COMPARISON OF GROWTH AND SURVIVAL OF BROWN MUSSEL ( *Mytilopsis adamsi* ) CULTURED IN ESTUARINE AND MARINE WATERS

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ABSTRACT

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| The brown mussel (*Mytilopsis adamsi*) is a small bivalve mollusk that typically reaches a maximum length of 1.5 cm. It is a filter feeder, consuming zooplankton, phytoplankton, and suspended organic matter. Originally distributed throughout the Indo-Pacific region, this species is now found in several countries, including Malaysia, Taiwan, and Australia. In Indonesia, brown mussels have recently begun to be cultivated, primarily as a natural feed source for economically valuable crustaceans such as crabs and lobsters.This study aimed to determine the differences in the growth and survival of brown mussels ( *M. adamsi* ) in the estuary and marine environments. The importance of this study was in determining the optimal location for cultivating brown mussels (*M. adamsi*). The experiment consisted of 2 treatments (estuarine and marine), with 10 replicates per treatment, resulting in a total of twenty experimental units, using 50 brown mussels (*Mytilopsis adamsi*) per replication. Data that followed a normal distribution were analyzed using an independent samples t-test at a significance level of *p* < 0.05. The data did not meet the assumption of normality, the non-parametric Mann–Whitney U test was used as an alternative statistical method. The culture experiment was conducted for 90 days in two locations: an estuarine zone in Bagek Kembar Village and a marine zone in Cendi Manik Village, West Lombok Regency, West Nusa Tenggara, Indonesia. The results showed that absolute, relative, and specific length, as well as the survival rate of brown mussels, were significantly higher (*p* < 0.05) in the estuarine zone compared to the marine zone. The estuary zone's absolute, relative, and length-specific growth were 19.70 mm, 608%, and 2.35%, respectively, and the survival rate was 70%. Meanwhile, the absolute, relative, and length-specific growth in the marine zone were 13.12 mm, 471%, and 1.95%, respectively, and the survival rate was 57%. The average length of mussels in the estuary and marine environment reached 22 mm and 15 mm, respectively. The final weight of the mussels in the estuary was 1.10 g, while in the sea was 0.48 g. The weight of the mussel meat cultured in the estuary zone was around 0.71 grams per mussel, which was higher than mussel meat cultured in the seawater, which was around 0.19 grams per mussel. The total organic matter in the estuary and the marine zone was 70-110 mg/L and 35-65 mg/L, respectively. This study demonstrates that the estuarine environment provides significantly more favorable conditions for the growth and survival of brown mussels (Mytilopsis adamsi) compared to the marine environment. Estuarine waters, formed at the confluence of seawater and freshwater, create nutrient-rich ecosystems with abundant natural food sources that promote faster mussel growth. In contrast, marine waters are characterized by higher salinity and limited nutrient availability, which may constrain the growth performance of M. adamsi. |

*Keywords: Mytilopsis adamsi, estuarine, marine, growth, survival rate.*

1. INTRODUCTION

Indonesia is a maritime country with vast ocean areas and abundant marine resources spread across its many islands. However, these resources have not yet been fully utilized. One of the marine species that deserves more attention for its potential use is the brown mussel (Mytilopsis adamsi), A small-sized bivalve, reaching a length of approximately 1.5 cm, and functioning as a filter feeder by consuming phytoplankton, zooplankton, and suspended organic matter. This species uses byssal threads to attach itself to underwater surfaces and often lives in dense groups on rocks, wood, or artificial structures. In addition to its adaptability and ecological role, M. adamsi is known to contain high levels of protein and important minerals, making it a valuable nutritional resource. Historically, M. adamsi spread throughout the Indo-Pacific region in the 19th century and is now found in countries such as Fiji, India, Malaysia, Taiwan, Japan, and Australia. In Indonesia, this species has been recorded in local waters and is beginning to be cultivated, especially as a natural feed source for crustaceans such as crabs and lobsters. With its good nutritional content, strong adaptability, and potential for cultivation, M. adamsi could become an important species for sustainable aquaculture development (Wangkulangkul, 2018).

