformity indices

The uniformity index values obtained in the water column of Prigi Bay were 0.45 ± 0.01 at 0.0-0.3 m depth (surface water column), 0.39 ± 0.06 at a depth of 2.5 m, 0.38 ± 0.01at a depth of 5 m and 0.43 ± 0.04 at the 25m depth or bottom of the water column. These index values indicated that the uniformity of plankton in Prigi Bay was moderate. At the same time, the uniformity values obtainedin Tawang Bay were 0.46 ± 0.01 at 0.0-0.3 m depth, 0.41 ± 0.05 at a depth of 2.5 m, 0.42 ± 0.07 at a depth of 5 m, and 0.46 ± 0.05 at 25 m depth or bottom of the water column. Similarly, uniformity indices of plankton in Tawang Bay were also considered at a moderate level, Figure 3.

Domination index

Dominance index values obtained from the waters of Prigi Bay were 0.21 ± 0.03 at the 0.0-0.3 m depth, 0.26 ± 0.05 at a depth of 2.5 m, 0.31± 0.02 at a depth of 5 m and 0.24 ± 0.05 at the 20 m water depth. These values mean no plankton species were dominant in the natural habitat of spiny lobster larvae (Prigi Bay). While the dominance index values obtained from Tawang Bay waters were 0.13 ± 0.03 at the 0.0-0.3 m depth, 0.28 ± 0.05 at a depth of 2.5 m, 0.30 ± 0.03 at a depth of 5 m, and 0.16 ± 0.05 at the 20 m depth. Similarly, the values obtained from the surface to the bottom of the waters show that no species dominate in Tawang Bay (Figure 4).

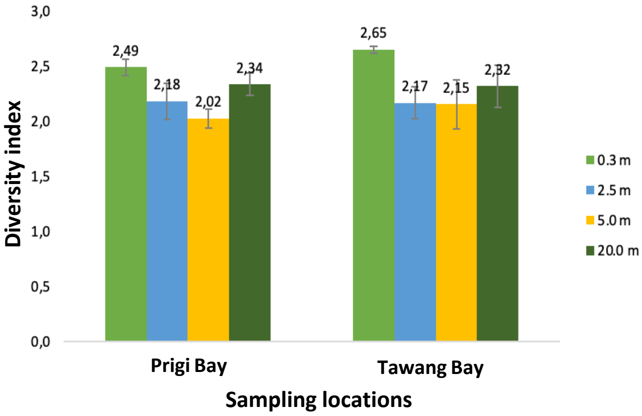

Figure 2. Diversity indices of plankton identified at the water column of Prigi Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates

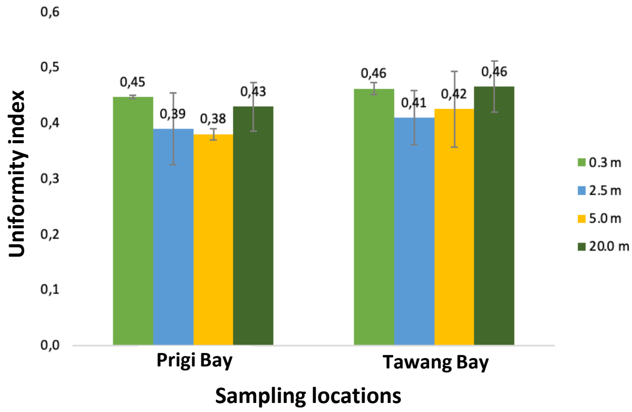

Figure 3. Uniformity indices of plankton identified in Prigi Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates

