Vol. 6 No. 2 Edisi Mei 2026 E. ISSN. 2775-2445

Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

ANALYZING ECOLOGICAL INTERACTIONS OF MARINE ORGANISMS FOR LOCAL ENVIRONMENT-BASED ANIMAL ECOLOGY LEARNING

Aulia Azmi[1], Rusnizar[2], Asyifa Umaira[3], Hanifah Fakhirah[4], Nadia Aldyza[5*]
[1,2,3,4] Faculty of Teacher Training and Education, Universitas Almuslim
[5*] Faculty of Teacher Training and Education, Universitas Almuslim
[*]Email: nadia.aldyza@gmail.com

DOI: https://doi.org/10.37081/jipdas.v6i2.4680

Abstract

Animal ecology learning in biology education remains predominantly theoretical and often overlooks the potential of local environments as authentic learning resources. Addressing this gap, the present study analyzes the ecological relationships among marine biota based on field observations and explores their potential to support context based animal ecology learning. This study employed a descriptive qualitative approach complemented by quantitative data. Data were collected through field observations using the belt transect method across three observation lines in the coastal area of Beurawang, Sabang. The data were analyzed descriptively to identify marine biota, examine their ecological roles, and relate these findings to key concepts in animal ecology learning. In addition, Spearman correlation analysis was applied to examine relationships among species. The findings identified five dominant marine biota groups, namely sea stars (*Linckia laevigata*), sea urchins (*Echinoidea*), nudibranchs (*Nudibranchia*), coral reefs (*Anthozoa*), and giant clams (*Tridacna* sp.), each contributing differently to the coastal ecosystem. The correlation analysis revealed significant positive associations among several species, with coral reefs acting as a central component that strongly influences the presence of other organisms. This indicates that coral habitat structure plays a crucial role in shaping the distribution and stability of benthic communities. Importantly, the study highlights that field based ecological data offers strong potential as meaningful learning resources. The empirical findings can be integrated into instructional practices to support the teaching of ecological concepts such as species interactions, trophic relationships, adaptation, and ecosystem balance in a more contextual and relevant manner. This study therefore contributes to bridging the gap between ecological field research and biology education by promoting the use of local environmental contexts in learning.

Keywords: Ecology, Marine Biota, Correlation, Learning, Environment

1. INTRODUCTION

Animal ecology learning in biology education plays a strategic role in helping students understand the reciprocal relationships between organisms and their environments. Animal ecology does not merely address the presence of organisms, but also explores the complex interactions within ecosystems, including trophic relationships, adaptation, as well as population and community dynamics (Begon et al., 2020; Odum & Barrett, 2020). Ideally, the learning of animal ecology should foster students' critical, analytical, and contextual thinking skills in interpreting environmental phenomena (Bissinger & Bogner, 2018). However, in practice, animal ecology instruction often remains largely theoretical and focused on conceptual mastery, with limited opportunities for direct field experience. As a result, students tend to understand concepts in an abstract manner and struggle to relate them to real environmental conditions.

This limited connection between theory and real-world contexts can affect the quality of students' understanding of ecological concepts. Students frequently encounter difficulties when interpreting concepts such as species interactions, ecological niches, and ecosystem balance in the absence of empirical experience. This suggests the need for instructional approaches that better connect theory with practice. One promising approach is the use of local environment based learning, which draws on the surrounding environment as a learning resource. This approach emphasizes the use of real contexts in the learning process, enabling students to develop deeper and more meaningful understanding (Ardoin et al., 2020). Coastal environments represent ecosystems with high biodiversity and complex ecological interactions. These ecosystems not only serve as habitats for a wide range of marine organisms but also function as life supporting systems with ecological, economic, and educational value (Barbier et al., 2019). The diversity of marine biota found in coastal areas offers significant potential as a learning resource in animal ecology. Through field observation activities, students can directly examine organism diversity, morphological characteristics, and ecological interactions within the ecosystem. In this way, learning is no longer confined to textbooks but is enriched by real experiences that can strengthen students' conceptual understanding (Fägerstam & Blom, 2022).