Mytilopsis adamsi is a highly adaptable species capable of surviving in a wide range of aquatic environments, including estuarine and marine conditions (Maghfiroh, 2023). Estuarine ecosystems are generally nutrient-rich due to riverine input, making them favorable for mussel cultivation (Murniati, 2010). The estuarine zone also exhibits high fertility, characterized by the presence of dissolved nutrients and abundant natural food sources, which support optimal growth of brown mussels. In contrast, marine environments are rich in plankton diversity, which also contributes to mussel development. Moreover, marine aquaculture offers the advantage of increasing production without requiring large land areas (Halimatussa’diyah *et al.,* 2022). Given these environmental characteristics, both estuarine and marine systems present promising potential for the cultivation of M. adamsi.

This study was conducted to evaluate the differences in the growth and survival of brown mussels (*Mytilopsis adamsi*) cultured in estuarine and marine environments. The selection of appropriate cultivation sites is crucial, as environmental conditions directly influence growth performance and survival rates in mussel farming. Suboptimal site selection may negatively affect both the growth and quality of the cultured mussels. Therefore, this research aims to determine the optimal cultivation site for *M. adamsi* to improve productivity and farming efficiency, which could positively impact the availability of brown mussels as a sustainable feed source. Specifically, brown mussels may serve as a natural, nutrient-rich diet for economically important crustacean species such as lobsters and crabs.

1. research methods

**2.1 Research methods**

This mussel cultivation was conducted over 90 days, from December 2024 to March 2025. The study took place in two locations: the estuarine zone in Bagek Kembar and the marine zone in Cendi Manik Lombok Barat district, Nusa Tenggara Barat. Additional analyses, including water quality and plankton identification, were carried out at Balai Perikanan Budidaya Laut Lombok. The equipment used in this study included nets, collectors, ropes, sample bottles, plankton nets, water quality measuring instruments, digital calipers, and scale.

The experimental design consisted of two treatments—cultivation in estuarine and marine environments—with ten replications each, yielding a total of 20 experimental units. Each unit used 50 brown mussels (*M. adamsi*), making a total of 1,000 mussels. Prior to statistical analysis, data normality was assessed using the Shapiro–Wilk test. For normally distributed data with equal variances, an independent samples t-test was applied to compare the two treatments (estuarine vs. marine). For data that did not meet the assumptions of normality, the non-parametric Mann–Whitney U test was used as an alternative. Statistical analyses were conducted separately for each parameter, including absolute growth, relative growth, length-specific growth, final weight, meat weight, and survival rate. Results were considered statistically significant at *p* < 0.05. Water quality parameters, total organic matter (TOM), plankton abundance, and stomach content were analyzed descriptively.

The research began with the collection of mussel larvae using collectors measuring 20 × 20 cm. A total of 20 collectors were soaked for 24 hours in a breeding tank to facilitate the attachment of mussel larvae. The mussels had an initial size of 2.5–3.0 mm before undergoing the 30-day rearing period. The number of mussels on each collector was standardized to 50 individuals. After this initial stage, the collectors were transferred to the estuarine and marine cultivation sites. The mussels were then cultured for 90 days using the longline method, in which they were placed inside mesh bags and suspended from ropes. During the rearing period, shell length growth, water quality, and plankton abundance were monitored every 14 days, while total organic matter (TOM) was measured every 20 days. At the end of the cultivation period, stomach content analysis was conducted to identify the types of plankton consumed by the mussels.

 1 2

Description:

1. Rope
2. Float
3. Bag
4. Substrate
5. Weight

 3 4

**Figure 1. Experimental Unit** 5

3. RESULTS AND DISCUSSION

3. 1 Growth of brown mussels ( *M. adamsi* ).

The results demonstrated that the absolute, relative, and specific length growth, as well as the survival rate of *Mytilopsis adamsi*, were significantly higher (*p* < 0.05) in the estuarine zone than in marine waters. In the estuarine environment, absolute length growth reached 19.70 mm, relative growth was 608%, and the specific growth rate (SGR) was 2.35% (Fig. 2–4), with a survival rate of 70% (Fig. 7). In contrast, mussels cultured in marine waters exhibited an absolute length growth of 13.12 mm, relative growth of 471%, an SGR of 1.95%, and a survival rate of 57%. After 90 days of cultivation, the average shell length of mussels in the estuarine environment reached 22 mm, which was significantly greater (*p* < 0.05) than that observed in marine waters (15 mm) (Fig. 5). The final total weight of mussels in the estuarine zone was 1.10 g, compared to 0.48 g in the marine zone. Moreover, the average meat weight per individual mussel was 0.71 g in the estuarine zone, significantly higher (*p* < 0.05) than that in the marine environment, which averaged 0.19 g (Fig. 6). These findings suggest that estuarine conditions provide a more favorable environment for the growth and survival of *M. adamsi* compared to marine waters.

