

ESTIMATION OF ABUNDANCE, BIOMASS AND NUTRITIONAL CONTENT ANALYSIS OF THE SEA CUCUMBER SPECIES *Paracaudina bacillis* IN THE WATERS OF SINABOI ROKAN HILIR

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Abstrak: Sea cucumbers are marine organisms of the phylum Echinodermata that play an important ecological role as deposit feeders while also holding high economic value as a functional food source. This study aimed to determine the abundance and biomass of *P. bacillis*, analyze its nutritional content (moisture, ash, protein, fat, carbohydrate, calcium (Ca), and magnesium (Mg)), and confirm the identity of the sea cucumber species found in the waters of Sinaboi, Rokan Hilir. The research was conducted from March to June 2026 using a survey method, with the sampling station determined through purposive sampling. A single research station was established, consisting of three transects spaced approximately 500 m apart, each 100 m in length. Morphological, anatomical, and spicule identification confirmed that the specimens found were *P. bacillis*. The mean abundance of *P. bacillis* was $2,000 \pm 250$ ind/ha, with the highest value at transect 1 (2,250 ind/ha) and the lowest at transect 2 (1,750 ind/ha). Mean biomass was recorded at 5.96 ± 0.259 kg/ha, following a distribution pattern consistent with abundance. Proximate analysis showed protein as the dominant nutritional component (45.94%), followed by ash (37.76%), carbohydrate (6.85%), moisture (6.02%), and fat (3.44%), while calcium (0.0046%) and magnesium (0.0017%) were found in very small amounts. The high protein content indicates that *P. bacillis* has potential as an alternative, economically valuable source of animal protein, so these data can serve as a basis for the sustainable management of sea cucumber resources in the waters of Sinaboi.

Keywords: *Paracaudina bacillis*, abundance, biomass, nutritional content, Sinaboi waters

I. INTRODUCTION

Sea cucumbers are one of the marine biota from the phylum Echinodermata that play an important ecological role as well as hold high economic value in Indonesian waters. Ecologically, sea cucumbers function as deposit feeders that process sediment and organic matter on the seabed, thereby contributing significantly to supporting nutrient cycling in benthic ecosystems and maintaining the quality of aquatic substrates (Oktamalia et al., 2016). In Indonesian waters, sea cucumbers are found from various genera such as *Holothuria*, *Stichopus*, and *Bohadschia*, which are widely distributed across coral reef ecosystems, seagrass meadows, and muddy substrates (Handayani et al., 2017).

In terms of nutritional content and bioactive potential, sea cucumbers have long been recognized as a functional food source rich in nutrients and bioactive compounds. Proximate analysis results show that sea cucumbers contain varying levels of moisture, ash, protein, fat, and carbohydrates depending on the species and habitat. For example, the black sea cucumber (*H. edulis*) contains a protein content of 54.93% and fat content of 1.27%, while the sandfish (*H. scabra*) contains 32.64% protein and 0.23% fat (Dasilva et al., 2025). Nevertheless, the nutritional content of sea cucumbers can vary depending on species, season, geographical location, aquatic environmental conditions, and post-harvest handling methods (Renyaan et al., 2024).

As an export commodity, the selling price of sea cucumbers generally ranges from IDR 250,000–700,000/kg (Wiadnyana et al., 2009), although this price varies considerably depending on species and region of origin. For instance, a study in Sorong City, Southwest Papua, showed that the selling price from fishermen ranged from IDR 50,000/kg for low-value species such as the *kawasa* sea cucumber (*Bohadschia marmorata*) to IDR 912,500/kg for the *gosok* sea cucumber (*H. scabra* and *H. lesoni*), which are classified as high economic value (Arafat et al., 2024). Meanwhile, in South Sulawesi, sea cucumber prices are generally reported to range from IDR 150,000 to IDR 500,000/kg (Tangko, 2009). These price differences between species and regions are influenced by factors such as size, drying quality, scarcity level, and export market demand, particularly from China and Hong Kong as the main destination countries in the global dried sea cucumber trade (Arafat et al., 2024).