The use of field observation data plays an important role in bridging theory and practice. Data obtained from direct observation can serve as contextual and relevant learning materials. In addition, observation activities help develop students' scientific skills, including observing, identifying, classifying, and analyzing ecological phenomena. Therefore, field based learning not only enhances conceptual understanding but also supports the development of essential science process skills in biology education. Several types of marine biota commonly found in coastal areas, such as sea stars, sea urchins, coral reefs, giant clams, and nudibranchs, exhibit distinct characteristics and ecological roles within the ecosystem. Sea stars, for example, contribute to maintaining population balance through predation and detritivory. Sea urchins function as regulators of algal growth, while coral reefs serve as primary habitats for various marine organisms and play a key role in maintaining ecosystem stability. Meanwhile, nudibranchs are often regarded as indicators of environmental conditions due to their sensitivity to changes in water quality. The diversity and ecological roles of these organisms can be utilized to illustrate key concepts in animal ecology, including biodiversity, food chains, species interactions, and ecosystem balance (Begon et al., 2020).

Despite its considerable potential, the use of field observation results as a learning resource in biology education has not been optimally and systematically implemented. Most instructional practices still rely on conventional learning resources that do not fully incorporate local environmental potential. This has resulted in limited integration between field research findings and classroom learning. In fact, such integration is essential for creating learning experiences that are relevant, contextual, and grounded in real situations (Ardoin et al., 2020). However, studies that utilize field observation data of marine biota as a direct source of learning materials are still limited, particularly those that integrate ecological relationship analysis among species into animal ecology instruction. In many cases, field observations are used only for descriptive purposes without further linking the ecological roles and interspecies relationships to learning content. As a result, the potential of empirical data, especially from coastal ecosystems, has not been fully explored as a structured and conceptually relevant learning resource in animal ecology.

Based on these considerations, this study aims to analyze the ecological relationships among marine biota based on field observation data in a coastal environment. In addition, the study explores the relevance of these ecological findings to animal ecology learning within a local environmental context. The findings are expected to contribute to the enrichment of biology instruction by providing empirically grounded examples that support the understanding of ecological concepts.

2. METHODS

This study employed a descriptive approach supported by quantitative data to analyze the ecological relationships among marine biota based on field observations. This approach was selected to provide a systematic and factual description of the observed organisms, particularly in identifying marine biota and examining their ecological roles within the coastal ecosystem (Creswell & Creswell, 2018). The research was conducted in the coastal waters of Beurawang, Sabang, an area characterized by shallow marine ecosystems with relatively high biodiversity. Fieldwork was carried out during low

Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

tide conditions to facilitate direct observation and identification of marine organisms in their natural habitats.

Data were collected through field observation, documentation, and literature review. Field observation served as the primary data collection technique, allowing the researcher to obtain firsthand information on the types and characteristics of marine biota present at the study site. Observations were conducted using the belt transect method, in which a defined observation path is established to record the presence of organisms within a specified area. This method was chosen for its effectiveness in assessing the distribution and diversity of coastal organisms in a systematic and measurable manner (English, Wilkinson, & Baker, 2020). Each transect measured 50 meters in length, with a total observation width of 2 meters, consisting of 1 meter on each side of the transect line. This configuration provided a representative sampling area for identifying the presence and distribution of marine biota. A total of three transects were established parallel to the shoreline. The parallel placement was intended to capture the distribution of marine organisms within relatively homogeneous zones, ensuring more consistent data and enabling comparisons across transects (Hill & Wilkinson, 2019).

To increase the level of detail and the number of analysis units, each transect was systematically divided into smaller observation plots along its length. This division resulted in a total of 30 observation plots across all transects. Each plot represented a distinct segment within the transect area, allowing for more detailed recording of species abundance and spatial distribution. This approach made it possible to capture not only general patterns across transects but also finer scale variations within the study area. Within each observation plot, the number of individuals for each type of marine biota was recorded, including sea stars, sea urchins, nudibranchs, coral reefs, and giant clams. Observations were conducted by following the transect line and examining the designated belt area on both sides. All individuals found within the plot boundaries were counted and documented to support accurate identification. This procedure enabled the collection of detailed and systematically organized data suitable for both descriptive and quantitative analysis.

Data analysis was carried out in several stages, including the identification of marine biota, classification based on taxonomic groups, and analysis of their ecological roles. Quantitative data in the form of species abundance were further analyzed using Spearman correlation to examine relationships among species, with a significance level of 0.05 (Field, 2018). In addition, the results were interpreted to explore their relevance to animal ecology learning, particularly in illustrating ecological concepts such as species interactions, trophic relationships, adaptation, and ecosystem balance within a local environmental context. Through this approach, the study not only generates ecological data but also highlights their potential contribution to more contextual and meaningful biology instruction.

