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

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Abstract. *Masithah FD, 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 Tawang and Karanggongso Bays, Natural Settlement Habitats of Spiny Lobster Larvae in East Java Indonesia. Biodiversitas 24: xxxx.* Tawang and Karanggongso 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 Karanggongso Bay. In addition, 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 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 Karanggongso 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: diversity, diets, 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 plankton as 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 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, 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.

Karanggongso 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 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

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, 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.

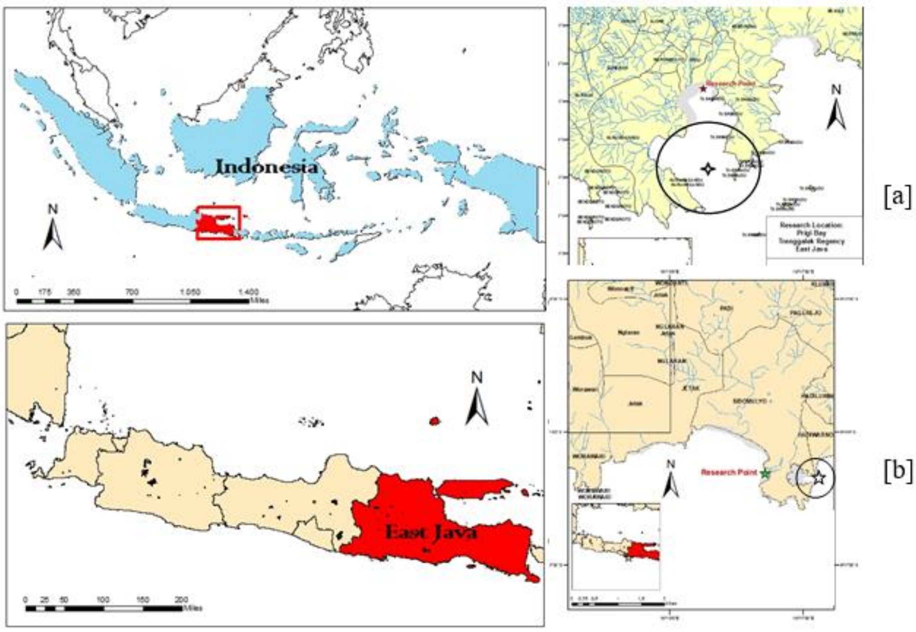

Figure 1. Two sampling locations: Karanggongso Bay, Trenggalek Regency [a], and Tawang Bay, Pacitan Regency [b], East Java, Indonesia

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Karanggongso 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 Karanggongso Bay, with water temperature ranging from 28.2-28.3 ºC, with a lower DO concentration (3.35 mg/L). Moreover, Tawang Bay has a 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):

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

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 index, *S* is the total number of species The dominance index (d) was calculated using the following equation (Berger and Parker 1970):

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

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 were collected from Karanggongso 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.

Table 1. Plankton species identified from Karanggongso Bay at four depths of 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

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

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

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, 12 plankton species were identified from the water sample at 5m 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 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 indicate 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 also have moderate diversity, Figure 2.

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 moderate. 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 also considered at a moderate level, Figure 3.