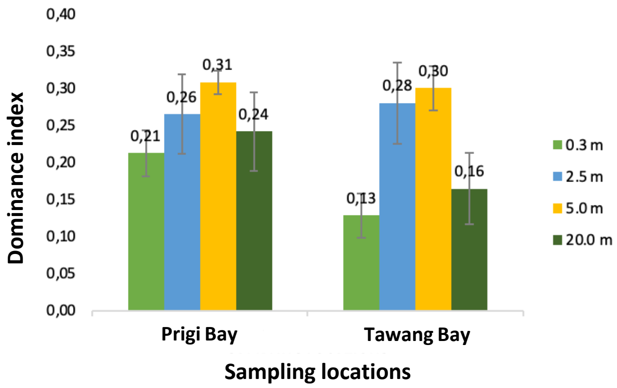

Figure 4. Domination indices of plankton identified at Prigi Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates

Discussion

Environmental conditions, including physical, chemical, and biological factors in natural habitats, highly determine the recruitment rates of lobster larvae (Keulder 2005). Several studies have previously reported the physical and chemical characteristics of the settlement area of lobster (Amin et al. 2022b; Boudreau et al. 1992; Lillis and Snelgrove 2010). However, studies viewing biological aspects of settlement habitat in natural environment lobster larvae are still very limited. Meanwhile, many studies conclude that biological factors such as plankton availability would be important information on the natural diets of lobster larvae (O'Rorke et al. 2014). Thus, the present study investigated the diversity, uniformity, and dominance of plankton in two common settlement areas of lobster larvae in East Java (Karangongso of Prigi Bay and Tawang Bay) in Indonesia. The sampling was performed in 4 different depths, which were 0.3 m, 2.5 m, 5 m, and 20 m depth, as lobster larvae vertically migrated from the bottom during the daytime to the surface of the water during the nighttime. It was also discovered that the diversity indices of plankton at both locations were 2.02-2.49 at Karanggongso of Prigi Bay, and 2.15-2.65 at Tawang Bay. The diversity index values found at these two locations were all less than 3, which means at a moderate level**.** The high or low value of plankton diversity can be caused by the evenly distributed abundance of each individual. In another sense, no species have relatively more diversity than other species (Awwaluddin et al. 2017). Therefore, thediversity indices of plankton at Prigi Bay and Tawang Bay, which are at a moderate level may suggest that plankton communities are in relatively equal distribution of different species, with no species being significantly more prevalent than others (Awwaluddin et al. 2017).

Similarly, the uniformity indices of plankton in both settlement areas were classified at a moderate level (0.38-0.45 at Prigi Bay and 0.41-0.46 at Tawang Bay). The uniformity values found at each location, Karanggongso of Prigi Bay water and Tawang Bay water, are categorized as moderate uniformity. The uniformity value is categorized as moderate if the value ranges from 0.4-0.6 (Ulfah et al. 2019). The availability of nutrients, food, and predation processes can affect the high value of uniformity because it affects the type and amount of plankton. Besides that, physical and chemical factors also affect the value of uniformity because it will affect the growth of plankton (Nugroho et al. 2020)**.** In addition, since the distribution of plankton in both water samples is uniform, a high degree of uniformity can be asserted**.** While the dominance indices ranged from 0.21-0.31 at Prigi Bay and 0.13-0.30 in Tawang Bay. The result indicates no dominant species at both locations since all values < 0.05. Dominance index values obtained in both waters indicate the absence of plankton which dominates in Prigi Bay and Tawang Bay. The dominance index value indicates whether organisms are dominant in a water environment. A value between 0.5 to 1 on the dominance index shows the presence of dominant organisms in the water. On the other hand, a value less than 0.5 indicates no dominant organisms are present in the water (Berger and Parker 1970).

