Abundance and Diversity of Polychaete Worms in Kapuas Estuary, West Kalimantan

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Submitted March 08th 2023 and Accepted July 03rd 2023

Abstract

Estuaries provide valuable ecosystem services, but they are also subject to environmental pressures due to high anthropogenic activities. The diversity and abundance of Polychaete can be used as indicators of the health of the Kapuas estuary, but supporting data are currently lacking. The objective of this research is to assess the quality of the Kapuas estuary through a Polychaete community approach. The study employed a survey method by selecting ten Polychaete sampling points based on their surrounding environmental conditions. Samples were collected from each point using a Petite Ponar grab, filtered, sorted, and grouped by family. The Polychaete specimens were identified up to the genus level. The data were analyzed descriptively. A total of 108 Polychaete individuals were found, comprising nine genera and seven families. The highest abundance was observed in the genera Capitella (Capitellidae) and Sternaspis (Sternaspidae), with 778 ind.m^{-2} and 667 ind.m^{-2}, respectively. The diversity of Polychaete in the Kapuas estuary was classified as low, with diversity index ranging from 0.5 to 1.21. The high abundance, low diversity, and presence of indicator genera of organic pollutants such as Capitella *indicate that the Kapuas estuary is affected by organic contamination.*

Keywords: *Bioindicators, Capitella, Kupuas estuarine, Polychaetes, Sternaspis*

https://doi.org/10.36987/jpbn.v9i2.4003

INTRODUCTION

Estuaries provide significant ecosystem services such as food production, nutrient cycling control, erosion control, recreation, and the maintenance of biogeochemical cycles (Nie et al., 2023). Estuaries also serve as sheltered habitats, feeding grounds (Schwartzkopf & Heppell, 2020), as well as spawning grounds and nursery grounds for aquatic animals (Denis et al., 2022). Additionally, estuaries act as locations for the accumulation of pollutants (Angeli *et al.*, 2022) and nutrients from urban activities (Branoff, 2020) as well as agriculture (Sirabahenda et al., 2017) along river channels. The potential loss of estuarine habitats will remain high without proper management (Stamp et al., 2022).

The Kapuas River is suspected to have experienced pollution, indicated by the high of Biological Oxygen Demand (BOD) (Purnaini et al., 2019). Domestic, agricultural, and industrial activities along the river can contribute to organic waste. These various activities can degrade the environmental quality of the river, both physically, chemically, and biologically. Existing studies related to the Kapuas estuary include salinity distribution (Sugito et al., 2018), water flow (Agustini et al., 2013), pollution assessment through physical parameters (Hermansyah, 2022) and chemical parameters, microplastics (Sugandi et al., 2021), and heavy metal content such as Cd (Nengsih et al., 2023). Biological parameters in determining the water quality status of the Kapuas estuary are limited to studies on periphyton (Saputra et al., 2018) and heavy metals in fish (Arisma et al., 2023).

Benthic biota is one of the components of the estuarine ecosystem, along with plankton and nekton. Polychaetes, as one of the components in the benthic community, play an important role in the food web in estuaries. Furthermore, polychaetes can be used as bioindicators to monitor the environmental quality of the estuary, particularly in relation to anthropogenic impacts (Samikkannu et al., 2018).

Studying polychaetes as part of the environmental assessment can provide recommendations for sustainable river management. However, research on polychaetes in the Kapuas estuary is still very limited. The aim of this study is to obtain data on the abundance and diversity of polychaetes in the Kapuas estuary. This data and information can be used to assess the water quality of the Kapuas estuary for various purposes.

METHOD

The research was conducted from April to October 2020. Polychaete samples were collected from the Kapuas estuary, West Kalimantan. Sample analysis was carried out at the Zoology Laboratory, Faculty of Mathematics and Natural Sciences (FMIPA), Tanjungpura University, Pontianak.

The equipment used in this research included a Ponar grab, binocular microscope, tweezers, Olympus CX31 microscope, GPS etrex 10, multimeter EZ-9909-SP, DO meter (DO9100), and benthic sieves with sizes of 1mm, 0.5mm, and 0.25mm. The materials used were 4% formalin solution and 70% alcohol. Sample collection was conducted at the research locations, as shown in Figure 1.