3. RESULT AND DISCUSSION

Field observations conducted using the belt transect method across three observation lines in the coastal area of Beurawang revealed the presence of five main types of marine biota, namely blue sea stars (*Linckia laevigata*), sea urchins (class Echinoidea), nudibranchs (order Nudibranchia), coral reefs (class Anthozoa), and giant clams (*Tridacna* sp.). These organisms were found across a range of substrates, including sand, coral rubble, and live coral, indicating a heterogeneous habitat structure within the coastal ecosystem (Graham & Nash, 2019). The distribution patterns varied among species. Blue sea stars were more frequently observed on mixed substrates in relatively clear waters, while sea urchins were more abundant on hard substrates covered with algae. Nudibranchs were found only in specific microhabitats, whereas coral reefs dominated the habitat structure across all transects. Giant clams were attached to live coral and exhibited a relatively limited distribution.

These patterns suggest that each organism occupies specific habitat preferences in accordance with its ecological requirements, such as food availability, shelter, and environmental conditions. The dominance of coral reefs as the primary habitat structure further highlights their critical role in supporting the presence and abundance of other organisms. This finding is consistent with previous

Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

studies showing that coral cover and structural complexity are closely associated with the distribution and abundance of marine biota, including both fish and benthic organisms (Aldyza et al., 2022a). Moreover, well maintained coral ecosystems contribute to greater community stability and support higher levels of biodiversity (Aldyza et al., 2022b). Overall, these observations reinforce the importance of substrate heterogeneity and coral reef presence as key factors influencing species distribution and ecological interactions in coastal ecosystems.

a. Ecological Role of Blue Sea Star (*Linckia laevigata*)

The blue sea star functions as a benthic predator, feeding on small organisms such as mollusks and organic detritus. This predatory activity contributes to regulating prey populations, thereby preventing the dominance of particular species within the community (Menge et al., 2016). In addition, the movement of sea stars across the substrate facilitates bioturbation, which plays a role in nutrient cycling on the seafloor. In the context of animal ecology learning, the blue sea star can serve as an example to illustrate ecological niche concepts and the role of predators in maintaining ecosystem balance. Its radial symmetry and ambulacral system also reflect morphological adaptations to marine environments.

b. Ecological Role of Sea Urchins (Echinoidea)

Sea urchins act as primary herbivores in coastal ecosystems, particularly in controlling algal growth on coral substrates. Their grazing activity helps maintain coral surfaces free from excessive algal cover, thereby supporting coral larval recruitment and the growth of new colonies (Wijaya et al., 2022). However, excessively high sea urchin densities may also lead to substrate degradation due to overgrazing. The interaction between sea urchins and algae highlights their role as ecological regulators that contribute to maintaining balance within coastal ecosystems (Suryanti et al., 2020).

c. Ecological Role of Nudibranchs (Nudibranchia)

Nudibranchs are carnivorous organisms that typically feed on sponges, hydrozoans, and other small benthic organisms. Their ecological role is closely associated with regulating the populations of specific benthic communities. In addition, nudibranchs are widely recognized as bioindicators due to their sensitivity to environmental changes, including pollution and temperature fluctuations. Their striking body coloration serves as a defensive mechanism through aposematism, signaling the presence of toxic or unpalatable substances to potential predators. In the context of animal ecology learning, nudibranchs provide a useful example for explaining concepts such as adaptation, bioindication, and the relationship between organisms and environmental quality.

d. Ecological Role of Coral Reefs (Anthozoa)

Coral reefs represent a key component of coastal ecosystems, functioning primarily as habitat providers for a wide range of marine organisms. Their complex structures create living spaces, shelters, and feeding grounds for numerous species. In addition, coral reefs contribute to ecosystem stability through their symbiotic relationship with zooxanthellae, which play a role in energy production through photosynthesis. The presence of both live and dead coral observed in this study reflects the dynamic nature of the ecosystem, influenced by environmental factors. In animal ecology learning, coral reefs are highly relevant for illustrating concepts such as ecosystems, biodiversity, and interactions between biotic and abiotic components.

e. Ecological Role of Giant Clams (*Tridacna* sp.)

