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Spatial and Temporal of Meroplankton in a Semi-enclosed Bay: Insights from Ambon Bay

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ABSTRACT

Meroplankton is a temporary planktonic phase of marine organisms. Despite their critical role in the ecosystem, the study of their distribution and dynamics in Ambon Bay is still limited. Therefore, this study aims to investigate the spatial distribution and dynamics of meroplankton in Ambon Bay. Study conducted during the southeast monsoon (August and September) to transition II (October and November) 2022. Meroplankton was captured using a plankton net towed vertically from approximately 20 m, near the bottom, to the surface, and immediately preserved in formaldehyde (final concentration of 4%). A stemple pipette was used for subsamples, and they were observed under a stereo microscope. Thirteen groups of meroplankton were recorded, with three groups (Bryozoa, Phoronida, and Brachiopoda larvae) being newly reported in this area. Bivalvia and Polychaeta larvae had the highest abundance. Meroplankton abundance was consistently higher in the inner Ambon Bay (240.62-3029.02 ind.m^{-3}) than in the outer Ambon Bay (85.63-955.41 ind.m^{-3}), highlighting the ecological significance of this area as a potential spawning and larval nursery ground. Most meroplankton taxa were recorded across all sampling seasons, except for Phoronida and Stomatopoda, which were only observed during the southeast monsoon. In comparison to previous studies, the abundance of Echinodermata peaked during the transition I to the southeast monsoon, whereas Polychaeta exhibited peak abundance during the northwest monsoon. This study offers significant insights into the diversity, spatial distribution, and dynamics of meroplankton in Ambon Bay.

1. Introduction

Meroplankton are organisms that spend only a part of their life cycle as planktonic (Weydmann-Zwolicka *et al.* 2021; Zhang *et al.* 2025). Initially, they live in the water column during their early developmental stages, such as the egg or larval stage. Their planktonic duration can vary from hours to months, depending on the taxonomic group and environmental conditions (Stübner *et al.* 2016), and they transform into benthic or other types of organisms when mature. During the peak season of spawning, they can be particularly numerous and may even outnumber holoplankton abundance (Mulyadi and Saputra 2019). Therefore, they play an important role in the marine ecosystem as both consumers and prey (Descôteaux *et al.* 2021), as well as in maintaining population viability.

The distribution and dynamics of meroplankton in marine ecosystems are influenced by complex interactions among biological traits, including spawning time and location, larval behavior, planktonic larval duration, and hydrodynamic processes (Pineda *et al.* 2007). These processes resulted in the occurrence and abundance of meroplankton on both temporal and spatial scales. The physical processes, such as currents, affect larval transport, causing spatial decoupling between the production of local communities and the settlement of juveniles (Michelsen *et al.* 2017; Ershova *et al.* 2019). Food availability influences their distribution, with high larval abundance often found in areas with high food abundance (Tiedemann and Brehmer 2017; Pattrick *et*

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al. 2021). Furthermore, they are the primary vector for dispersal of adult organisms and have a significant impact on population connectivity (Cowen and Sponaugle 2009; Meyer-Kaiser *et al.* 2022). Therefore, knowledge about the larval stage is crucial in understanding the population dynamics and may be used in developing optimal marine protected areas (Shanks *et al.* 2003; Michelsen *et al.* 2017).

Ambon Bay is a semi-enclosed bay located on Ambon Island, which is separated by a sill into two parts known as Inner Ambon Bay (IAB) and Outer Ambon Bay (OAB) (Salamena 2024). The IAB is typically closed and shallower topographically, with soft, muddy sediments, while the OAB has characteristics that are deeper and more typical of the open ocean. Furthermore, the IAB is highly influenced by runoff from the river, resulting in high productivity in this area (Basit *et al.* 2012). Massive red tides may also occur during the rainy season (Likumahua 2013). The area is home to complex ecosystems, including coral reefs, seagrasses, and mangroves (Suyadi *et al.* 2021). The IAB exhibits greater coverage of mangroves and seagrass, whereas the coral reef ecosystem is more developed in the OAB (Indrabudi and Alik 2017; Limon and Marasabessy 2019). This disparity results in varying biodiversity between IAB and OAB (PPLD-LIPI 2018), which may also influence the dispersal of larvae in this area (Ruli *et al.* 2022).

Despite meroplankton having a crucial role in marine ecosystems, information on their dynamics and distribution in Ambon Bay is still limited. Different taxonomic groups of meroplankton have been explored in this area, including fish eggs and larvae, Mollusca, Crustacea, Echinodermata, and Annelida (Mulyadi 2010; Ruli *et al.* 2022, 2023; Romdon *et al.* 2023). Generally, the studies were integrated and became part of the zooplankton community (Mulyadi and Saputra 2019), ichthyoplankton assemblages (Romdon *et al.* 2023), conducted only on one season (Ruli *et al.* 2022; Ruli *et al.* 2023), or only focused on one part of Ambon Bay, such as in the IAB (Mulyadi 2010). Previous studies have focused on a single season or sub-basin (IAB); however, no study has investigated the monthly variation of meroplankton communities in this region, nor the monthly differences between the IAB and OAB. The current study examines meroplankton assemblages over four consecutive months in both IAB and OAB, aiming to provide a more comprehensive understanding of the spatial and temporal variability of meroplankton in this area. Therefore, conducting monthly sampling from the southeast monsoon to the second transitional season makes it possible to identify previously unreported groups, to elucidate their monthly dynamics, and to verify whether meroplankton concentrations are consistently higher in the IAB, as suggested by earlier studies.

The study aimed to investigate the composition, abundance, dynamics, and spatial distribution of meroplankton in Ambon Bay. Particularly, we aimed to answer (1) how many groups or biodiversity of meroplankton in this area, (2) whether meroplankton abundance varies between the IAB and OAB, and (3) whether there are fluctuations of meroplankton in Ambon Bay during the SEM and TS II. Furthermore, we also compare our results with those of previous studies to estimate the peak spawning season of meroplankton in Ambon Bay.

2. Materials and Methods

2.1. Sample Collection

The study was conducted in Ambon Bay during SEM (August–September) to TS II (October–November) 2022. During the study, eight stations were selected along Ambon Bay, spanning a longitude range of 128.17061°E to 128.23758°E and a latitude range of 3.68474°S to 3.63774°S. Stations 1–4 were located in the Outer Ambon Bay (OAB), while Stations 5–8 were situated in the Inner Ambon Bay (IAB) (Figure 1).

Meroplankton were collected using a plankton net (mesh size 100 µm, diameter 30 cm) towed vertically from 20 m to the surface or from near the bottom to the surface when the depth of the location is less than 20 m. A total of 32 samples were collected. After collecting, samples were immediately preserved with 4% formaldehyde and placed in a cool box before analysis in the Laboratory. The hydrographic characteristics of the water column (salinity and temperature) were measured at each sampling location using a CTD (Valeport miniCTD DR).