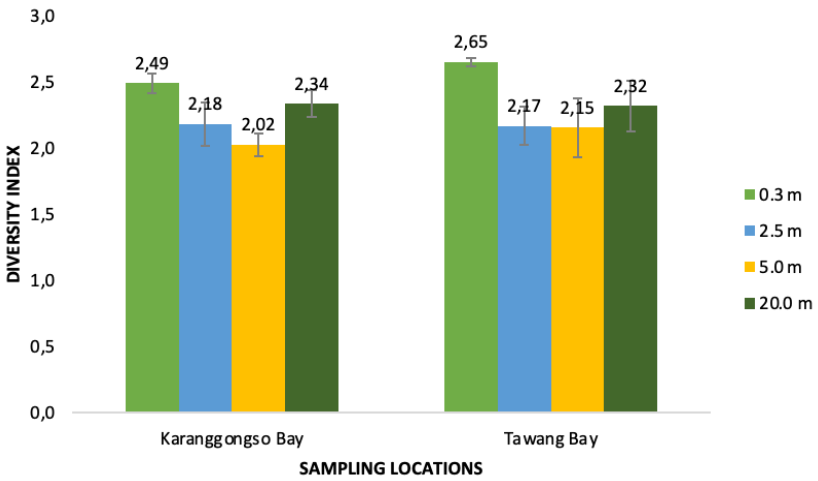

Figure 2. Diversity indices of plankton identified at the water column of Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates

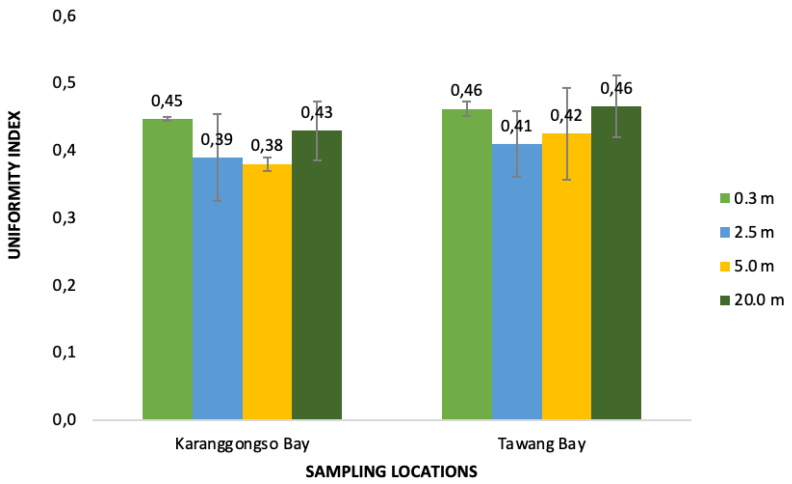

Figure 3. Uniformity indices of plankton identified in Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates

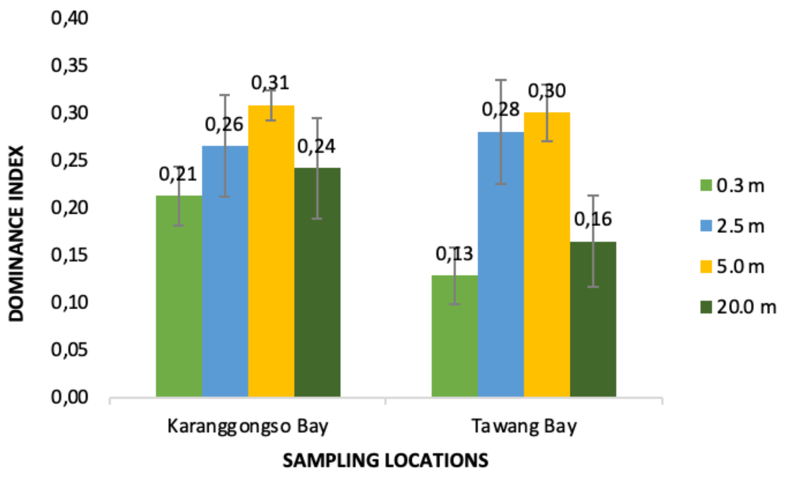

Figure 4. Domination indices of plankton identified at Karanggongso Bay and Tawang Bay, East Java, Indonesia. Bars are the average values with a standard deviation of three replicates

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 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, the values obtained from the surface to the bottom of the waters show that no species dominate in Tawang Bay (Figure 4).

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 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. In another sense, no species have relatively more diversity than other species (Awwaluddin et al. 2017). 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, Karanggongso Beach water and Tawang Beach 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 Karanggongso 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 Karanggongso 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 Karanggongso 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 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 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. Of these 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 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, *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 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 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 & 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. 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; 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 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 & 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; 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, 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 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 studied.

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