Potential diet for lobster seeds

The result also revealed that 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 at a depth of 5 m, and 13 at 20 m (bottom) of Prigi Bay. At the same time, 17 plankton species were discovered on the surface of Tawang Bay waters: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m,and 12 species at the seafloor. In general, the number of plankton species identified in the present study is higher than in previous studies reported from other lobster larvae settlement habitats in Awang Bay, West Nusa Tenggara (Amin et al. 2022b) and Wedi Ombo Bay, Yogyakarta(Trijoko and Pasaribu 2004). The most abundant species identified from Prigi Bay are mainly from Phylum Arthropoda, including *Paracyclopina* sp, *Oithona* sp,*Acartia* sp, and *Calanus* sp. Other prominent species included *Prorocentrum* sp., *Dinophysis* sp., and *Ceratium* sp., which belonged to the phylum Dinoflagellata. While phylum Arthropoda, including *Acartia sp., Oithona sp., Oncaea sp., Calanus sp., Paracyclopina,* and *Macropthalmus* sp., also dominated the most abundant species found in Tawang Bay. Plankton species in this area are also dominated by phylum Dinoflagellata such as *Ceratium* sp., *Prorocentrum* sp., and *Dinophysis* sp. Ofthese identified plankton species, 11 species were found in both locations, including *Acartia* sp., *Ceratium* sp., *Dynophysis* sp., *Euphausia* sp., *Microstella* sp., *Oithona* sp., *Paracyclopina* sp., *Pteropod*s sp., *Rizosolenia* sp., *Sagita* sp., *Synedra* sp. These findings suggest that the planktonic community in both bays is dominated by speciesbelonging to the phylum Arthropoda and Dinoflagellata, which are known to be important components of the marinefood web.

Among the identified plankton species, few species have been documented as potential live diets in aquaculture, including *Oithona* sp., for a live diet of European seabass (*Dicentrarchus labrax*) postlarvae (Magouz et al. 2021a) and shrimp larvae (Dinesh Kumar et al. 2017). Therefore, *Acartia* sp. could possess a live diet for seabass larvae, *Lates calcarifer* (Rajkumar 2006), fat snook, *Centropomus parallelus* (Barroso et al. 2013), and many other aquatic larvae (Sarkisian et al. 2019). Some studies also confirmed that these plankton species were identified in the content stomach of lobster larvae. For instance, *Oithona* sp. has been reported from the stomach content of spiny lobsters at the early life stage (Amin et al. 2022c; Khvorov et al. 2012). Furthermore, *Oithona* sp. has been described as a marine calanoid copepod with high protein content, ~59.33% (Santanumurti et al. 2021), therefore frequently used as a live diet for fish or shrimp larvae. Another study has documented that *Oithona* sp. had a high content of fatty acid profiles including polyunsaturated fatty acids (26.47%) and omega-3 fatty acids (36.30), which are higher than a commercial live diet such as *Artemia* sp. (Magouz et al. 2021b). Furthermore, *Acartia* sp. has also been documented to be a good live dietfor aquatic larvae such as seabass larvae, *Lates calcarifer* (Rajkumar 2006), and fat snook, *Centropomus parallelus* (Barroso et al. 2013). *Acartia clausi* has been described to have higher contents of proteins (63.12%) and lipids

(16.65%) and is also richer in n - 3 fatty acids (33.94%) than *Artemia nauplii* and rotifers (Rajkumar 2006). The plankton species have also been identified in spiny lobster larvae's stomach content (Amin et al. 2022b; Amin et al. 2022c). In addition, a member of Acartia (*Acartia tonsa*) had been documented to provide an important nutritional benefit to fat snook larvae undergoing metamorphosis (Vanacor-Barroso et al. 2017).

Other potential food sources for lobster larvae identified in the present study are zooplankton and phytoplankton. The plankton results found at each station consist of Bachillariophiceae (*e.g., Rizosolenia* sp., *Synedra* sp., *Cyclotella* sp.) and Copepoda (e.g., *Oithona* sp., *Acartia*sp., *Calanus* sp.). These plankton groups were identified at each station, highlighting their potential as a food source for lobster larvae. Diatoms, which belong to the phytoplankton group Bachillariophiceae, contain essential nutrients required for the growth of lobster larvae, such as PUFA (Polyunsaturated Fatty Acid). The PUFA is the major fatty acid in Bachillariopiceae diatoms (Pahl et al. 2010), including EPA (eicosapentaenoic acid, 20:5 n-3)and DHA (docosahexaenoic acid 22:6 n-3). Therefore, PUFA is the major fatty acid in Bachillariopiceae diatoms (Pahl et al. 2010). PUFA content of these diatoms is relatively high, with levels ranging between 23.4 and 60.7% (Valera and Saavedra, 2016). High PUFA content was identified in several plankton species as potential prey for spiny lobster larvae *Jasus edwardsii*, and these long- chain fatty acids are an essential nutrient for spiny lobster (Koshio and Kanazawa 1994; Liddy et al. 2004; Wang 2013).