Despite their high nutritional and economic value, sea cucumber populations in various regions of Indonesia are now facing serious pressure due to overexploitation. Sea cucumbers have exhibited a chronic overfishing phenomenon in some areas, such that they are naturally no longer able to recover quickly, as has occurred in the Seribu Islands National Park area, where their presence has significantly declined compared to the previous decade (Asriyana et al., 2019). Sea cucumber resource management reported from several regions, such as in Malaumkarta Village, Sorong Regency, has demonstrated that local approaches supported by scientific data are highly effective in maintaining the sustainability of sea cucumber populations in the wild (Arafat et al., 2022). Therefore, the availability of scientific data on the abundance and biomass of sea cucumbers in a given water body becomes a highly crucial foundation for formulating appropriate and sustainable management policies.

Sinaboi Waters, located in Sinaboi District, Rokan Hilir Regency, Riau Province, is a coastal area characterized by mangrove ecosystems, muddy substrates, and shallow waters that ecologically has the potential to serve as a habitat for various benthic biota, including the sea cucumber species *P. bacillis*. This area has long served as a livelihood base for local fishermen who utilize various marine products from the seabed, including economically valuable benthic biota (Fitriani et al., 2015). However, to date, there has been no comprehensive scientific data regarding the estimated abundance, biomass, or nutritional content of *Paracaudina bacillis* sea cucumbers specifically originating from Sinaboi Waters, Rokan Hilir. Based on this, the present study was conducted to fill this scientific data gap as a tangible contribution to the sustainable management and utilization of sea cucumber resources in the coastal region of Rokan Hilir Regency.

II. RESEARCH METHODOLOGY

2.1 Time and Place

This study was conducted from March to June 2026. Sampling was carried out in March 2026 in the waters of Sinaboi, Rokan Hilir Regency (Figure 1). This location was selected based on the consideration that the population of the sea cucumber *P. bacillis* is relatively abundant there and that the area serves as a traditional fishing ground for the local community. Sample analysis was carried out at two laboratories: the Marine Biology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Riau, and the testing laboratory of Vahana Scientific Padang, West Sumatra.

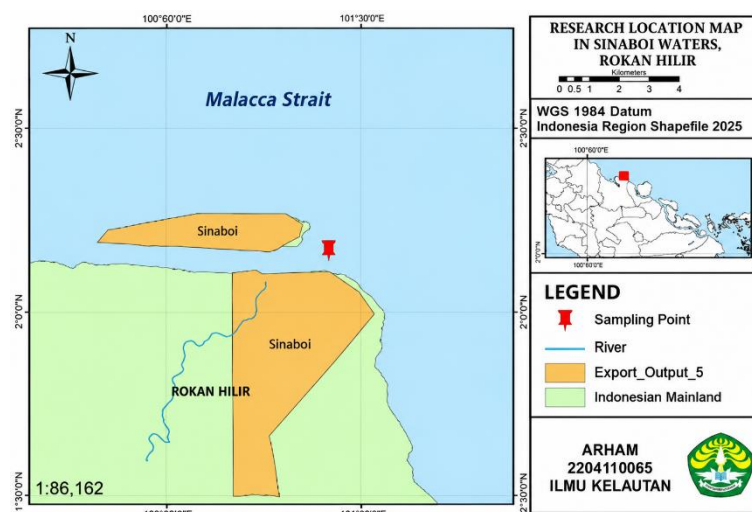


Figure 1. Map of the study location

2.2 Sampling Method

The method used in this study was a survey method, namely direct field observation and sample collection, which was then analyzed in the laboratory. The parameters measured included abundance, biomass, and nutritional content (moisture, ash, protein, fat, carbohydrate, calcium, and magnesium). Biomass analysis was carried out at the Marine Biology Laboratory of Universitas Riau, while nutritional content analysis was carried out at the Vahana Scientific Laboratory. Proximate analysis followed the standard method of the Association of Official Analytical Chemists (AOAC, 2020) using standard laboratory equipment.

Sampling was carried out at each transect. Sea cucumber samples were collected using a boat equipped with a towed net, commonly referred to as a pull net/drag net (Figure 2). Sampling was conducted at the lowest tide. The boat equipped with the towed net traveled from the starting point—the coastal or shore area still inundated with water—to the endpoint of the transect, namely the offshore area, with a transect length of ± 100 meters. Towing was carried out once for each transect. The distance between sampling transects was approximately 500 meters. The catch from each transect was collected, and sea cucumbers were then separated from other biota caught incidentally.