This difference in growth performance is attributed to the varying environmental characteristics between the two cultivation sites. According to Muhtadi *et al*. (2024), Mussels can grow up to 2.5 cm in length within 3 months of cultivation, which is the typical size used as broodstock in aquaculture systems. Tokumon *et al.* (2016) noted that estuarine environments generally contain higher nutrient concentrations than marine waters, contributing to better growth conditions. Similarly, Zainuri et al. (2023) explained that estuaries, as transitional zones where freshwater meets seawater, are typically rich in nutrients, creating favorable conditions for faster bivalve growth compared to marine environments, which are characterized by higher salinity and lower nutrient availability. Jafar (2023) also emphasized that the growth of brown mussels is strongly influenced by environmental factors such as substrate type and natural food availability. Mussels cultured in muddy, nutrient-rich substrates exhibit more optimal growth than those reared in sandy or rocky habitats.

Brown mussels cultivated in estuarine environments tend to have greater total and meat weights than those reared in marine environments. According to Abadi (2025), mussel growth in terms of length and weight is influenced by environmental quality and food availability; the better these conditions, the heavier the mussels and the more meat they produce. Dari (2023) also stated that estuarine areas are highly suitable for brown mussel growth due to their abundant nutrient availability, weaker water currents, and lower predator pressure. Estuarine environments are known for their high productivity, supported by rich nutrient content and stable physico-chemical conditions. In contrast, marine environments often present limiting factors such as strong currents, higher salinity, and limited food availability, all of which can hinder the optimal growth of mussels.​

**Figure 2. Absolute Length Growth​**

**Figure 3. Relative length growth**

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**Figure 4. Specific length growth**

**Figure 5. Length growth over 90 days**

**Figure 6. Final Weight and Meat Weight**

**Figure 7. Survival Rate**

* 1. **Total Organic Matter** (**TOM)**

The results of the study showed that the (TOM) content was higher in the estuarine zone compared to the marine environment (Fig. 8). The higher fertility of waters in the estuarine zone is attributed to the abundance of nutrients, as indicated by TOM levels ranging from 70–110 mg/L, while TOM in the marine zone ranged from 35–65 mg/L. This finding is supported by Ningrum et al. (2024), who noted that the optimal TOM concentration in aquatic environments typically ranges from 0.01 to 30 mg/L. According to Jubaedah (2021), high levels of Total Organic Matter (TOM) in aquatic environments can lead to a decrease in dissolved oxygen (DO) and promote algal blooms. Although the TOM values observed in this study exceed the optimal range, stated that Astriani *et al.* (2022) explained that high TOM concentrations can serve as a valuable natural food source. This is because TOM contains both dissolved and particulate organic compounds, as well as inorganic nutrients, which are essential for the growth of phytoplankton and benthic microorganisms. These organisms, in turn, form the base of the food chain and serve as natural food for shellfish, including brown mussels.

Several factors contribute to TOM levels, such as phytoplankton biomass, detritus, and organic matter carried by river discharge. These components enhance the nutrient content of the water, supporting phytoplankton growth and potentially leading to blooms. In conditions where inorganic nutrients are limited, phytoplankton can utilize organic matter as an alternative carbon, nitrogen, and phosphorus source. According to Silaban (2021), estuarine waters with muddy substrates and high organic content provide ideal conditions for the growth of brown mussels, especially in calm and nutrient-rich environments where physical disturbances and predator pressure are minimal. .

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**Figure. 8 TOM (Total Organic Meter)**

* 1. **Plankton Abundance**

Based on the results of the study, plankton in the estuary was dominated by Chaetoceros with an abundance of 840 ind/L, followed by Skeletonema (360 ind/L) and Copepoda (253 ind/L). In contrast, in the marine environment, Nauplius showed the highest abundance (350 ind/L), followed by Skeletonema (331 ind/L) and Protoperidinium (256 ind/L). The abundance data are presented in Table 1.