2.2. Laboratory Processing

One week after sampling, laboratory analysis was conducted at the Plankton Lab of the National Research and Innovation Agency in Ambon. In the laboratory, the sample was positioned in a glass beaker (200 mL) and homogenized by vigorous random stirring, and then a subsample of 5 mL was taken using a stemple pipette. The subsample was observed under a stereo microscope (Nikon SMZ1270) at magnifications ranging from 4x to 40x. Meroplankton was identified morphologically to the

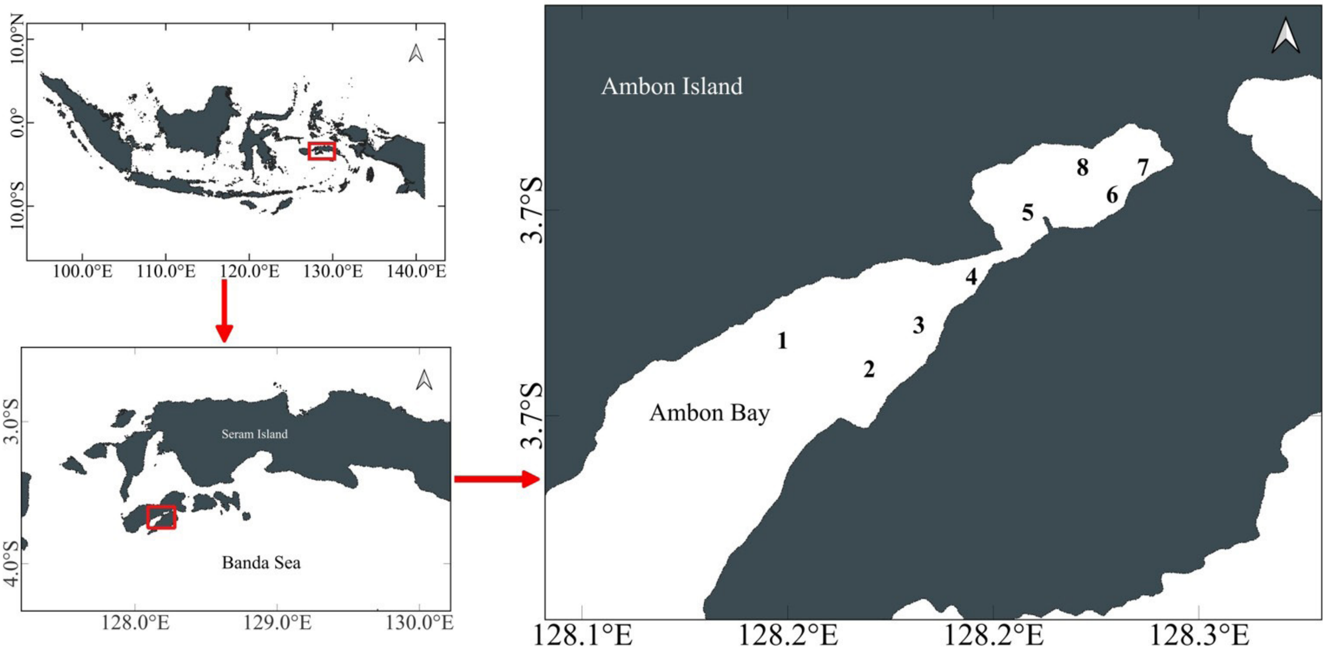

Figure 1. Sampling locations

lowest possible level of taxa using available references (Castellani and Edward 2017) due to the complexity of identifying them and being prone to error as well as lower accuracy rate when the identification until the genus and species-level (Leis 2015; Zhang *et al.* 2025), meroplankton were categorized into major groups (Class to phylum) and referred to previous studies in Ambon Bay (Mulyadi 2010; Ruli *et al.* 2022). Meroplankton abundances were expressed as the number of individuals per cubic meter (ind.m^{-3}).

2.3. Analysis Data

The Mann–Whitney U test was used to test whether temperature, salinity, as well as total and dominance group abundance of meroplankton are significantly different between IAB and OAB. Principal Component Analysis (PCA) was performed to describe the correlation structure among different environmental parameters, and Spearman's correlation was used to assess the relationship between environmental parameters and meroplankton abundance. The analyses were generated using R 4.3.3 (R Core Team 2024) using the vegan package v2.6-4 (Oksanen *et al.* 2022).

3. Results

3.1. Environmental Parameters and Their Correlation with Meroplankton Abundance

Figure 2 shows the spatial and seasonal variations in temperature and salinity in Ambon Bay. Both surface and average salinity were higher in OAB than in OAB during the study periods. In terms of temporal, these values exhibited fluctuations. Furthermore, the surface temperature was generally higher in OAB than in IAB during the research periods. Additionally, both surface and average temperatures were higher during TS II than during SEM, for both IAB and OAB.

The results of the PCA (Figure 3) visualize the structure of associations between environmental variables (salinity and temperature) and stations. Stations within the OAB region are characterized by high salinity and have a positive correlation with salinity. Meanwhile, stations in the IAB region exhibit low salinity and have a negative correlation with salinity. The difference of salinity between IAB and OAB is significant (p-value <0.01, Hedges' g: -1.14 (large) with 95% CI = -1.90, -0.38). Regarding temperature in both locations, its influence is both subtle and its correlation is notable.

Furthermore, the difference in temperature between the two locations is not significantly different (p-value >0.05, Hedges' g: -0.01 (negligible) with 95% CI = -0.71, 0.69). The PCA result was supported by the Spearman's correlation result (Table 1). Both environmental factors exhibit a negative correlation with meroplankton abundance, although the correlation with temperature is so weak that it can be considered negligible (Table 1). The negative correlation that IAB has with salinity causes IAB to have a higher abundance of meroplankton than OAB, since salinity