Figure 2. Sampling collector (Drag Net)

2.3 Research Procedure

2.3.1 Identification of Sea Cucumber Samples

Species identification of sea cucumbers was carried out by examining the ossicle structure in the body wall tissue. Ossicles are microscopic calcareous spicules that form the internal skeleton of the class Holothuroidea and exhibit distinctive shapes for each species (Arriescado et al., 2022). The identification process began with taking a sample of the sea cucumber's body wall tissue from the dorsal or ventral side using a scalpel or forceps. The tissue sample was then soaked in a sodium hypochlorite (NaOCl) solution, or bleach solution, for several minutes until the soft tissue dissolved, leaving only the ossicle structures. The cleaned ossicles were then placed on a glass slide and covered with a cover glass. The preparation was subsequently observed under a light microscope at a specific magnification to examine the shape and type of ossicles. The ossicle shapes observed included several common types such as table, button, rod, plate, and rosette, which serve as diagnostic characters in sea cucumber species identification. The observed ossicle shapes were then compared with identification keys and relevant taxonomic literature, namely the scientific journal *The paracaudinid sea cucumbers of Australia and New Zealand (Echinodermata: Holothuroidea: Molpadida: Caudinidae)* by O'Loughlin et al. (2011), allowing for more accurate identification of the sea cucumber species.

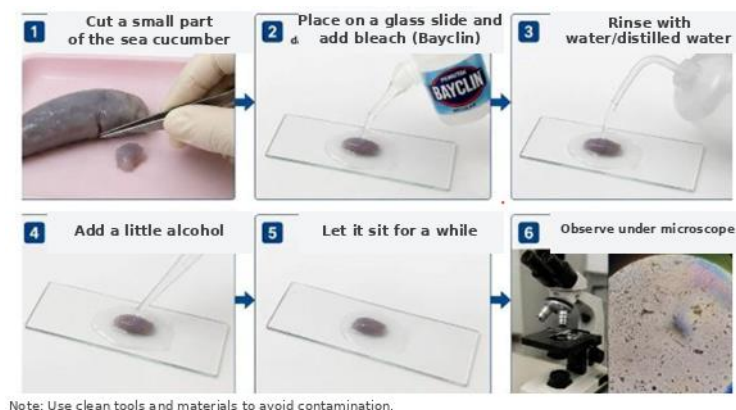


Figure 3. Sample identification process

2.3.2 Sea Cucumber Abundance

Sea cucumber samples used in this study were the species *P. bacillis* found at each transect. The samples were collected and placed in an icebox before being analyzed in the laboratory. To determine the abundance of sea cucumbers, the following formula (Odum, 1971) was used.

$$\text{Abundance} \left(\frac{\text{ind}}{\text{ha}} \right) = \frac{\text{Total number of individuals}}{\text{Area (m}^2\text{)}} \times 10,000 \quad (1)$$

2.3.3 Estimation of Sea Cucumber Biomass

Estimation of *P. bacillis* biomass was carried out using the transect method commonly used in marine benthic population studies. At each 100-meter transect, (a) the number of individuals was counted, (b) the dry weight of the sea cucumbers was measured, and (c) the mean biomass per transect was calculated. Biomass was calculated using the formula:

$$\text{Biomass} \left(\frac{\text{kg}}{\text{ha}} \right) = \frac{\text{Total weight of individuals (kg)}}{\text{Area (m}^2\text{)}} \times 10,000 \quad (2)$$

2.3.4 Moisture Content Analysis

Moisture content was determined using the gravimetric method, namely by drying the sample in an oven at a temperature of 100–105°C until a constant weight was achieved (weighing difference ≤ 0.0002 g) (Bilgin and Tanrikulu, 2018). A crucible containing a 2-gram sample was placed in an oven at 105°C for 3–5 hours and then cooled in a desiccator for 30 minutes until it reached room temperature. The sample was subsequently weighed and its weight recorded, and the drying, cooling, and weighing steps were repeated until a constant weight was obtained. Moisture content was calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{(b - c)}{(b - a)} \times 100\% \quad (3)$$

Where: a = weight of empty crucible (g);

b = weight of crucible + wet sample (g);

c = weight of crucible + dried sample (g).

2.3.5 Ash Content Analysis

Ash content was determined using the dry ashing method with a muffle furnace at 550–600°C for 4–6 hours until white or grayish-white ash was obtained (AOAC, 2020). A crucible containing a 2-gram sample was placed in an oven at 105°C for 120 minutes and then placed on a hot plate until the sample turned black. The crucible was subsequently transferred to a muffle furnace at 550–600°C for 4–6 hours until white ash was obtained, after which it was cooled in a desiccator until it reached room temperature. The sample was then weighed and its weight recorded. Ash content was calculated using the following formula:

$$\text{Ash content (\%)} = \frac{(b - c)}{(b - a)} \times 100\% \quad (4)$$

Where: a = weight of empty crucible (g);

b = weight of crucible + sample before ashing (g);

c = weight of crucible + ash (g).