Samples were taken from ten predetermined sampling points based on the surrounding environmental conditions. The ten sampling points consisted of three sections. Sampling points 1-5 were located in the outer part of the estuary, sampling points 6 and 7 were in the middle part adjacent to the mangrove forest of Pulau Panjang, sampling point 8 was in the middle part near the mouth of Kapuas Kecil and Kapuas Besar rivers, and sampling points 9 and 10 were located north of Kapuas Besar river, which had various activities in the riparian area such as residential areas and the Wajok industrial zone (rubber processing industry, food and beverage industry, and power plant). The distance between points from the inner river towards the outer area was 5.7 km from point 10 to point 8 and 8.3 km from point 8 to point 3.

Sediment samples were collected using a Petite Ponar grab with a surface area of 225 cm^2 at each sampling point. The sediment samples were then sieved using sieves with sizes of 1 mm, 0.5 mm, and 0.25 mm. The sieve contents were placed in sample bottles and preserved with 4% formalin. The samples were sorted and separated based on families. Prior to identification in the laboratory, the samples were transferred to 70% alcohol and grouped by families. Morphological characteristics were used in the identification process using a stereo microscope (Labomed) and a compound microscope (Olympus CX23) until the genus level genus (Rosli et al., 2018).

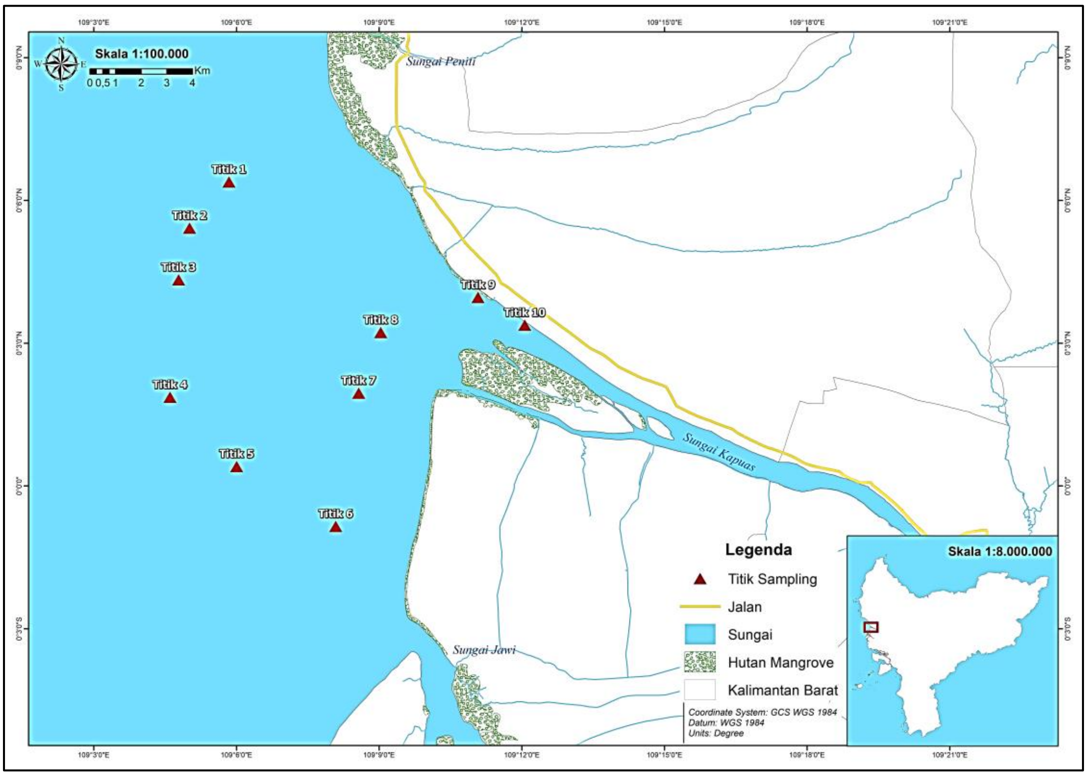

Figure 1. Polychaete sampling points in the Kapuas Estuary.