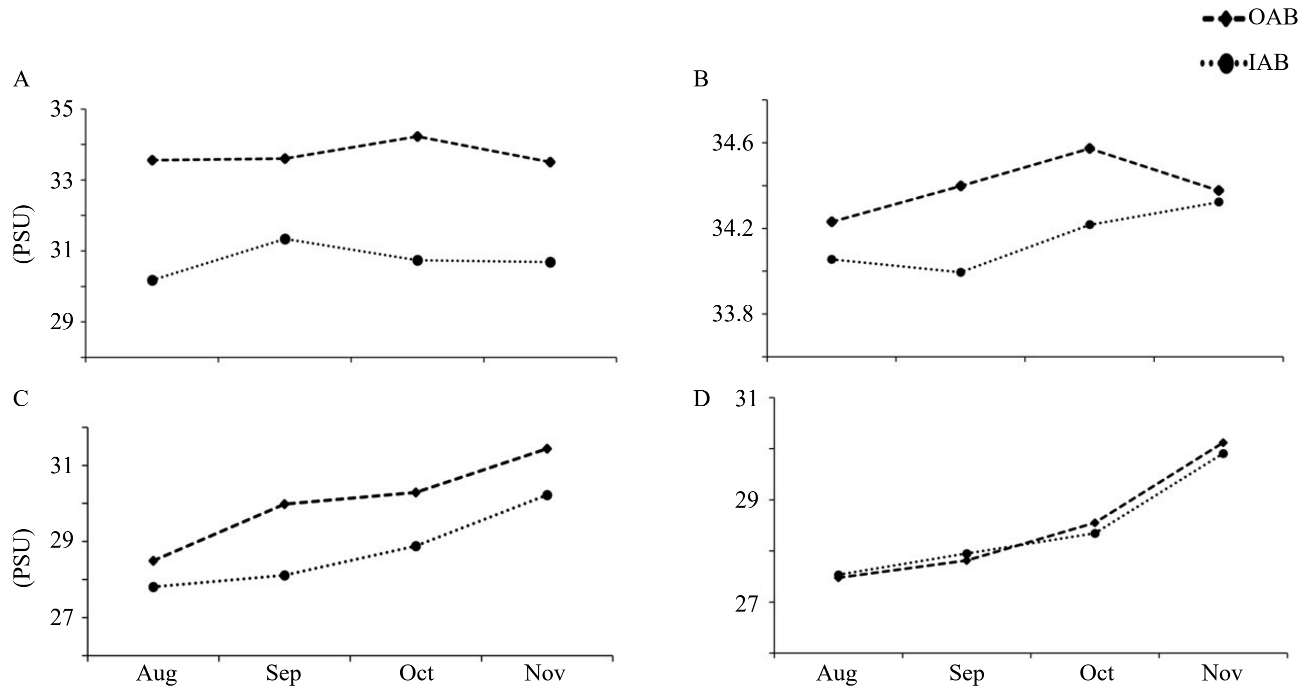

Figure 2. Salinity and Temperature (A) surface salinity, (B) average salinity, (C) surface temperature, (D) average temperature of stations

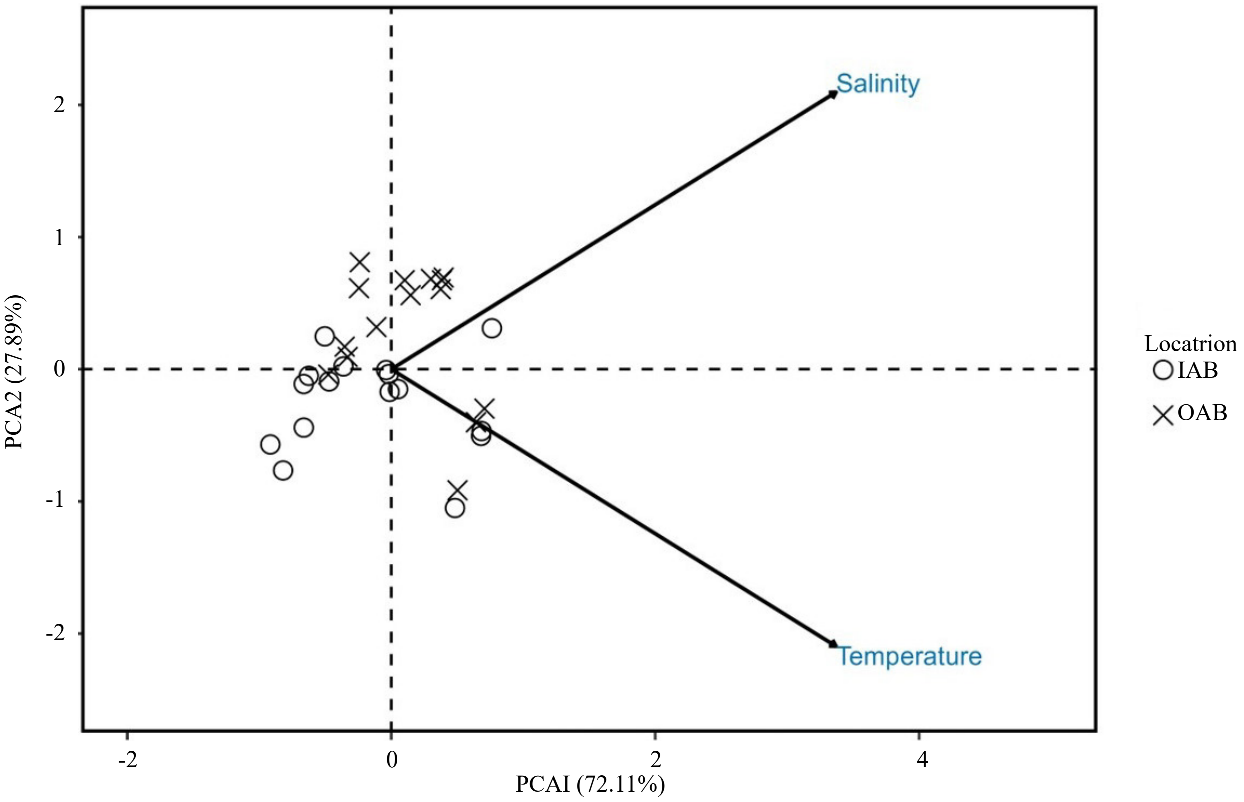

Figure 3. The result of the PCA analysis

Table 1. Correlation between meroplankton abundance and environmental parameters

	Temperature	Salinity	Total abundance
Temperature	1		
Salinity	0.5029	1	
Total abundance	-0.0132	-0.4106	1

and total abundance of meroplankton have a moderate negative correlation.

3.2. Meroplankton Community

The meroplankton collected throughout the study period consisted of 13 groups. They represented nine phyla, namely Annelida (Polychaeta), Mollusca (Gastropod and Bivalvia), Brachiopoda, Chordata (fish larvae and fish eggs), Crustacea (Cirripedia, Decapoda, and Stomatopod), Cnidaria, Echinodermata, Bryozoa, and Phoronida (Figure 4). Furthermore, the existence of Bryozoa, Phoronida, and Brachiopoda was newly reported in the bay.

3.3. The Meroplankton Distribution

During the campaign between SEM and TS II 2022, the total meroplankton abundance in Ambon Bay exhibited a spatial heterogeneity pattern between IAB and OAB (Figures 5 and 6). Meroplankton abundance was consistently higher in the IAB than in the OAB across all months and seasons. In the IAB, the abundance ranged from 240.62 to 3029.02 individuals/m^3/m^3, while in the OAB, it ranged between 85.63 and 955.41 individuals/m^3. Furthermore, based on statistical analysis (Mann–Whitney U), both areas were significantly different (p-value <0.01, Hedges' g: 2.21 (large) with 95% CI = -1.31, 3.10) (Figure 6A).