2.3.6. Protein Analysis

Protein content was analyzed using the Kjeldahl method in accordance with AOAC (2020) standards. Protein content was calculated by multiplying total nitrogen by a conversion factor of 6.25, based on the assumption that protein contains approximately 16% nitrogen ($100/16 = 6.25$) (Hossain et al., 2020). *Digestion.* A 1-gram sample of ground sea cucumber was placed into a Kjeldahl flask, followed by the addition of 1 gram of catalyst ($\text{K}_2\text{SO}_4:\text{CuSO}_4$) and 10–15 mL of concentrated H_2SO_4 . The mixture was then digested at 350–420°C for approximately 2 hours until a clear greenish solution was obtained, after which 50–100 mL of distilled water was added. *Distillation.* The digested solution was transferred into an Erlenmeyer flask, and 50–75 mL of 40% NaOH was added. Distillation was carried out for 5–10 minutes until the distillate volume in the flask reached approximately 75–100 mL, or until a green/blue color appeared, indicating the capture of ammonia (NH_3). *Titration.* The distillate was titrated with 0.1 N HCl until the color changed to pink or pale purple, and the volume of HCl used was recorded. Protein content was calculated using the following formula:

$$\% \text{ Protein} = \% \text{ N} \times \text{conversion factor} \quad (5)$$

Nitrogen content was calculated using the following formula:

$$\% \text{ N} = \frac{(V1 - V0) \times N \times 14,007 \times fp}{W} \quad (6)$$

Where: V1 = volume of HCl/ H_2SO_4 used for sample titration (mL);

V0 = volume of HCl/ H_2SO_4 used for blank titration (mL);

N = normality of standard HCl/ H_2SO_4 solution;

14.007 = atomic weight of nitrogen;

fp = dilution factor;

W = sample weight (g).

2.3.7 Fat Analysis

Crude fat was analyzed using the Soxhlet solvent extraction method with petroleum ether or diethyl ether as the solvent. The principle of this method is semi-continuous lipid extraction, in which the solvent is heated, evaporates, condenses, and drips into the extraction chamber containing the sample, then siphons back into the heating flask carrying the extracted lipids (O'Keefe, 2016). The extraction process was carried out for 3–6 hours, after which the solvent was evaporated and the fat residue was weighed to calculate the fat percentage (Drawell, 2024). A dried sample weighing 3–5 grams was wrapped in filter paper or a thimble, then placed into a Soxhlet tube with 150–200 mL of petroleum ether or n-hexane added. Extraction was carried out for 6–8 hours, after which the thimble was separated from the Soxhlet tube, and the tube was dried in an oven at 105°C for 1–2 hours. It was subsequently cooled in a desiccator and weighed. Fat content was calculated using the following formula:

$$\text{Fat content (\%)} = \frac{(b - a)}{\text{sample weight}} \times 100\% \quad (7)$$

Where: a = weight of empty fat flask (g);

b = weight of flask + fat (g).

2.3.8 Carbohydrate Analysis

Carbohydrate content of the sea cucumber was determined using the by-difference method, namely 100% minus the total percentage of moisture, protein, fat, and ash content. This method is a practical approach widely used in proximate analysis due to its simplicity (Sroyraya et al., 2017). Carbohydrate content was calculated using the following formula:

$$\text{Carbohydrate content (\%)} = 100\% - (\text{moisture content} + \text{ash content} + \text{protein content} + \text{fat content}) \quad (8)$$

2.3.9 Calcium Analysis

Calcium content was analyzed using Atomic Absorption Spectrophotometry (AAS) in accordance with AOAC (2016) procedures. The principle of this method is the measurement of light absorbance by calcium atoms at a specific wavelength of 422.7 nm, with calcium concentration in the sample determined based on a calcium standard calibration curve.

Sample Preparation (Dry Ashing). A 2–3-gram portion of the ground dried sample was placed into a porcelain crucible and dried in an oven at 105°C for 2 hours, then heated on a hot plate until the sample turned black. The sample was subsequently placed in a muffle furnace at 550°C for 4–6 hours, after which it was cooled in a desiccator for 15–30 minutes.