Environmental parameters such as temperature, pH, salinity, turbidity, and depth were measured directly (in situ). Other parameters, such as total organic carbon and sediment texture, were analyzed ex-situ (in the laboratory). Total Organic Carbon (TOC) was analyzed using the Walkey & Black method, while the sediment texture was separated into three fractions: sand, silt, and clay.

Data on genus composition were analyzed descriptively. Diversity was calculated using the Shannon-Wiener diversity index (H'):

$$H' = -\sum_{i=1}^{s} Pi \ln Pi$$

H' represents the diversity index, Pi represents the proportion of species i to the total number of genera or ni/N, where ni is the number of individuals of genus i and N is the total number of genera in a sampling point.

The formula for calculating the abundance (K) of each genus is:

$$K = a \text{ x } 1000/b$$

where: "a" is the number of individuals of each genus, "b" is the surface area of the Petite Ponar grab (225 cm²), and "10000" is the conversion factor from square centimeters (cm²) to square meters (m²).

RESULTS AND DISCUSSION

The research conducted in the Kapuas estuary found a total of 108 individuals of Polychaete. The number of Polychaete individuals found in each sampling point is presented in Figure 2. The highest number of individuals was found in sampling point 7, accounting for 31% of the total. On the other hand, sampling points 4, 5, and 6 had the lowest number of individuals. The high number of individuals in sampling point 7 can be attributed to the abundance of *Sternaspis* (Sternaspidae) in that area. Additionally, sampling points 8 and 9 also had a higher number of individuals of *Capitella* (Capitellidae). This contributes to the lower diversity index observed in the area. The diversity index, calculated using the Shannon-Wiener index, is influenced by the abundance and species diversity within an area. In this case, the dominance of certain species like *Sternaspis* and *Capitella* results in lower species diversity. This is reflected in the lower diversity index.

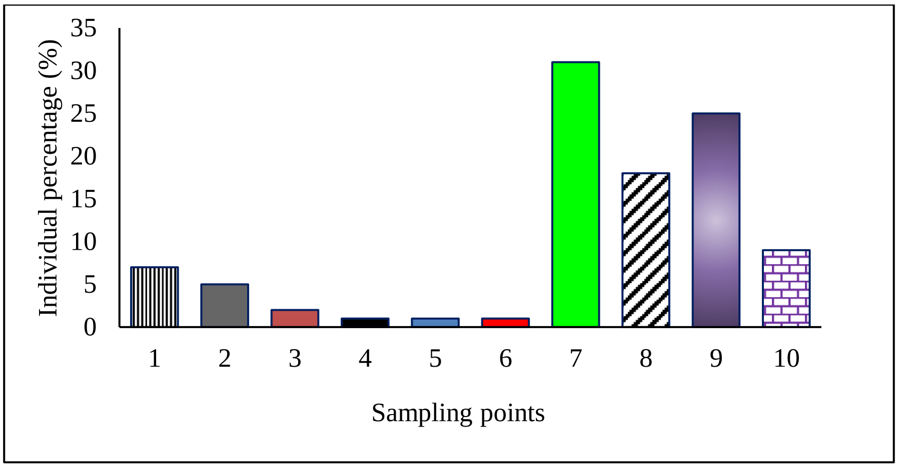

Figure 2. Percentage of Polychaete individuals at all sampling points.

Sampling points 7-10, located in front of the mouth of the Kapuas River and near residential areas, have a higher percentage of Polychaete individuals compared to sampling points 1-3. On the other hand, no Polychaete individuals were found at sampling points 4-6. These sampling points are situated on the outer-southern side of the estuary with better mangrove vegetation.

The composition of Polychaete found based on the number of individuals is presented in Figure 3. The families with the highest number of individuals, in descending order, are Capitellidae and Sternaspidae, followed by Nephtyidae and Cossuridae. The Capitellidae family is found in greater abundance both in terms of the number of individuals and the number of genera. This family exhibits morphological similarities with oligochaete worms, characterized by a tapered to rounded anterior shape, absence of appendages, elongated cylindrical body, undeveloped parapodia, and setae growing directly from the body.