The Meroplankton dominance group also showed a significant difference in abundance between locations (Figure 6B-F). Bivalvia larvae abundance in IAB ranged from 134.47 to 2123.14 ind.m^{-3}, while in IAB it ranged from 35.39 to 396.32 ind.m^{-3} (Hedges' g: 2.08 (large) with 95% CI = 1.20, 2.95). Polychaeta abundance ranged from 21.23 to 1273 ind.m^{-3} in IAB and from 8.49 to 247.70 ind.m^{-3} in OAB (Hedges' g: 1.21 (large) with 95% CI = 0.44, 1.97). Gastropoda larvae abundance was 14.15 to 219.39 ind.m^{-3} in IAB and 11.32 to 191.08 ind.m^{-3} in OAB (Hedges' g: 0.90 (large) with 95% CI = 0.16, 1.64). Echinodermata maximum abundance was 339.70 ind.m^{-3} in IAB and 21.23 ind.m^{-3} in OAB (Hedges' g: 0.92 (large) with 95% CI = 0.18, 1.66). Cirripedia maximum abundance was 7.08 to 283.09 ind.m^{-3} in IAB and 191.08 ind.m^{-3} in OAB (Hedges' g: 0.92 (large) with 95% CI = 0.18, 1.66). Overall, the meroplankton groups had a wide distribution in Ambon Bay. However, only two groups, Phoronida and Stomatopoda, were found to have a limited distribution in IAB.

3.4. Meroplankton Dynamics

Meroplankton abundance in Ambon Bay exhibited a peak in August, followed by a sharp decline in September and a gradual increase through November (Figure 7A). The highest abundance was found in August (1292.42 ind.m^{-3}). The value decreased by half in September (634.29 ind.m^{-3}). In the subsequent month, the abundance showed a gradual increase, reaching 992.57 ind/m^3 in October and 1,251.42 ind/m^3 in November.

The fluctuations of meroplankton abundance in Ambon Bay were mainly triggered by Bivalvia and Polychaeta larvae, which were the most dominant meroplankton during the study (Figure 7B). Polychaeta larvae showed a fluctuating trend in abundance, where in August their average abundance was 504.25 ind.m^{-3}, then decreased significantly until October (71.21 ind.m^{-3}). Although it increased in November (309.80 ind.m^{-3}), its abundance was lower than in August. The Bivalvia larvae also showed a changing trend with peak abundance on TS II (November). In August, its average abundance was 418.88 ind.m^{-3}, then decreased in September (317.59 ind.m^{-3}). However, in the following months it increased (599.79 ind.m^{-3}) to almost twice as high in October and reached a peak in November at 715.23 ind.m^{-3}.

The other larval groups also have a trend in abundance during the research periods (Figure 8). The abundance of Echinodermata had the highest value in SEM (August) (average 116.33 ind.m^{-3}) and subsequently decreased sharply to reach the lowest value in September (3.54 ind.m^{-3}). In the following months, the abundance showed a slight increase between October (23.00 ind.m^{-3}) and November (20.44 ind.m^{-3}). Phoronida and Stomatopod larvae were only observed in SEM (August), with average abundances of 82.27 individuals per m^3 and 1.01 individuals per m^3, respectively. Bryozoa were abundant in September, with a density of 13.14 individuals per cubic meter.

Some meroplankton groups were abundant during the TS II, including fish eggs, Cnidaria, Gastropoda, fish larvae, Decapoda, and Brachiopoda larvae. Fish eggs abundance increased during the study period and reached a peak in November (average 37.24 ind.m^{-3}).

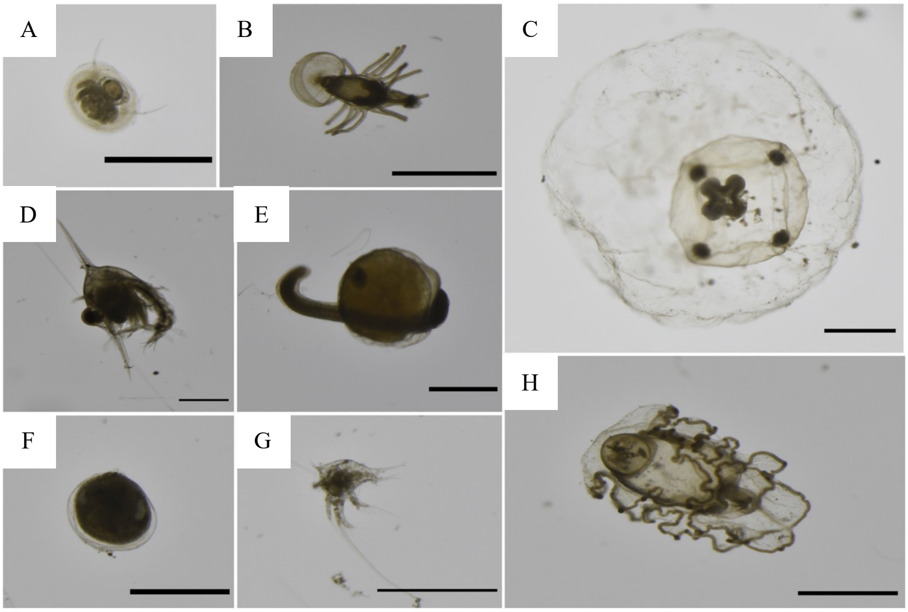

Figure 4. The meroplankton in Ambon Bay: (A) Brachiopoda, (B) Phoronida, (C) Cnidaria (*Bougainvillea* sp.), (D) Decapoda (Zoea), (E) Fish larvae, (F) Bivalvia, (G) Cirripedia, (H) Echinodermata (Scale bar: 0.5 mm)