Giant clams function as filter feeders that remove organic particles from the water column, thereby contributing to water clarity. They also engage in a mutualistic symbiosis with zooxanthellae that reside within their tissues. These symbiotic algae perform photosynthesis and provide nutrients to the host, while the clams offer protection and a suitable habitat. This relationship positions giant clams as important contributors to nutrient cycling within coastal ecosystems. In animal ecology learning, giant clams can be used to explain concepts such as mutualistic symbiosis, nutrient cycles, and the interactions between organisms and their environment.

Vol. 6 No. 2 Edisi Mei 2026 E. ISSN. 2775-2445
Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

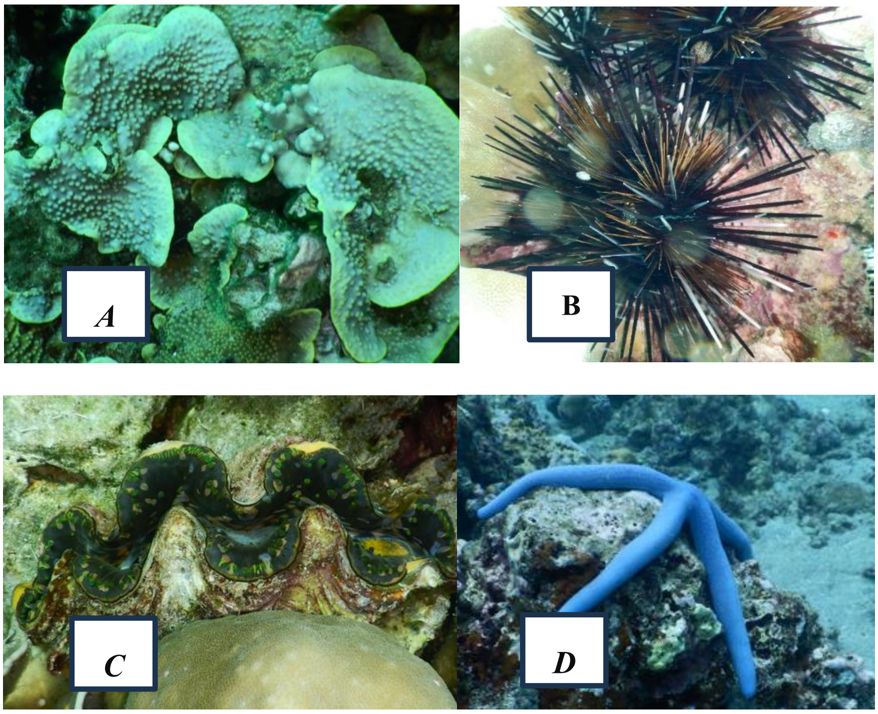

Figure 1. Some marine biota of Beurawang waters. A) Coral reefs, B) Sea urchins, C) Clams, and D) Blue starfish.

Table 1. Correlation Analysis Results

Correlations

			Bintang_Laut	Bulu_Babi	Nudibranch	Karang	Kima
Spearman's rho	Bintang_Laut	Correlation Coefficient	1.000	.056	.524**	.498**	.443*
		Sig. (2-tailed)	.	.770	.003	.005	.014
		N	30	30	30	30	30
	Bulu_Babi	Correlation Coefficient	.056	1.000	.637**	.711**	.263
		Sig. (2-tailed)	.770	.	.000	.000	.161
		N	30	30	30	30	30
	Nudibranch	Correlation Coefficient	.524**	.637**	1.000	.649**	.190
		Sig. (2-tailed)	.003	.000	.	.000	.314
		N	30	30	30	30	30
	Karang	Correlation Coefficient	.498**	.711**	.649**	1.000	.336
		Sig. (2-tailed)	.005	.000	.000	.	.069
		N	30	30	30	30	30
	Kima	Correlation Coefficient	.443*	.263	.190	.336	1.000
		Sig. (2-tailed)	.014	.161	.314	.069	.
		N	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Based on the results of the Spearman correlation analysis, an overview of the relationships among species within the observed benthic community was obtained, including sea stars, sea urchins, nudibranchs, coral reefs, and giant clams. In general, the analysis revealed several significant relationships with varying strengths, ranging from moderate to very strong, indicating the presence of ecological associations among these organisms (Brandl et al., 2019; Begon et al., 2020).