The presence of Polychaete families indicates the presence of organic pollutants, and some of its species are often used as indicator species for estuarine pollution (Méndez, 2022). Generally, species within this family exhibit non-selective deposit- feeding behavior, consuming all particles within the sediment.

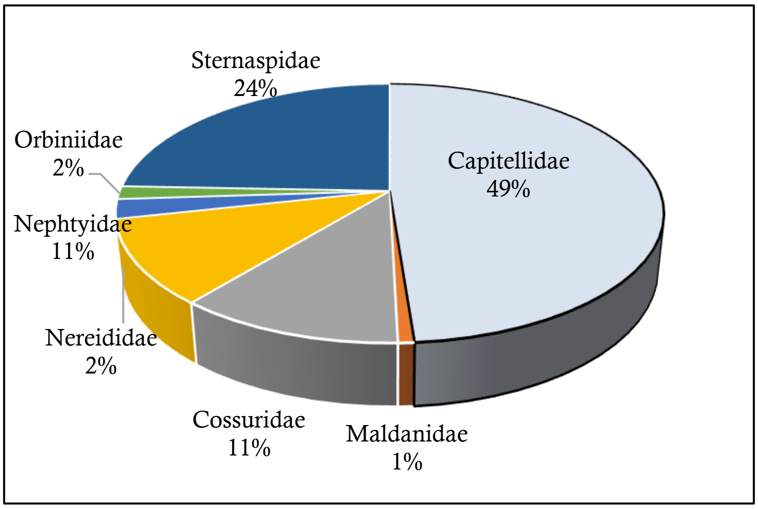

Figure 3. Composition of Polychaete families based on the number of individuals.

The second most abundant family found is Sternaspidae. This family is commonly found in muddy and sandy substrates at various water depths, although it can also be found in waters with coarse sand substrates (Drennan et al., 2019). The distribution of this family is wide luas (Zhadan et al., 2017), and they are known as deposit feeders (Tantikamton et al., 2015), with their branchiae positioned on the sediment surface to facilitate oxygen exchange for the body.

The family Nephtyidae burrows into sediments in intertidal areas and can tolerate low-oxygen sediment conditions by utilizing anaerobic metabolic pathways, indicating the presence of low oxygen in the sediments. The presence of this family can also be used as an indication of disturbances to sediment stability due to its opportunistic nature (Maximov & Berezina, 2023), as they tend to appear after physical disturbances (sediment perturbation) (Sobczyk et al., 2023). The family Cossuridae commonly inhabits muddy habitats from intertidal to deep-sea areas. They are deposit feeders that extend ciliated tentacles into the sediment, directing food particles along the tentacles toward the mouth (Zhadan et al., 2015). Cossuridae prefers sediments with high organic matter derived from detritus.

Other families found in smaller numbers include Nereididae, Orbiniidae, and Maldanidae. Nereididae does not have a specific habitat and is more widely distributed, but they prefer feeding on the sediment surface, being omnivorous and feeding on rich organic matter (Fernández-Rodríguez et al., 2019). Maldanidae is a family that exhibits various feeding types, ranging from non-selective deposit-feeding to filter feeding in different sediment layers. A total of nine genera were found, with fewer genera within a single family, with Capitellidae and Nereididae having two genera each, while other families have one each genus (Figure 4).