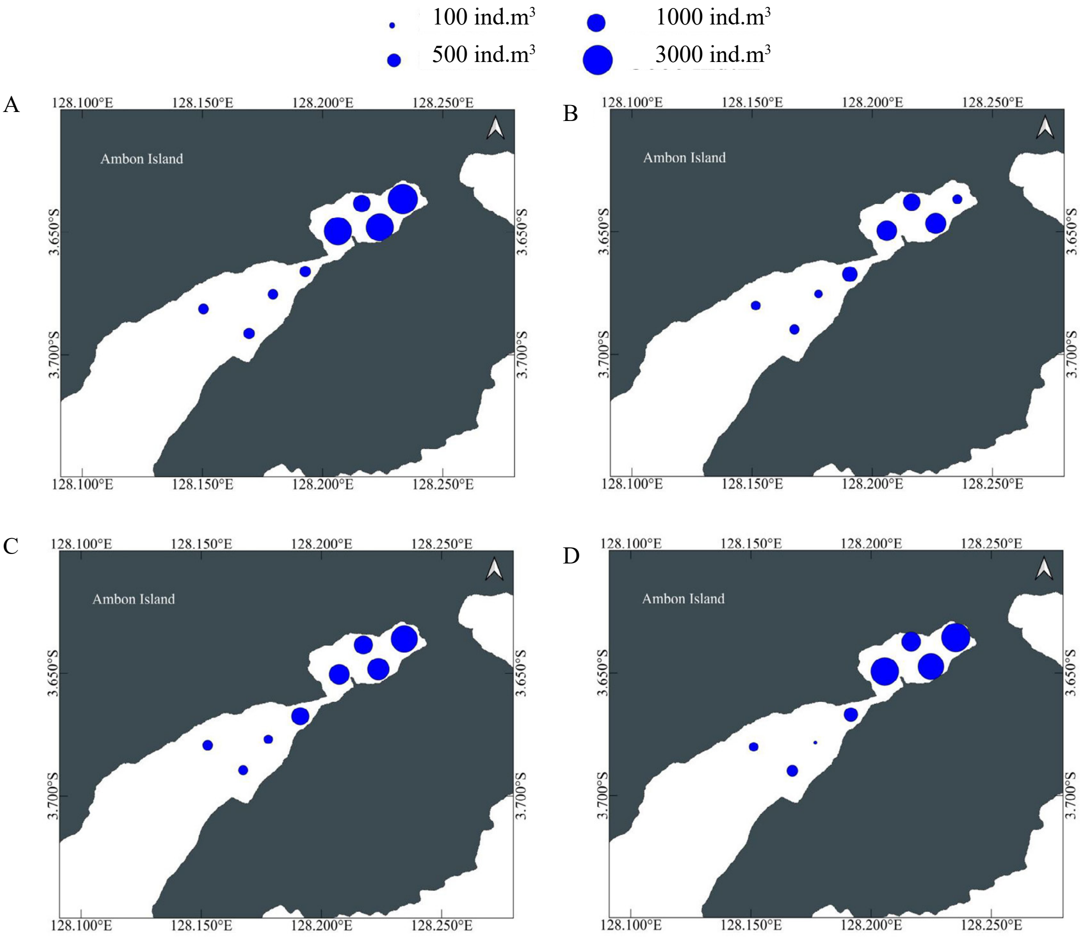

Figure 5. Spatial distributions of meroplankton abundance (A) August, (B) September, (C) October, (D) November

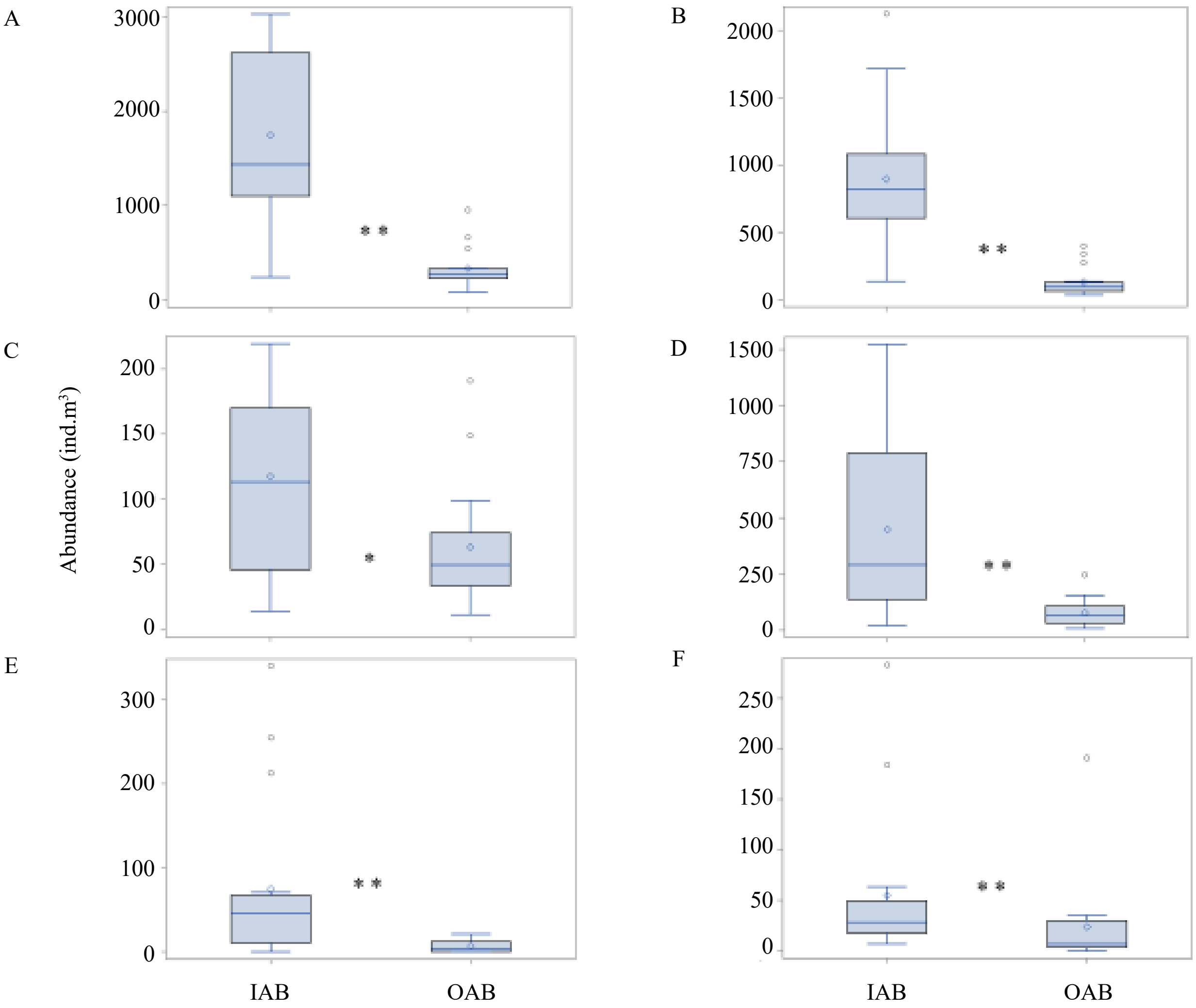

Figure 6. Comparison of abundance of meroplankton between IAB and OAB (A) total abundance, (B) Bivalvia larvae, (C) Gastropoda larvae, (D) Polychaeta larvae, (E) Echinodermata larvae, (F) Cirripedia larvae, *: p<0.05, **: p<0.01