Ash Dissolution. Five milliliters of concentrated HCl was added slowly to the crucible containing the ash and heated on a hot plate at approximately 80°C while stirring until the ash was completely dissolved. Approximately 20 mL of distilled water was then added and stirred until homogeneous, after which the solution was filtered through Whatman No. 42 filter paper into a 100 mL volumetric flask, followed by the addition of 10 mL of 1% LaCl₃.

Preparation of Calcium Standard Solutions. A 1000 ppm calcium stock solution was prepared from CaCO₃ and diluted to obtain standard concentrations (0, 1, 2, 4, 6, and 8 ppm). Each standard solution was then supplemented with 1% LaCl₃ and distilled water up to a final volume of 100 mL.

AAS Measurement. The absorbance of the standard series was measured at a wavelength of 422.7 nm with a slit width of 0.7 nm using an air-acetylene flame. Each sample was analyzed in triplicate, and the measured absorbance values were recorded. Calcium content was calculated using the following formula:

$$\text{Ca content (mg/g)} = \frac{(C \text{ sampel} - C \text{ blank}) \times V \times fp}{W \times 1000} \quad (9)$$

Where: C sample = calcium concentration from the calibration curve (ppm/mg/L);

C blank = blank concentration;

V = final volume of sample solution (mL) = 100 mL;

Fp = dilution factor;

W = sample weight (g).

2.3.10 Magnesium Analysis

Magnesium content was analyzed using the same method as calcium analysis, namely Atomic Absorption Spectrophotometry (AAS). The principle of this method is the measurement of light absorbance by magnesium atoms at a specific wavelength of 285.2 nm (Skoog et al., 2014).

Sample Preparation (Dry Ashing). A 2–3-gram portion of the ground dried sample was placed into a porcelain crucible and dried in an oven at 105°C for 2 hours, then heated on a hot plate until the sample turned black. The sample was subsequently placed in a muffle furnace at 550°C for 4–6 hours, after which it was cooled in a desiccator for 15–30 minutes.

Ash Dissolution. Five milliliters of concentrated HCl was added slowly to the crucible containing the ash and heated on a hot plate at approximately 80°C while stirring until the ash was completely dissolved. Approximately 20 mL of distilled water was then

added and stirred until homogeneous, after which the solution was filtered through Whatman No. 42 filter paper into a 100 mL volumetric flask, followed by the addition of 10 mL of 1% LaCl₃.

Preparation of Magnesium Standard Solutions. A 1000 ppm magnesium stock solution was prepared from MgSO₄ and diluted to obtain standard concentrations (0, 1, 2, 4, 6, and 8 ppm). Each standard solution was then supplemented with 1% LaCl₃ and distilled water up to a final volume of 100 mL.

AAS Measurement. The absorbance of the standard series was measured at a wavelength of 285.2 nm with a slit width of 0.7 nm using an air-acetylene flame. Each sample was analyzed in triplicate, and the measured absorbance values were recorded. Magnesium content was calculated using the following formula:

$$\text{Mg content (mg/g)} = \frac{(\text{C sampel} - \text{C blank}) \times V \times fp}{W \times 1000} \quad (10)$$

Where: C sample = magnesium concentration from the calibration curve (ppm/mg/L);

C blank = blank concentration;

V = final volume of sample solution (mL) = 100 mL;

Fp = dilution factor;

W = sample weight (g).

2.4 Data Analysis

The abundance and biomass data obtained were analyzed descriptively using Microsoft Excel software to illustrate the variation in values across transects, with the data subsequently presented in the form of tables and graphs. Meanwhile, the sea cucumber nutritional analysis data were calculated for the mean and standard deviation of each parameter and presented in tables and graphs to display the percentage of each parameter.

III. RESULTS AND DISCUSSION

3.1 Results

3.1.1 General Condition of the Study Site

The waters of Sinaboi are located in Sinaboi Subdistrict, Rokan Hilir Regency, Riau Province, directly bordering the Malacca Strait. This area is characterized by mangrove ecosystems, shallow waters, and extensive tidal flats, and plays an important role in capture fisheries as well as the economic activities of the local community. The coastal topography is generally flat, with substrate ranging from muddy to sandy. Water quality measurement results showed a temperature range of 27–29°C, salinity of 28–29‰, pH of 6.8–7, and clarity of 90–100 cm, indicating that water conditions are fairly good and support marine life, including *P. bacillis*.