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e-ISSN: 2685-7332

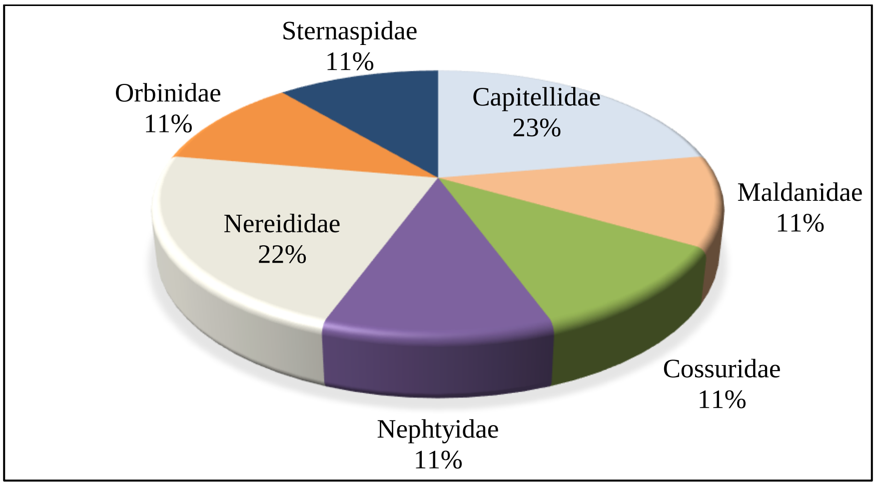

Figure 4. The composition of Polychaete based on the number of genera.

Genera with higher relative frequencies were found in *Capitella* and *Cossura* with 20% each, followed by *Nephtys* and *Notomastus* with 16% and 12% respectively (Figure 5). The genus *Capitella* is known to thrive in muddy habitats with high organic matter content and low oxygen levels, making it widely used in assessing water pollution (Méndez, 2022).

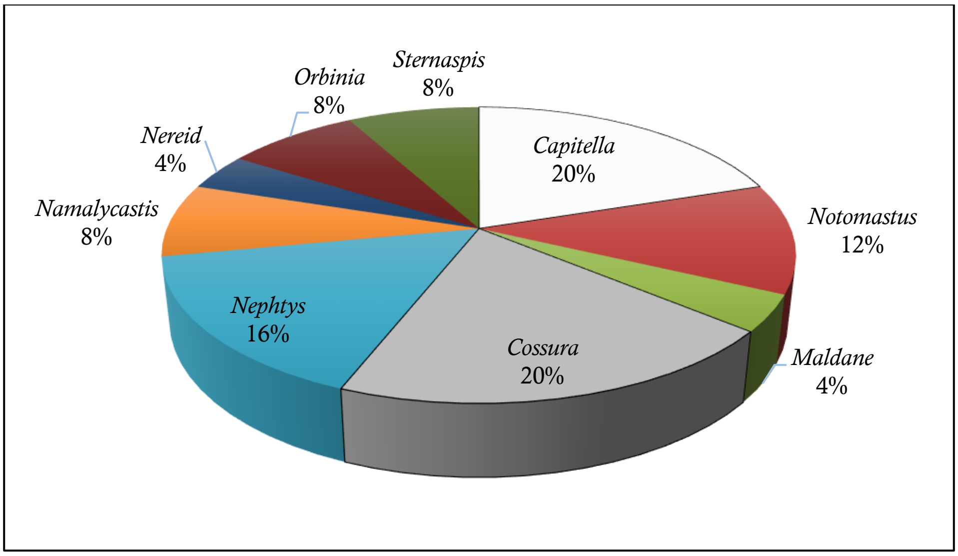

Figure 5. Relative frequencies (%) of Polychaete genera.

Capitella and *Sternaspis* were found to be the most abundant genera compared to other genera. The abundance of these two genera significantly contributed to the total abundance of individuals at each station. Stations 8 and 9 had high abundance of *Capitella*, while station 7 had the highest abundance of *Sternaspis* (Table 1).