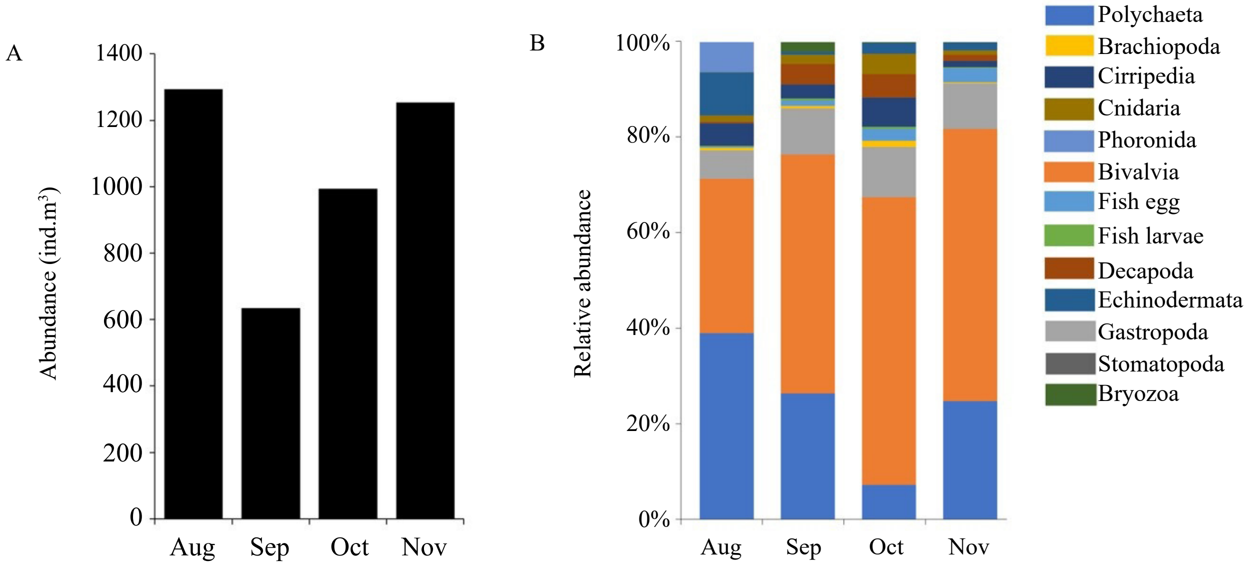

Figure 7. Abundance of meroplankton during the study (A) total abundance, (B) relative group abundance

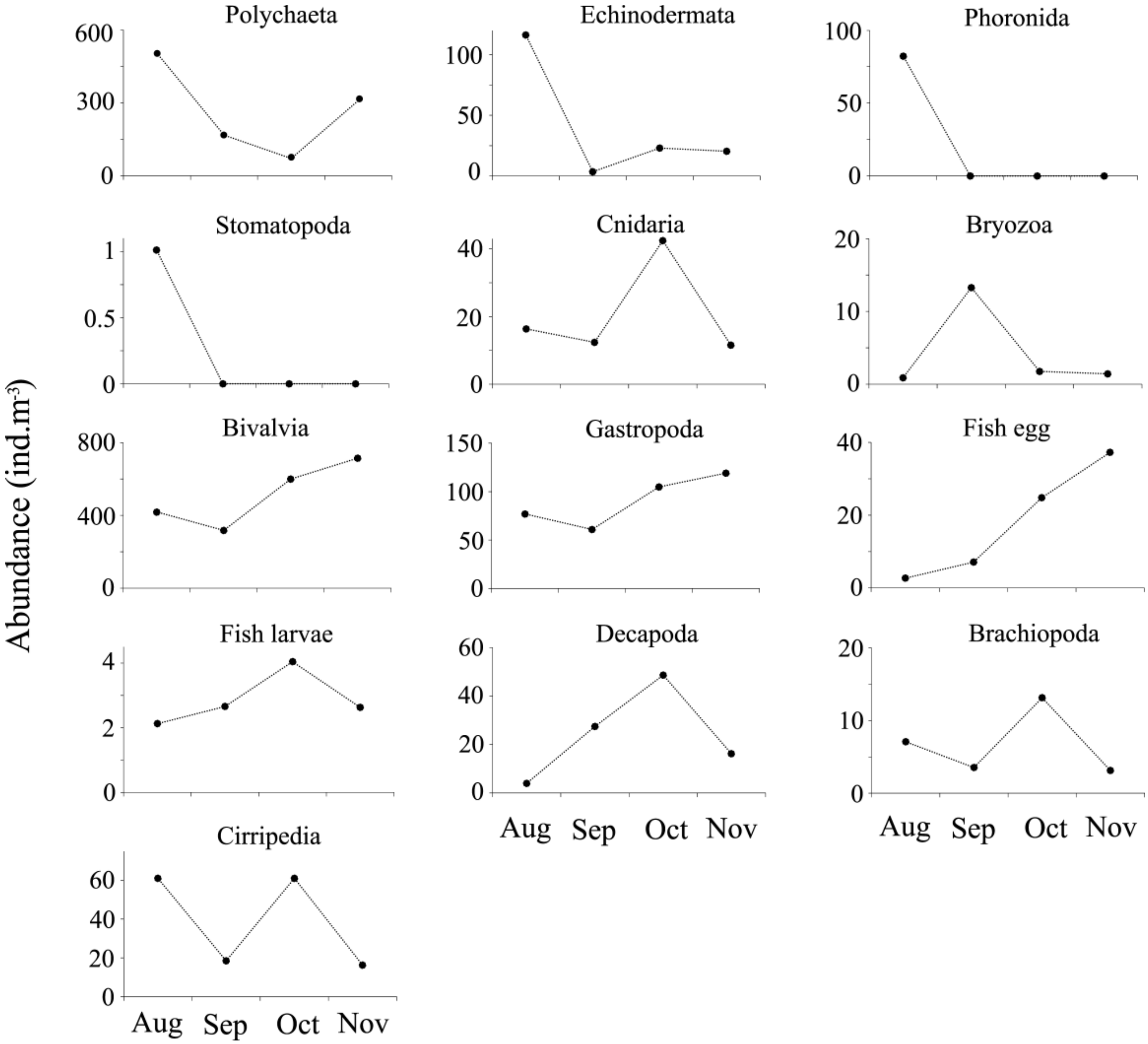

Figure 8. The meroplankton abundance group during the study

Decapoda, Brachiopoda, fish larvae, and Cnidaria were high in October (average 48.66 ind.m^{-3}, 13.14 ind.m^{-3}, 4.04 ind.m^{-3}, and 42.46 ind.m^{-3}, respectively) while Cirripedia larvae fluctuated during the campaign.

4. Discussion

4.1. Meroplankton Composition and Dominance

The results of our study revealed a varied diversity of meroplankton groups in Ambon Bay. The occurrence of a diverse meroplankton (e.g., Bivalvia, Gastropoda, Echinodermata, Polychaeta, fish larvae and eggs) was consistent with findings from previous studies (e.g., Mulyadi 2010; Ruli *et al.* 2022) and the surrounding area (Nusa Laut Island) (Mulyadi and Adi 2020). The existence of these groups indicates the ecological richness of marine organisms in the area, which is supported by various ecosystems, including seagrasses, mangroves, and coral reefs, as well as hard and soft substrates that serve as habitats for diverse marine organisms (PPLD-ILIPI 2018).

A notable finding was the documentation of the first occurrence of larval groups belonging to Bryozoa, Phoronida, and Brachiopoda in Ambon Bay, indicating a higher taxonomic diversity of meroplankton found than previously recognized. Their larval presence may indicate a more varied benthic ecosystem, given that this region lies within the global center of marine biodiversity, resulting in a potential for discovering additional larval groups in this area. The absence of these groups in earlier records (e.g., Mulyadi 2010; Ruli *et al.* 2023) may be attributed to limitations in temporal resolution. The extended monthly sampling in this study has likely increased the probability of capturing these larvae. Therefore, a higher temporal resolution is recommended for future studies to provide a more comprehensive overview of meroplankton diversity in this area (Weydmann-Zwolicka *et al.* 2021).