3.1.2 Identification of Sea Cucumber Samples

Identification conducted at the Research and Innovation Agency (BRIN) laboratory, based on the observation of spicule/ossicle structures in the body wall tissue along with morphological and anatomical features as supporting data, showed that the specimen had a body length of 80–150 mm with a smooth, pinkish to pale skin surface, and lacked papillae, tube feet, or tubercles. The body shape was elongate, with a tail-like posterior end. The mouth, located anteriorly, was surrounded by 15 sucker-like tentacles. Anatomically, the specimen possessed a crown-shaped calcareous ring consisting of radial and interradial pieces, with the radial pieces measuring 9 mm in height and the interradial pieces 6 mm, both 8 mm in width. The specimen had two unbranched, fringe-shaped gonads and lacked Cuvierian tubules, the specialized sticky defensive organs. Observation of the spicule/ossicle structure in the body wall tissue revealed rod-shaped spicules present in relatively small numbers. The species obtained from the Sinaboi waters can be seen in Figure 4.

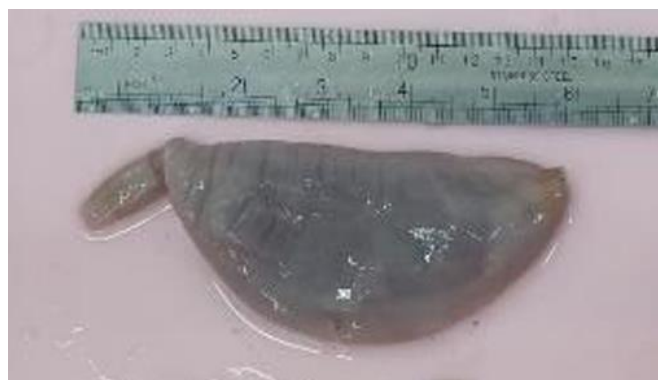


Figure 4. Morphology of *P. bacillis*

3.1.3 Abundance of *P. bacillis*

The abundance of *P. bacillis* found in Sinaboi waters, based on three observation transects, is presented in the graph shown in Figure 5.

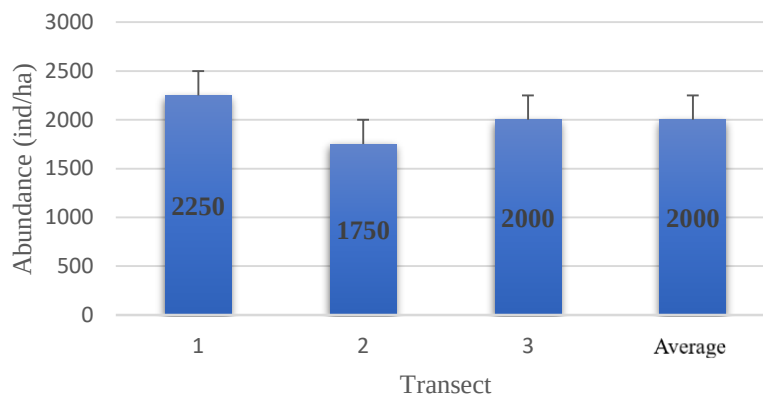


Figure 5. Average abundance ($\pm$ SD) of *P. bacillis* at each transect

Observations at the three transects showed variation in the abundance of *P. bacillis*. The highest abundance was found at transect 1 (2,250 ind/ha), followed by transect 3 (2,000 ind/ha), while the lowest abundance was found at transect 2 (1,750 ind/ha). The overall mean abundance of *P. bacillis* in the waters of Sinaboi was $2,000 \pm 250$ ind/ha. More detailed data on the distribution of abundance at each station can be seen in Table 1.

Table 1. Abundance of *P. bacillis* at each transect in the waters of Sinaboi

Transect	Total Collected	Abundance (ind/m ²)	Abundance (ind/ha)
1	45	0.225	2,250
2	35	0.175	1,750
3	40	0.200	2,000
Mean	–	–	$2,000 \pm 250$

3.1.4 Biomass of *P. bacillis*

The biomass of *P. bacillis* found in Sinaboi waters, based on three observation transects, is presented in the graph shown in Figure 6.