Significant relationships at the 99 percent confidence level ($p < 0.01$) were found among several species pairs. Sea stars showed moderately strong positive correlations with nudibranchs ($r = 0.524$) and coral reefs ($r = 0.498$). This suggests that an increase in the abundance of sea stars tends to be accompanied by an increase in the abundance of nudibranchs and corals within the same

Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

observation sites. These correlations may reflect similarities in habitat preferences or potential overlap in the use of environmental resources (Odum & Barrett, 2020). In addition, strong relationships were observed between sea urchins and nudibranchs ($r = 0.637$), as well as between sea urchins and coral reefs ($r = 0.711$). The highest correlation value between sea urchins and coral reefs indicates a very strong association, suggesting that coral structures play a crucial role in supporting sea urchin abundance (Graham & Nash, 2019).

Furthermore, the relationship between nudibranchs and coral reefs also showed a strong positive correlation ($r = 0.649$; $p < 0.01$). This finding reinforces the assumption that coral reefs function as primary habitats for various benthic organisms, including nudibranchs. In marine ecological contexts, coral reefs provide high structural complexity, offering shelter, feeding grounds, and breeding sites for many species (Graham & Nash, 2019; Aldyza et al., 2022a). Therefore, the strong correlations between coral reefs and several other organisms indicate that corals serve as a key component in maintaining the stability of benthic communities (Aldyza et al., 2022b).

At the 95 percent significance level ($p < 0.05$), a moderate correlation was found between sea stars and giant clams ($r = 0.443$). This suggests that increases in sea star abundance tend to be followed by increases in giant clam abundance, although the relationship is not as strong as those observed in other species pairs. On the other hand, several species pairs did not show significant relationships, such as between sea urchins and giant clams ($r = 0.263$; $p > 0.05$), and between nudibranchs and giant clams ($r = 0.190$; $p > 0.05$). This indicates that the presence of giant clams is not directly associated with variations in the abundance of these species within the study area, but is more likely influenced by specific environmental factors such as light availability and substrate conditions (Knop, 1996; Neo et al., 2017).

Overall, the observed correlation patterns suggest that most species are positively associated with one another, pointing to shared habitat preferences or environmental conditions that support their co-occurrence (Brandl et al., 2019; Begon et al., 2020). Coral reefs, in particular, appear to play a central role in structuring the community, as reflected by their significant correlations with multiple species. These findings indicate that the presence and condition of coral reefs strongly influence the distribution and abundance of other benthic organisms (Graham & Nash, 2019; Aldyza et al., 2022a). Therefore, maintaining the sustainability of coral reef ecosystems is essential for preserving the overall balance of benthic communities.

Integration into Animal Ecology Learning

The results of the observation indicate that the marine organisms identified at the study site are closely related to key concepts in animal ecology. This relationship is reflected not only in their morphological characteristics but also in their ecological roles and the interactions occurring among organisms within the ecosystem. Sea stars, for instance, function as predators that contribute to regulating the populations of other organisms, while also demonstrating morphological adaptations that support this role. Sea urchins can be understood as primary consumers that help control algal growth, making them particularly relevant for explaining trophic dynamics and population balance within an ecosystem. This role is supported by previous findings showing that sea urchins play an important ecological function in regulating macroalgae and maintaining the stability of coral reef and seagrass ecosystems (Klau et al., 2025).

In addition, nudibranchs exhibit high sensitivity to environmental changes, which makes them suitable examples of bioindicator organisms. Coral reefs, on the other hand, illustrate the complexity of ecosystems with high levels of biodiversity and serve as essential habitats for a wide range of marine species. Giant clams represent mutualistic symbiosis through their association with zooxanthellae, which plays a role in energy flow and nutrient cycling. Furthermore, the relationship between ecosystem components, such as coral cover and organism abundance, highlights the strong ecological linkages within coastal habitats (Wijaya et al., 2022). Overall, the diversity of ecological roles observed in these organisms demonstrates that field-based observations are not merely descriptive but are capable of illustrating various forms of ecological interactions in a concrete and meaningful way.

Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

The use of observational data provides a meaningful contribution to the achievement of learning competencies in animal ecology. Through the empirical data obtained, students are given the opportunity to directly identify biodiversity, understand relationships among organisms, and examine the roles of each component in maintaining ecosystem balance. This process encourages students not only to receive concepts at a theoretical level, but also to develop them through data-driven analysis. As a result, learning becomes more meaningful as it involves scientific reasoning grounded in real evidence (Adriadi et al., 2024). In addition, field observation activities help strengthen science process skills, including the ability to observe, identify, classify, and interpret ecological phenomena based on actual findings. Learning, which is often initially characterized by a one-way transfer of knowledge, can thus shift toward a more active and participatory process, where students are directly engaged in constructing their own understanding.