Copepoda (Hexanauplia) is a rich source of protein, particularly in gastropods; it is also high in calcium content which is important for lobster during molting (Kirno et al. 2012). Several studies, such as those by Alka (2016), Chow (2011), and Connel (2007), have reported the presence of copepods in the digestive tracts of lobster larvae. That suggests copepods are a preferred food for lobster larvae. Protein is the predominant organic nutrient in the spiny lobster larvae and their preferred prey (Wang 2013). This is consistent with prior examinations of digestive enzymes of phyllosoma of *J.edwardsii* and *Panulirus ornatus*, which reveal that they necessitate a high-protein diet and will utilize protein to generate energy during food deprivation (Johnston et al. 2004a, 2004b, 2006). Copepods contain high protein content, ranging from 28.9-84.9 % of dry weight, indicating that lobster larvae consume prey with high protein content (Wang and Jeffs 2014). The protein content of the copepods follows the amount of protein incorporated into artificial feeds for some of the crustacean's larvae, including crab, shrimp, and clawed lobster species, which ranges between 30% to 60% protein (Conklin et al. 1980; Guillaume 1997; Holme et al. 2009). Moreover, copepods are also high in lipids, ranging from 11.3-12.4% (Wang and Jeffs 2014). Rich-lipid diets can be properly digested by the spiny lobster larvae and utilized to supply energy, especially during a food scarcity (Johnston et al. 2004; Liddy et al. 2003; Liddy et al. 2004; Ritar et al. 2003). Furthermore, late-phase phyllosoma of spiny lobster probably targets high lipid prey as they prepare to accumulate an enormous amount of lipid to fuel their non-feeding post-larval stage (Jeffs et al. 2001a, 2001b). The presence of copepods, especially *Oithona* sp., *Acartia* sp., and *Calanus* sp., in a high abundance value at the Karanggongso of Prigi Bay and Tawang Bay could provide a significant source of high lipid natural diets for spiny lobster larvae. These results suggest that these plankton species are a potential diet for spiny lobster larvae. Therefore, in vivo trials using aquatic animals especially for developing ornate lobster hatcheries, should be further studied.

In conclusion, the number of plankton species found in both locations was more abundant in the surface water (0-0.3 m) compared to the deeper water column. A total of 17 plankton species were identified from the surface water, 13 species at a depth of 2.5 m, 11 species at a depth of 5 m, and 13 species at 20 m (bottom) of Prigi Bay. Similarly, 17 plankton species were discovered from the water surface of Tawang Bay: 11 species at a depth of 2.5 m, 12 species at a depth of 5 m, and 12 species at the seafloor. Based on the diversity, uniformity, and dominance indices, both locations had moderate plankton diversity, and no specific species was dominant over the others. Among the identified plankton species, several members of Bachillariophiceae, Copepoda, and Hexanauplia, such as *Oithona* sp., *Calanus* sp., *Paracyclopina* sp., and *Acartia* sp., are considered potential live feed for lobster larvae, and thus should be further studied.

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REFERENCES

Amin M, Fitria A, Muslichah NA, Musdalifah L. 2022a. The ecological habitat of spiny lobster (*Panulirus* spp.): Case study on lobster fishing ground in Trenggalek, East Java, Indonesia. IOP Conf Ser: Earth Environ Sci 1036 (1): 012067. DOI: 10.1088/1755-1315/1036/1/012067.