The Bivalvia and Polychaeta groups were the primary components of the meroplankton community in Ambon Bay, accounting for 67% and 82% of the total meroplankton abundance, respectively. The high abundance of these two taxa is likely attributable to their reproductive capacity (Rouse and Pleijel 2001; Stübner *et al.* 2016). Adult Bivalvia and Polychaeta populations are established in the Ambon Bay ecosystem (Islami and Mudjiono 2009; Pamungkas and Glasby 2015; Pamungkas 2017), and these local populations may potentially produce large larval abundances during this study. Furthermore, previous studies, such as Mulyadi and Saputra (2019), have reported the dominance of Polychaeta larvae in the zooplankton community of Ambon Bay, which constituted up to 91% in OAB and 73% in IAB during the northwest monsoon (NWM). This high contribution indicates that both groups play a vital ecological role in Ambon Bay as grazers and prey during the spawning period.

In contrast, the dominance of the Bivalvia group has not been documented in area 4. Although the existence of Bivalvia larvae in Ambon Bay has been reported by Mulyadi (2010), their maximum abundance was only 40 ind.m^{-3} (in May) and was captured at only one station out of six stations in IAB. Conversely, the present study found larvae at all stations and distributed them in both IAB and OAB. The non-capture of Bivalvia larvae by earlier studies may be attributed to differences in sampling methodology, particularly in the mesh size of plankton nets, with larger mesh sizes, such as NORPAC (330 µm) (Mulyadi 2010) or other nets with a mesh size of 300 µm (Ruli *et al.* 2022). Previous studies have shown that a larger mesh size can underestimate the presence of small larvae, particularly in the early stages of larval development, such as those of Bivalvia (Michelsen *et al.* 2017).

Furthermore, Riccardi (2010) reported that using larger net meshes could reduce the chances of capturing a high abundance of Bivalvia larvae. One of the common bivalve species in Ambon Bay is Gafrarium tumidum (Islami 2014), which is known to descend to the bottom of the water when the diameter of larvae ranges between 170 µm and 200 µm (Jagadis 2011); consequently, nets with mesh sizes larger than this range would be inadequate for capturing them. The use of a 100 µm mesh net in the present study likely increased the retention of smaller larvae, potentially contributing to the higher observed abundance of Bivalvia larvae compared to previous studies.

4.2. Meroplankton Spatial Distribution

The distribution of meroplankton within Ambon Bay revealed a distinct spatial pattern. Our findings indicate a varied distribution of meroplankton, with high abundance observed in the IAB compared to the OAB. This spatial variability is consistent with a previous study on zooplankton (Mulyadi and Saputra 2019) and meroplankton distribution (Ruli *et al.* 2022), underscoring the critical role of IAB as a spawning and feeding ground for various marine organisms.

Multiple factors likely contribute to the highest abundance of meroplankton in the IAB. Firstly, stations in the IAB have lower salinities than the OAB, indicating a significant input of freshwater from terrestrial runoff (Saputra and Lekalette 2016). This input can provide regular, substantial nutrients (Ikhsani *et al.* 2016), leading to high primary productivity in this area, which serves as a primary food source for meroplankton (Basit *et al.* 2012), particularly those with planktotrophic feeding strategies, such as Bivalvia and Polychaeta. Therefore, the IAB provides a good environment and sufficient food for the growth of meroplankton.

Secondly, the distribution of meroplankton may reflect the local distribution of the adult population in Ambon Bay. Although this study did not include direct sampling of the adult population, previous research provides supporting evidence for this association (PPLD-LIPI 2018). The IAB area is characterized by a large mangrove cover and seagrass ecosystems as well as muddy substrates, which are favorable ecosystems and substrates for various benthic and fish species. These habitats have been reported to support a higher density of the benthic communities in Ambon Bay (Islami *et al.* 2018), which is an important factor influencing the spatial distribution of marine larvae (Hsieh *et al.* 2010; Stübner *et al.* 2016). For instance, Islami and Mudjiono (2009) reported higher densities of mollusks (bivalves and gastropods) in the IAB than in the OAB. Similarly, adult Crustacea were found to have the highest diversity in IAB, as well as Echinodermata (PPLD-LIPI 2018). The distribution patterns of these adult organisms align with the distribution of larval abundance in this study and previous studies (Ruli *et al.* 2022). These findings highlight a potential link between the adult population and meroplankton abundance, emphasizing the importance of adult habitat availability in shaping larval spatial patterns within Ambon Bay.

Conversely, the relatively lower meroplanktonic abundance observed in the OAB may be linked to increased water exchange from the Banda Sea. Due to its direct exposure to open waters, the water circulation in this area is more intense compared to the IAB, which is relatively more enclosed (Salamena *et al.* 2021, 2023). These conditions in the OAB could lead to greater advection of larvae out of the bay. In this study, most larval taxa observed in IAB were also present in OAB. This pattern suggests a higher degree of larval dispersal in the OAB, potentially due to its more open hydrodynamic conditions. Consequently, larval abundance in the OAB is relatively lower compared to the more enclosed IAB.

4.3. Meroplankton Dynamics in Ambon Bay

The results of this study illustrate some trends in the spawning season of adult organisms in Ambon Bay. Although we only collected data for four months during the SEM and TS II, combining this with earlier studies provides insight into the temporal dynamics of spawning through their abundances. Most meroplankton groups were recorded at every sampling event; however, Phoronida and Stomatopoda were only found during SEM (August).

Several groups of meroplankton exhibited higher numbers during the TS II monsoon, such as Bivalvia larvae, fish eggs, and Gastropoda larvae. However, it cannot yet be concluded that this period represents the peak spawning season for these groups in Ambon Bay. For instance, since studies on the existence of Bivalvia larvae in Ambon Bay are limited (Mulyadi 2010), it's difficult to compare and develop seasonal patterns of their peak spawning time. However, by coexisting with its adult, we hypothesize that its dynamics in this study could be due to the spawning time of the common bivalve in Ambon Bay, *Gafrarium tumidum* (Islami 2014). It spawns continuously every year, with peak spawning and gonad maturity occurring in October and November (Jagadis and Rajagopal 2007; Nurdin 2009; Islami 2014), which may explain the high densities found in our study during TS II (November). Similarly, the fish eggs and Gastropoda larvae also showed high abundances during the TS II. Compared to other seasons, as reported by previous studies of fish egg abundance, Ruli *et al.* (2022) found an average abundance of 7.78 individuals m-3 during TS I 2022.