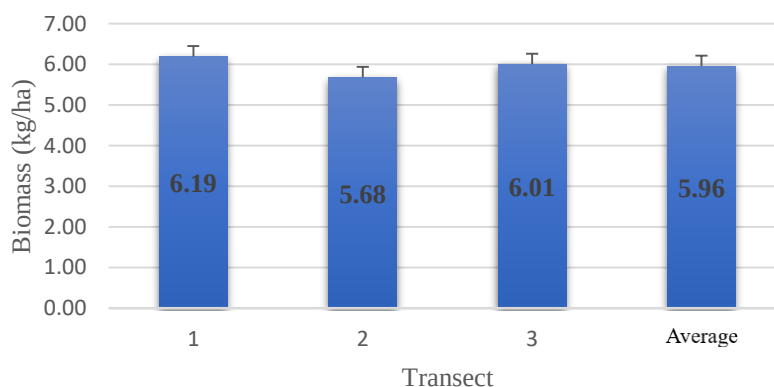


Figure 6. Average biomass ($\pm$ SD) of *P. bacillis* at each transect

Observations at the three transects showed variation in the biomass of *P. bacillis*. The highest biomass was found at transect 1 (6.19 kg/ha), followed by transect 3 (6.01 kg/ha), while the lowest biomass was found at transect 2 (5.68 kg/ha). The overall mean biomass of *P. bacillis* in the waters of Sinaboi was 5.96 ± 0.259 kg/ha. This biomass distribution pattern is consistent with the abundance pattern of individuals at the three transects, where transect 1 consistently showed the highest value and transect 2 the lowest. More detailed data on biomass at each station can be found in Table 2.

Table 2. Biomass of *P. bacillis* at each transect in the waters of Sinaboi

Transect	Total Weight (g)	Biomass (g/m ²)	Biomass (kg/ha)
1	123.8	0.619	6.19
2	113.6	0.568	5.68
3	120.1	0.601	6.01
Mean	—	—	5.96 ± 0.259

3.1.5 Nutritional Content of *P. bacillis*

The analysis of the nutritional content of *P. bacillis* found in the waters of Sinaboi is presented in the graph shown in Figure 7.

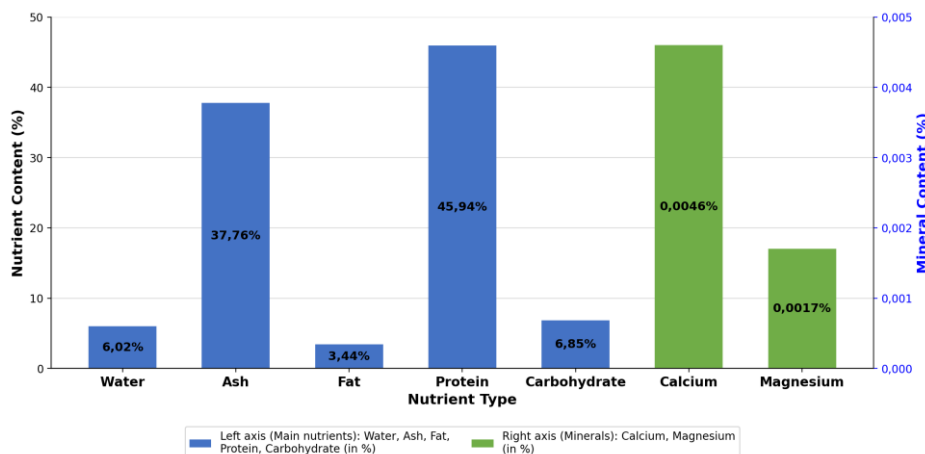


Figure 7. Nutritional content (±SD) of *P. bacillis* from the waters of Sinaboi

Based on the analysis of the nutritional content of *P. bacillis*, seven nutritional parameters were measured, namely moisture, ash, fat, protein, carbohydrate, calcium, and magnesium. The results showed that protein was the highest nutritional component, at 45.94%, followed by ash (37.76%), carbohydrate (6.85%), moisture (6.02%), and fat (3.44%). Calcium and magnesium contents were the lowest, at 0.0046% and 0.0017% respectively, indicating that these two minerals are present only in very small amounts in the body of *P. bacillis*. Overall, the dominance of protein content, which accounts for nearly half of the total nutritional composition, indicates that *P. bacillis* has potential as an animal protein source that could be further utilized. More detailed data on the nutritional content of the sea cucumber *P. bacillis* found in Sinaboi are presented in Table 3.