Plankton found in the estuarine zone included both zooplankton and phytoplankton, such as Chaetoceros, Skeletonema, and Copepoda. In the marine zone, the identified plankton included Prorocentrum, Skeletonema, Nitzschia, Coscinodiscus, and Chaetoceros. Although species like Chaetoceros and Skeletonema, which are considered good feed for brown mussels (*M. adamsi*), were found in both environments, the higher abundance of plankton in the estuary zone is believed to better support their growth. According to Widiarti (2016), Prorocentrum belongs to the dinoflagellate group and has the potential to be toxic when present in high concentrations. The greater diversity and nutritional content of plankton in the estuary may contribute to enhanced growth of brown mussels. .

**Table 1. Plankton Abundance**

|  |  |  |
| --- | --- | --- |
|  | Genus | Abundance \ L |
|  | Thalssiosira | 135 |
|  | Nitzschia | 122 |
|  | Synedria | 98 |
|  | Brachionus | 110 |
|  | Skeletonema | 360 |
|  | Copepoda | 253 |
| Estuarine | Anabaena | 95 |
|  | Melosira | 157 |
|  | Closterium | 63 |
|  | *O. princeps* | 98 |
|  | Oscillatoria | 166 |
|  | *Nauplius* | 233 |
|  | Scenedesmus | 47 |
|  | Coscinodiscus | 89 |
|  | Ceratium | 453 |
|  | Chaetocheros | 840 |
|  | *Keratella cochlearis* | 132 |
|  | Rhizomesolenia  | 112 |
|  | Nauplius | 350 |
|  | Synedra | 133 |
|  | Asterionella | 67 |
|  | Leptocylindrus | 65 |
|  | Coscinodiscus | 103 |
|  | Pyrocyst | 58 |
|  | Protoperidinium | 256 |
| Marine | Rhizomesolenia | 95 |
|  | *Prorocentrum* | 134 |
|  | Copepoda | 132 |
|  | Bacillariophyceae | 40 |
|  | Oscillatoria | 32 |
|  | *Keratella cochlearis* | 38 |
|  | Chaetoceros | 321 |
|  | Ceratium | 232 |
|  | Pleurosigma | 33 |
|  | Thalassiosira | 106 |
|  | Skeletonema | 331 |
|  | Pinnularia | 16 |
|  |  |  |

### **Analysis of plankton in stomach**

The analysis of stomach contents of brown mussels (*M. adamsi*) cultured in the estuarine zone revealed the presence of various plankton species, including Thalassiosira, Peridinium, Navicula, Nitzschia, and Chaetoceros. In contrast, stomach of mussels from the marine zone contained Prorocentrum, Skeletonema, Nitzschia, and Chaetoceros (Table 2). Most plankton identified in both environments were diatoms, particularly Thalassiosira, Chaetoceros, and Skeletonema.

According to Fadila et al. (2021), Thalassiosira is considered a high-quality natural feed source for bivalves due to its rich protein content and essential fatty acids, which are critical for optimal growth. The high growth performance observed in mussels cultured in the estuarine zone may be attributed to the availability and abundance of such nutritious plankton. This is supported by Rahayu et al. (2024), who noted that the presence of microalgae such as Chlorella, Chaetoceros, Navicula, and Thalassiosira is a diatom commonly used in aquaculture and plays a significant role in supplying essential nutrients to mussels, thereby promoting enhanced growth.

**Table 2. Plankton analysis in stomach**

|  |
| --- |
| genus of plankton |
| Estuarine | Marine |
| Thalassiosira | Prorocentrum |
| Peridinium | Skeletonema |
| Navicula | Nitzschia |
| Nitzschia | Chaetocheros |
| Chaetocheros |  |

### **Water Quality**

The water quality parameters observed during the research included pH, temperature, salinity, and light intensity. Measurements were taken daily throughout the 14-day cultivation period. The water quality data are presented in Table 3.