Table 1. The abundance of Polychaete genera

Families	Genera	Abundance (ind.m^{-2})										Total
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Capitellidae	*Capitella*	0	0	22	0	0	0	44	222	400	89	778
	Notomastus	0	0	0	0	0	0	44	0	156	22	222
Maldanidae	*Maldane*	0	22	0	0	0	0	0	0	0	0	22
Cossuridae	*Cossura*	44	89	0	0	22	0	0	0	44	111	311
Nephtyidae	*Nephtys*	89	0	0	22	0	0	22	156	0	0	289
Nereididae	*Namalycastis*	22	0	22	0	0	0	0	0	0	0	44
	Nereid	0	0	0	0	0	0	0	22	0	0	22
Orbinidae	*Orbinia*	22	0	0	0	0	0	0	22	0	0	44
Sternaspidae	*Sternaspis*	0	0	0	0	0	22	644	0	0	0	667
Total		178	111	44	22	22	22	756	422	600	222	2400

The diversity of Polychaete obtained during the study falls into the low category with Shannon-Wiener index (H) ranging from 0.50 to 1.21 (Figure 6). Sampling points 4, 5, and 6 did not find any Polychaete individuals, resulting in a Shannon index of zero. The high proportion of individuals without a proportional number of genera contributes to the low diversity index.

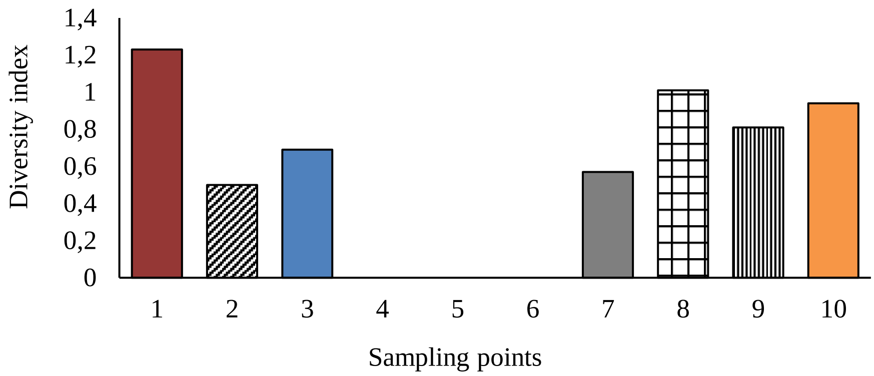

Figure 6. Diversity of Polychaete in Kapuas Estuary.

The diversity of Polychaete in Kapuas Estuary is relatively low. The limited number of Polychaete genera that are able to adapt to specific physical and chemical conditions in the habitat leads to dominance. Competition for resources and specific nutritional needs can prevent some genera from adapting. The number of individuals of each genus within a niche also contributes to the diversity index. A low diversity index indicates imbalance or environmental pressure.

The accumulation of organic matter carried from the upstream and middle parts of Kapuas River accumulates in the estuary, transforming from coarse particulate to fine particulate matter and becoming a major component of the sediment. The sedimentation rate in Kapuas Estuary is high, which limits the biota that can thrive in

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e-ISSN: 2685-7332

the rapidly accumulating sediment layers. Opportunistic Polychaete such as *Nephtys*, which can survive in high organic matter content in sediments like *Capitella* and *Notomastus*, prefer these conditions (Méndez, 2022; García-Garza et al., 2019). The low diversity, presence of indicator organisms for organic pollution, and the presence of opportunistic Polychaete indicate significant enrichment of organic matter in the sediment (Giangrande et al., 2005). Polychaete are also influenced by the organic matter content, especially in Nereididae and Capitellidae (Fernández-Rodríguez et al., 2019).

The organic matter content and environmental factors during the study are presented in Table 2. Kapuas Estuary is characterized by turbid water with low water clarity (<0.5 m) and acidic pH (<7) in deeper parts, particularly in the central and southern areas, while the northern part is shallower.

Table 2. The environmental factors of Kapuas Estuary

Parameters	Sampling points										Average
	1	2	3	4	5	6	7	8	9	10	
Temperature (°C)	27,0	28,0	28,5	28,0	28,5	29,0	29,5	30,0	30,5	32,0	29,1
Transparency (cm)	30,5	21	81,5	31,5	47,0	21,0	33,0	23,5	26,5	25,5	34,1
pH	6,0	6,0	6,2	6,4	6,8	6,6	5,8	6,8	6,8	6,0	6,34
Water Depth (m)	4,33	6,61	8,72	11,07	8,23	4,57	2,05	1,66	2,07	1,87	5,12
Salinity (ppt)	2,0	2,0	13,0	1,1	2,0	2,0	0	0	0	0	2,21
C-organic (%)	2,43	3,26	2,63	2,44	2,48	2,36	2,77	0,9	0,33	3,85	2,34
Sand (%)	0	0,38	0	0	0	0,38	3,75	50,7	90,3	4,11	14,96
Silt (%)	76,7	74,6	75,5	76,84	75,5	74	68,9	32,8	9,69	68,9	63,33
Clay (%)	23,3	25,1	24,6	23,16	24,5	25,6	27,3	16,5	0	27,0	21,70