Table 3. Nutritional content (mean ± SD) of *P. bacillis* from the waters of Sinaboi

Parameter	Content (%)
Water	6.02 ± 0.01
Ash	37.76 ± 0.10
Fat	3.44 ± 0.02
Protein	45.94 ± 0.07
Carbohydrate	6.85 ± 0.14
Calcium	0.0046
Magnesium	0.0017

3.2 Discussion

3.2.1 Identification of Sea Cucumber Samples

The morphological characters found in this specimen — a smooth skin surface colored pale pink to pale, an elongated body shape with a posterior end resembling a tail, and the absence of papillae, tube feet, and tubercles — show consistency with the distinctive characteristics of the genus *Paracaudina*. The presence of 15 sucker-shaped tentacles further supports this identification. Anatomically, the crown-shaped calcareous ring and the fringe-shaped, unbranched gonads, together with the absence of Cuvierian tubules and the presence of rod-shaped spicules, are consistent with the description of *P. bacillis* according to O'Loughlin et al. 2011. Based on the consistency of all these characters, the specimens in this study can be identified as *P. bacillis*.

3.2.2 Abundance

The mean abundance of *P. bacillis* in the waters of Sinaboi (2,000 ± 250 ind/ha) is relatively low compared with several other sea cucumber species in Indonesian waters, such as *Holothuria leucospilota*, whose abundance is strongly influenced by the density of seagrass ecosystems in its habitat. This difference can be explained by differences in habitat characteristics, in which *P. bacillis* is an inhabitant of soft muddy substrate that does not depend on seagrass or coral reef ecosystems, so that its level of abundance is naturally lower. The variation in abundance among transects (2,250, 1,750, and 2,000 ind/ha) likely reflects differences

in substrate condition and organic matter content, given that *P. bacillis* is a deposit feeder that is highly dependent on substrate quality as its food source.

3.2.3 Biomass

The mean biomass of *P. bacillis* (5.96 ± 0.259 kg/ha) is very low compared with large commercial sea cucumber species living on hard or rocky substrate, given that *P. bacillis* is a small-bodied sea cucumber that lives buried within fine muddy substrate. As a deposit feeder, the feeding and movement activity of *P. bacillis* within the substrate also plays a role in the process of sediment bioturbation and nutrient recycling on the seabed (Uthicke 1999). The pattern of biomass variation among transects is consistent with the pattern of individual abundance, indicating that the difference in biomass is more strongly influenced by the number of individuals found than by differences in individual body size, consistent with the relatively uniform body size of species within the genus *Paracaudina*.

3.2.4 Nutritional Content

The moisture content of *P. bacillis* (6.02%) falls within the range of good-quality dried sea cucumber (Herliany et al. 2016), indicating that the drying process was carried out properly so that the product also has good storage stability. The ash content (37.76%) is much higher than that of dried sea cucumber in general (Bordbar et al. 2014), which is likely related to the deposit-feeding habit of *P. bacillis*, which lives buried in mineral-rich muddy substrate. The protein content (45.94%) is above the range generally reported for fresh sea cucumber protein (Karnila et al. 2011), indicating the potential of *P. bacillis* as a high-protein food material, supported by the dominance of collagen structure in the body wall and muscle tissue, which is a general characteristic of the class Holothuroidea. The fat content (3.44%) is relatively low, a general characteristic of sea cucumbers, so that *P. bacillis* has potential as a low-fat protein source. The carbohydrate content (6.85%) falls within the general range of dried sea cucumber. Meanwhile, the calcium (0.0046%) and magnesium (0.0017%) contents are much lower than in other sea cucumber species (Rasyid 2017), which is likely related to the softer body-wall characteristics of *P. bacillis*, which does not have prominent calcified structures such as tubercles or calcareous papillae.

IV. CONCLUSION

The mean abundance of *P. bacillis* in the waters of Sinaboi was recorded at $2,000 \pm 250$ ind/ha, with the highest value at transect 1 (2,250 ind/ha) and the lowest at transect 2 (1,750 ind/ha). The mean biomass was recorded at 5.96 ± 0.259 kg/ha, with a distribution pattern consistent with its abundance. Proximate analysis results showed that *P. bacillis* has the highest protein content (45.94%), followed by ash content (37.76%), carbohydrate (6.85%), moisture content (6.02%), fat (3.44%), and very low calcium and magnesium (0.0046% and 0.0017%), so that *P. bacillis* has potential as an animal protein source. Based on the consistency of morphological, anatomical, and spicule structure characters, the sea cucumber specimens found in the waters of Sinaboi were identified as the species *Paracaudina bacillis*.

V. ACKNOWLEDGMENT

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