Amin M, Harlyan LI, Khamad K, Diantari R. 2022b. Profiling the natural settlement habitat of spiny lobster, *Panulirus* spp. to determine potential diets and rearing conditions in a lobster hatchery. Biodiversitas 23 (6): 2893-2898. DOI: 10.13057/biodiv/d230615.

Amin M, Taha H, Samara SH, Fitria A, Muslichah NA, Musdalifah L, Odeyemi OA, Alimuddin A, Arai T. 2022c. Revealing diets of wild-caught ornate spiny lobster, *Panulirus ornatus*, at puerulus, post-puerulus and juvenile stages using environmental DNA (eDNA) metabarcoding. Aquacult Rep 27: 101361. DOI: 10.1016/j.aqrep.2022.101361.

Amin M, Erwinda M, Nissa M, Nindarwi DD, Satyantini W, Alamsjah MA. 2022. Fatty acids profiles and growth performances of *Artemia franciscana* fed with different types of microalgae. Sains Malaysiana 51 (8): 2449-2459. DOI: 10.17576/jsm-2022-5108-09.

Awwaluddin A, Suwarso S, Setiawan R. 2017. Distribusi kelimpahan dan struktur komunitas plankton pada musim timur di Perairan Teluk Tomini. Jurnal Penelitian Perikanan Indonesia 11 (6): 33-56. DOI:

10.15578/jppi.11.6.2005.33-56. [Indonesian]

Barroso M, De Carvalho C, Antoniassi R, Cerqueira V. 2013. Use of the copepod *Acartia tonsa* as the first live food for larvae of the fat snook *Centropomus parallelus*. Aquaculture 388: 153-158. DOI: 10.1016/j.aquaculture.2013.01.022.

Berger WH, Parker FL. 1970. Diversity of planktonic foraminifera in deep-sea sediments. Science 168 (3937): 1345-1347. DOI: 10.1126/science.168.3937.1345.

Boudreau B, Simard Y, Bourget E. 1992. Influence of a thermocline on vertical distribution and settlement of post-larvae of the American lobster *Homarus americanus* Milne-Edwards. J Exp Mar Biol Ecol 162 (1): 35-49. DOI: 10.1016/0022-0981(92)90123-R.

Dinesh Kumar S, Santhanam P, Ananth S, Kaviyarasan M, Nithya P, Dhanalakshmi B, Park MS, Kim M-K. 2017. Evaluation of suitability of wastewater-grown microalgae (*Picochlorum maculatum*) and copepod (*Oithona rigida*) as live feed for white leg shrimp *Litopenaeus vannamei* post-larvae. Aquacult Intl 25: 393-411. DOI: 10.1007/s10499-016-0037-6.

Ihsan M, Jayadi EM, Sagista R, Hardianti YE, Ilahi WB, Muliasari H, Kalih LATWS. 2019. Analisis makanan alami dalam lambung dan mikrohabitat lobster pasir (*Panulirus homarus*) fase puerulus di teluk awang. J Riset Akuakultur 14 (3): 183-191. DOI: 10.15578/jra.14.3.2019.183-191. [Indonesian]

Kashinskaya E, Simonov E, Kabilov M, Izvekova G, Andree K, Solovyev M. 2018. Diet and other environmental factors shape the bacterial communities of fish gut in an Eutrophic Lake. J Appl Microbiol 125 (6): 1626-1641. DOI: 10.1111/jam.14064.

Keulder FJ. 2005. Puerulus and early juvenile recruitment of the rock lobster *Jasus lalandii* in relation to the environment at Lüderitz Bay. Namibia Rhodes University.

Khvorov S, Piontkovski S, Popova E. 2012. Spatial-temporal distribution of the palinurid and scyllarid phyllosoma larvae in Oman Coastal waters. J Agric Mar Sci 17: 53-60. DOI: 10.24200/jams.vol17iss0pp53-60.