Furthermore, Mulyadi (2010) conducted studies in the TS I and SEM 2010, recording abundances of 80–180 ind.m^{-3} and 48–120 ind.m^{-3}, respectively. In this study, the highest abundance documented in TS II was 184.01 ind.m^{-3}. These indicated that adult fish in Ambon Bay were spawning in all seasons. Gastropoda larvae were reported by Mulyadi (2010) with an abundance of 60 ind.m^{-3} during TS I and 24 ind.m^{-3} during SEM 2010, which was lower than reported in the present study. This difference could be due to variances in net size, where Gastropod larvae can pass through larger mesh sizes (Zhang *et al.* 2024). When combined with the previous study of Mulyadi (2010), the results from this study, conducted during different seasons, revealed that Gastropod larvae persistently occurred in Ambon Bay.

The highest abundances of Echinodermata and Polychaeta were recorded during the SEM (August) in Ambon Bay during the study. However, this period did not represent the time of their highest recorded peak abundance. Mulyadi (2010) reported a higher abundance of Echinodermata larvae during the TS I (May) and SEM (June) seasons. Thus, although they can be found in all seasons, the peak of spawning occurred only during TS I to the SEM in Ambon Bay. Similarly, Polychaeta larvae abundance was lower than documented by Mulyadi and Saputra (2019), who studied in NWM (March 2016), reaching 42.097 ind.m^{-3} and becoming the key component of the zooplankton community in Ambon Bay. Hence, it indicates that Polychaeta larvae in Ambon Bay can be found every season, but their abundance fluctuates, with the highest levels during the NWM (March).

The Cirripedia larvae have fluctuated during the study periods. Previous studies (Mulyadi 2010; Ruli *et al.* 2022) suggested that it appears in NWM, TS I, and SEM, indicating that it is actively spawning throughout the season in Ambon Bay. Adult Cirripedia populations are established on Ambon Island, and 28 species of Cirripedia have been reported in this area (Pitriana *et al.* 2020), which may release eggs at different times (Stübner *et al.* 2016). In addition, some studies report that Cirripedia tend to release their larvae when food conditions are abundant (Stübner *et al.* 2016; Weydmann-Zwolicka *et al.* 2021). Furthermore, studies have shown that during peak spawning season, they are one of the main constituents of the zooplankton community (Muxagata *et al.* 2004). Thus, it is also possible in Ambon Bay, given that it has high productivity due to the influence of upwelling from the Banda Sea and nutrient input from the land through the river (Basit *et al.* 2012; Ikhsani *et al.* 2016). However, this study and previous research have not revealed a consistent pattern in which they can be found in high abundance. Therefore, further studies are needed to determine their dynamics, especially in relation to upwelling and the rainy season, during which productivity in Ambon was higher.

Meroplankton groups, such as Phoronida, Bryozoa, and Brachiopoda, are newly reported in this study, whereas Cnidaria were previously reported by Ruli *et al.* (2022). Phoronida larvae were caught only in August (SEM). Its planktonic period can last weeks to months until it finds a suitable substrate (McGuinness *et al.* 2022). Although it has not been reported in other seasons, its spawning in Ambon Bay is still within the spawning period in other regions (Omelyanenko and Kulikova 2011; Moksnes *et al.* 2014). Bryozoan and Brachiopoda larvae's abundances were higher in September and October, respectively. However, this cannot be supposed to be their spawning peak in this area due to the limited data for these groups. Therefore, further studies are needed to determine their dynamics in Ambon Bay. In addition, Cnidaria was also reported by Ruli *et al.* (2023) in NWM (March 2022), where the maximum abundance was 5.66 individuals m^{-3}, which is higher than in this study.

Fish larvae, decapods, and stomatopods have low abundance during the study periods. Although they have been reported by previous studies (Mulyadi 2010; Mulyadi 2010; Ruli *et al.* 2022; Romdon *et al.* 2023), these results are not appropriate when compared to the results of this study because of their ability to avoid plankton nets (Queiroga and Blanton 2005; Zhang *et al.* 2024). Since our study used a small-sized net, it does not necessarily capture the largest size more comprehensively (Zhang *et al.* 2024). Nonetheless, since those larvae were recorded during the studies, it is emphasized that they exist and spawn during the whole season in Ambon Bay.

This study provides valuable insights into the spatial and temporal distribution of meroplankton in Ambon Bay. Thirteen groups of meroplankton were found in Ambon Bay, where Bryozoa, Phoronida, and Brachiopoda were documented for the first time in this area. In terms of abundance, Bivalvia and Polychaeta larvae were the dominant group. Meroplankton in Ambon Bay exhibited spatial differences, with higher abundance observed in IAB compared to OAB. Continued monitoring of meroplankton in this region can serve as a valuable approach for evaluating the ecological health and productivity of the bay, particularly in the face of anthropogenic pressures.

These findings have important implications for the management of coastal ecosystems in Ambon Bay. The presence of diverse larvae across different seasons highlights the critical role of this area as a continuous spawning and nursery ground. This underscores the necessity for targeted conservation efforts to preserve its ecological function in supporting the sustainability of marine populations in this area. However, in this study, the majority of larvae identified have also been recorded in other seasons by various studies, indicating that the spawning of adults occurs throughout the year. The observed spatial variability in meroplankton abundance, potentially linked to adult habitat distribution, underscores the need to prioritize the conservation of benthic habitats such as mangroves and seagrass beds. These areas not only support adult macrofauna but also serve as an important larval retention zone. These implications extend beyond the local context, offering valuable insights into other tropical coastal systems where benthic habitats and larval connectivity play equally vital roles. Although this study provides valuable insights into the spatial and temporal patterns of meroplankton in Ambon Bay, it also has several limitations that should be considered for future research in this region or elsewhere. Firstly, the study relied solely on plankton net samples collected during August to November 2022, using a 100 µm mesh size. As a result, certain taxonomic groups may be undetected, and larger-sized larvae may not be fully represented. Future studies should expand the temporal scope to include a broader range of sampling periods (daily to weekly) or seasons and consider using multiple mesh sizes to capture a wider diversity of larval forms and sizes. This approach would offer a more comprehensive understanding of meroplankton phenology and diversity. Secondly, the identification of meroplankton in this study was limited to the phylum and class. Morphological identification at early-life stages is often challenging due to the small size of larvae and the morphological similarities among closely related taxa. Therefore, it is strongly recommended that future studies integrate molecular approaches, such as DNA barcoding and metabarcoding, which have proven effective in overcoming the limitations of morphological identification during larval stages (Brandner *et al.* 2017; Ershova *et al.* 2019; Descôteaux *et al.* 2021).

Authors' Contributions

All authors have contributed to the final manuscript. The contribution of each author is as follows: FR: collected the data, analyzed the data, drafted the manuscript, and designed the figures and tables. SL and GGS: revised the main conceptual ideas and critically revised the article. AR: analyzed the data, drafted the manuscript, and designed the figures and tables.

Conflict of Interest

All the authors declare that they have no competing interests upon the publication of this paper.

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