**Table 3 Water Quality During Research**

|  |  |  |
| --- | --- | --- |
| day | Estuarine | Marine |
|  | pH | Salinity(ppt) | Temperature˚C | DOmg\l | pH | Salinity(ppt) | Temperature˚C | DOmg\l |
| 15 | 6.7 | 20 | 28 | 5.7 | 7.7 | 30 | 30 | 5.2 |
| 30 | 7.1 | 23 | 29 | 5.0 | 7.4 | 32 | 31 | 7.3 |
| 45 | 7.2 | 24 | 27 | 6.3 | 7.3 | 33 | 29 | 6.8 |
| 60 | 7.1 | 19 | 29 | 6.5 | 7.5 | 31 | 33 | 7.0 |
| 75 | 6.9 | 20 | 31 | 4.9 | 7.6 | 30 | 29 | 5.8 |

Water quality parameters observed during the study included pH, temperature, salinity, and dissolved oxygen (DO). Measurements were conducted every fourteen days during the rearing period (Table 3). The results indicated notable differences between the two environments. Salinity levels in the marine environment were significantly higher, ranging from 30–33 ppt, while the estuarine zone showed lower salinity values, ranging from 18–24 ppt. Temperature in the marine zone ranged from 29–33°C compare to 27–31°C in the estuarine zone. DO levels ranged from 5.2–7.3 mg/L in the sea and 4.3–7.0 mg/L in the estuary. According to Wangkulangkul (2018), the optimal temperature range for brown mussels is 20–35°C, indicating that both environments provided suitable thermal conditions for mussel growth. However, the optimal salinity range is 5–27 ppt, suggesting that the lower salinity in the estuarine environment is more favorable for brown mussel development. Muhtadi (2024) also noted that DO concentrations above 4 mg/L are sufficient to support mussel metabolism and reduce the risk of environmental stress, a condition met by both sites.

In terms of pH, marine waters exhibited slightly higher values (7.0–7.7) compared to the estuary (6.9–7.2). According to Hytchings et al. (2002), Mytilopsis can grow and thrive within a pH range of 6.5–7.5, indicating that the estuarine environment offers conditions that are more supportive of optimal mussel growth. These variations in water quality help explain the differences in growth and survival observed between the two environments. Silaban et al. (2021) noted that brown mussels possess a high tolerance to fluctuating environmental conditions. However, optimal growth is more likely when mussels are cultured in environments with stable and favorable parameters, such as those found in estuarine ecosystems.

4. Conclusion

The results of this study indicate that the growth performance of brown mussels (*M. adamsi*) is significantly better in the estuarine zone compared to marine waters. After 90 days of cultivation, the average shell length of brown mussels in the estuarine environment reached 22 mm, whereas in the marine environment it was only 15 mm. Absolute length growth in the estuary reached approximately 19 mm, while in marine waters it ranged between 10–15 mm. Relative length growth in the estuary was 608%, compared to 471% in the sea, and the specific growth rate was 2.35% in the estuary and 1.95% in the marine environment. In terms of survival, mussels cultured in the estuarine zone had a survival rate of 70%, which was higher than the 57% observed in the marine environment. These findings suggest that the estuarine zone provides more favorable environmental conditions for the cultivation of brown mussels.

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Reference

Abadi, MF, Suryono, CA, & Hartati, R. (2025). Analysis of the Relationship between Length and Weight of Blood Clams and Green Clams in Tambak Lorok Waters, Semarang. *Journal of Marine Research, 14* (1), 166-172.

Astriana, BH, Putra, AP, & Junaidi, M. (2022). Phytoplankton Abundance as an Indicator of Water Quality in Labangka Sea Waters, Sumbawa Regency. *Unram Fisheries Journal, 12* (4), 710-721. <https://doi.org/10.29303/jp.v12i4.400>

Dari, TO, Haser, TF, Putriningtias, A., Darsiani, D., Febri, SP, Harahap, & Iskandar, A. (2023). Water Quality in the Habitat of Sembilang Fish (Plotosus canius) in the Estuary of Langsa City. Journal of Tropical Fisheries Management *,* 7 *(* 2), 117-125.

Fadila, AR, Suminto, S., Subandiyono, S., & Chilmawati, D. (2021). The Effect of N:P Ratio in Culture Media on Growth Patterns and Protein Content of Thalassiosira sp. Tropical Aquaculture Science: *Indonesian Journal of Tropical Aquaculture, 5* (2), 147-158.