LeGresley M, McDermott G. 2010. Counting chamber methods for quantitative phytoplankton analysis-haemocytometer, Palmer-Maloney cell and Sedgewick-Rafter cell. UNESCO (IOC manuals and guides): 25-30.

Lillis A, Snelgrove PV. 2010. Near-bottom hydrodynamic effects on postlarval settlement in the American lobster *Homarus americanus*. Mar Ecol Prog Ser 401: 161-172. DOI: 10.3354/meps08427.

Magouz FI, Essa M, El-Shafei A, Mansour A, Mahmoud S, Ashour M. 2021a. Effect of extended feeding with live copepods, *Oithona nana*, and *Artemia franciscana* on the growth performance, intestine histology, and economic viability of european seabass (*Dicentrarchus labrax)* postlarvae. Fresenius Environ Bull 30: 7106-7116. DOI: 10.3390/ani11051188.

Magouz FI, Essa MA, Matter M, Tageldein Mansour A, Alkafafy M, Ashour M. 2021b. Population dynamics, fecundity and fatty acid composition of *Oithona nana* (Cyclopoida, Copepoda), fed on different diets. Animals 11 (5): 1188.

Mazzocchi M, Zagami G, Guglielmo L, Crescenti N, Hure J. 2012. Atlas of Marine Zooplankton Straits of Magellan: Copepods. Springer Science & Business Media.

Nugroho LA, Piranti AS, Sastranegara MH. 2020. Plankton community and water quality during maximum tidal range in Segara Anakan Cilacap. IOP Conf Ser: Earth Environ Sci 593: 012020. DOI: 10.1088/1755-1315/593/1/012020.

O'Rorke R, Lavery S, Wang M, Nodder S, Jeffs A. 2014. Determining the diet of larvae of the red rock lobster (*Jasus edwardsii*) using high-throughput DNA sequencing techniques. Mar Biol 161 (3): 551-563. DOI: 10.1007/s00227-013-2357-7.

Rajkumar M. 2006. Suitability of the copepod, *Acartia clausi* as a live feed for Seabass larvae (*Lates calcarifer* Bloch): Compared to traditional live-food organisms with special emphasis on the nutritional value. Aquaculture 261 (2): 649-658. DOI: 10.1016/j.aquaculture.2006.08.043.

Raza'i TS, Putra IP, Suhud MA, Firdaus M. 2018. Kelimpahan kopepoda (Copepods) sebagai stok pakan alami di Perairan Desa Pengudang, Bintan. Intek Akuakultur 2 (1): 63-70. DOI: 10.31629/intek.v2i1.628. [Indonesian]

Santanumurti M, Samara S, Wiratama A, Putri B, Hudaidah S. 2021. The effect of fishmeal on the density and growth of *Oithona* sp. (Claus, 1866). IOP Conf Ser: Earth Environ Sci 718 (1): 012042. DOI: 10.1088/1755-1315/718/1/012042.

Sarkisian BL, Lemus JT, Apeitos A, Blaylock RB, Saillant EA. 2019. An intensive, large-scale batch culture system to produce the calanoid copepod, *Acartia tonsa*. Aquaculture 501: 272-278. DOI: 10.1016/j.aquaculture.2018.11.042.

Trijoko T, Pasaribu DU. 2004. Inventarisasi Zooplankton untuk pakan alami larva udang karang (*Panulirus homarus* L.) di Teluk Wedi Ombo, Gunung Kidul, Yogyakarta. DOI: 10.22146/jfs.9040. [Indonesian]

Ulfah M, Fajri S, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conf Ser: Earth Environ Sci 348 (1): 012074. DOI: 10.1088/1755-1315/348/1/012074.

Vanacor-Barroso M, Carvalho CVAd, Antoniassi R, Ronzani-Cerqueira V. 2017. The copepod *Acartia tonsa* as live feed for fat snook (*Centropomus parallelus*) larvae from notochord flexion to advanced metamorphosis. Latin Am J Aquat Res 45 (1): 159-166. DOI: 10.3856/vol45-issue1-fulltext-15.