Water temperature affects the distribution and composition of Polychaete (Dorgham et al., 2014), but it only has an impact at high temperatures, which can affect diversity (Kohlenbach et al., 2023). The average water temperature found in this study is still classified as the warm water temperature in equatorial regions like West Kalimantan, so it does not significantly affect the diversity of Polychaete. This can be observed from the lowest temperature (sampling point 1) and the highest temperature (sampling point 10), where both sampling points have nearly the same diversity.

Low transparency reflects the limited penetration of sunlight into the water, which can be influenced by dissolved and suspended particles, plankton, organic matter, and microorganisms. The Polychaete species found in the study are predominantly deposit feeders, so low water clarity does not significantly affect their composition. The low acidity level (pH) can be attributed to the mixture of peat water, which is characteristic of rivers in West Kalimantan that flow through peatlands. Depth also does not directly affect the composition of Polychaete found in this study, as several genera can be found living in both shallow waters and deep sea environments (Dorgham et al., 2014).

Low salinity is due to the influx of freshwater into the estuary. The sediment texture is generally clayey silt, found in 8 sampling points, while sandy silt was found in 2 sampling points. The sampling points with sandy silt texture are located near the mouth of Kapuas River, where the sand is believed to be carried from upstream or from the sea. These points experience the convergence of river and sea currents, leading to sand deposition. These sampling points are often dredged as they serve as the entry and exit routes for ships to Pontianak Port. On the other hand, the clayey silt texture is found in the southern and northern parts of the estuary, which have mangrove vegetation and slower currents, promoting better sedimentation processes.

The diversity of Polychaete is also influenced by substrate type (Sobczyk et al., 2023). The Polychaete genera found in sandy silt sediment include *Capitella* and *Notomastus* (Capitellidae), *Cossura* (Cossuridae), *Nephtys* (Nephtyidae), *Nereid* (Nereididae), and *Orbinia* (Orbinidae). Polychaete are found in higher numbers in both sediment types, while other genera such as *Maldane*, *Namalycastis*, and *Sternaspis* are only found in clayey silt sediment. These three genera are found in the mangrove fringe of Kapuas Estuary. *Sternaspis*, in particular, is widely distributed and can live in various substrate types (Drennan et al., 2019). *Namalycastis* also prefers mud sediment with high organic matter content (Cai et al., 2013).

CONCLUSION

The composition of Polychaete consists of seven families and nine genera, with two genera, *Capitella* and *Sternaspis*, being the most abundant. The highest abundance is found in *Capitella* (Capitellidae) with 778 ind.m^{-2}, followed by *Sternaspis* (Sternaspidae) with 667 ind.m^{-2}. The diversity of Polychaete is classified as low, and the high abundance of *Capitella* indicates the presence of organic pollution in the Kapuas Estuary. Further research on the dynamics of *Capitella* is needed to provide additional important data for the management of the Kapuas Estuary.

ACKNOWLEDGEMENTS

We would like to express our gratitude to FMIPA UNTAN for providing research funding through the DIPA in 2020. We would also like to extend our thanks to the students who assisted in the field sampling and sample preparation in the laboratory.

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p-ISSN: 2442-9481
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How To Cite This Article, with *APA style* :

Junardi J., Riyandi R. (2023). Abundance and Diversity of Polychaete Worms in Kapuas Estuary, West Kalimantan. *Jurnal Pembelajaran dan Biologi Nukleus*, 9(2), 312-323. https://doi.org/10.36987/jpbn.v9i2.4003