Halimatussa'diyah, E., Karina, ST, Annisa, G., & Pulungan, NA (2022). Analysis of Cultivation Potential in Marine Ecosystems. *Journal of Education and Counseling, 4* (6), 10696-10701. <https://doi.org/10.31004/jpdk.v4i6.10091>

Jafar, J. (2023). Identification of Morphological Variation and Density of Feather Clams ( *Anadara antiquata* ) in Barru Regency. *Biology and Education Journal* , *3* (2), 97-111. <https://doi.org/10.25299/baej.2023.13611>

Jubaedah, S., Wulandari, S. Y., Zainuri, M., Maslukah, L., & Ismunarti, D. H. (2021). A study of organic matter content in the estuarine waters of the Jajar River, Demak Regency, Central Java. *Indonesian Journal of Oceanography*, 3(3), 230–236.

 <https://doi.org/10.14710/ijoce.v3i3.11442>

Maghfiroh, F., Ardiyansyah, F., & As'ari, H. (2023). Relative Abundance and Similarity of Gastropod Classes in the Mangrove Estuary Area of Muncar District, Banyuwangi. Biosense Journal, 6(01), 12–25. <https://doi.org/10.36526/biosense.v6i01.2493>

Muhtadi, A., Leidonald, R., Rahmawati, A., & Kautsari, N. (2024). New Record and Population Dynamics of The Invasive Bivalve *Mytilopsis Sallei* (Récluz, 1849) In A Tropical Coastal Lake From Indonesia. *BioInvasions Record* , *13* (2), 453–467.

Murniati, DC (2010). Composition of Ocypodidae Crab Species (Decapoda: Brachyura) in Mangrove and Estuary Ecosystems, Ujung Kulon National Park. Biota: tokumon *Scientific Journal of Life Sciences* , 257-265.

 <https://doi.org/10.24002/biota.v15i2.2724>

Ningrum, RW, Zainuri, M., & Wulandari, SY (2024). Study of Organic Material Content and Distribution in Pekalongan City Waters. *Indonesian Journal of Oceanography* , *6* (2), 159-164. <https://doi.org/10.14710/ijoce.v6i2.18193>

Rahayu, EP, Hastuti, S., & Widowati, LL (2024). Survival and Growth Profile of Green Mussels ( *Perna viridis* ) at Different Compound Structure Positions in Timbulsloko, Sayung, Demak. *Journal of Aquaculture Management and Technology, 13* (1), 1-10. <http://ejournal-s1.undip.ac.id/index.php/jamt>

Silaban, R., Silubun, DT, & Jamlean, AAR (2021). Ecological Aspects and Growth of Feather Clams ( *Anadara antiquata* ) in Letman Waters, Southeast Maluku Regency. *Indonesian Journal of Marine Science and Technology* , *14* (2), 120-131.

<https://doi.org/10.21107/jk.v14i2.10325>

Tokumon, R., Cataldo, D., & Boltovskoy, D. (2016). Effects of Suspended Inorganic Matter On Filtration and Grazing Rates Of The Invasive Mussel Limnoperna Fortunei (Bivalvia: Mytiloidea). *Journal of Molluscan Studies* , *82* (1), 201-204

Wangkulangkul, K. (2018). Comments on restricted distribution of Mytilopsis adamsi Morrison, 1946, a non-native false mussel in the Songkhla Lagoon System, southern Thailand. *Limnology,* *19* (1), 151-156

Widiarti, R., Pudjiarto, R., Fathoniah, I., & Adi, A. (2016). Epiphytic Dinoflagellates on Macroalgae with Potential to Cause Ciguatera Fish Poisoning in the Waters of Weh Island, Aceh**.** In *Proceedings of the National Seminar of the Indonesian Biodiversity Society* (Vol. 2, No. 1, pp. 97–102). <https://doi.org/10.13057/psnmbi/m020119>

Zainuri, M., Indriyawati, N., Syarifah, W., & Fitriyah, A. (2023). Correlation of Light Intensity and Temperature to Phytoplankton Abundance in the Estuary Waters of the Bangkalan Plate Edge. *Marina Oceanography Bulletin* , *12* (1), 20-26

<https://doi.org/10.14710/buloma.v12i1.44763>