Another strength of this integration lies in its contextual nature and its grounding in the local environment. The organisms observed originate from environments that are familiar to students, making it easier for them to relate theoretical concepts to real conditions around them. This not only supports conceptual understanding but also has the potential to foster environmental awareness and a sense of responsibility toward the surrounding ecosystem. In addition, the observational data can be further developed into various forms of instructional materials, such as modules, worksheets, and visual media that present ecological interactions in a more tangible way. The use of locally derived data as learning resources can enrich the learning process while also supporting the implementation of more contextual and research-based instruction.

Overall, the integration of field observation results into animal ecology learning demonstrates that empirical data from coastal environments can serve as an effective learning resource. This approach helps bridge theoretical concepts with real-world conditions, enabling students to develop a more comprehensive understanding. Moreover, learning that draws on research findings also contributes to the development of scientific skills and critical thinking. Therefore, the findings of this study provide a strong foundation for developing animal ecology instruction that is more contextual, relevant, and aligned with the characteristics of the local environment.

4. CONCLUSION

Based on the findings of this study, it can be concluded that the marine organisms identified in the coastal area of Beurawang, Sabang, exhibit interconnected ecological relationships and play significant roles in maintaining the balance of the benthic ecosystem. Coral reefs function as a key component that supports the presence and sustainability of other organisms. The results of field observations demonstrate strong potential as a local environment-based resource for animal ecology learning, as the empirical data obtained are able to explain ecological concepts in a contextual manner. Therefore, integrating field observation results into the learning process can enhance students' understanding of animal ecology concepts, particularly those related to species interactions, trophic relationships, and ecosystem dynamics. At the same time, this approach contributes to the development of students' critical, analytical, and contextual thinking skills, especially in linking theoretical knowledge with real environmental conditions.

5. REFERENCES

Adriadi, A., Ihsan, M., Wulandari, T., Suprayogi, D., & Rayani, N. (2024). Analisis keterampilan proses sains mahasiswa pada mata kuliah biologi lingkungan prodi biologi fakultas sains dan teknologi. Bio-Lectura: Jurnal Pendidikan Biologi, 11(1), 93–102. https://doi.org/10.31849/bl.v11i1.19310

Aldyza, N., Barus, T. A., Mulya, M. B., & Sarong, M. A. 2022a. Coral resilience inside and outside of Pesisir Timur Pulau Weh conservation zone, Sabang City, Indonesia. Biodiversitas, 23(11), 5744–5751. https://doi.org/10.13057/biodiv/d231126

Jurnal Imiah Pendidikan Dasar (JIPDAS)
Journal Page is available to https://jurnal.spada.ipts.ac.id/index.php/JIPDAS
Email: jipdas8@gmail.com

Aldyza, N., Barus, T. A., Mulya, M. B., Sarong, M. A., Afkar, A., Andi, F., et al. 2022b. Coral covers and the abundance of Chaetodontidae in Suaka Alam Perairan of Weh Island, Aceh. Biodjati, 7(1), 56–65. https://doi.org/10.15575/biodjati.v7i1.17604

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. Biological Conservation, 241, 108224. https://doi.org/10.1016/j.biocon.2019.108224

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2019). The value of estuarine and coastal ecosystem services. Ecological Monographs, 89(2), e01340. https://doi.org/10.1890/10-1510.1

Begon, M., Townsend, C. R., & Harper, J. L. (2020). Ecology: From individuals to ecosystems (5th ed.). Wiley-Blackwell.

Bissinger, K., & Bogner, F. X. (2018). Environmental literacy in practice: Education on ecological systems. Sustainability, 10(12), 4654. https://doi.org/10.1007/s10668-017-9978-9

Brandl, S. J., Rasher, D. B., Côté, I. M., Casey, J. M., Darling, E. S., Lefcheck, J. S., & Duffy, J. E. (2019). Coral reef ecosystem functioning: Eight core processes and the role of biodiversity. Frontiers in Ecology and the Environment, 17(8), 445–454. https://doi.org/10.1002/fee.2088

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Fägerstam, E., & Blom, J. (2022). Learning biology outdoors: Effects on students' understanding. Journal of Biological Education, 56(2), 150–163. https://doi.org/10.1080/14729679.2011.647432.

English, S., Wilkinson, C., & Baker, V. (1997). Survey manual for tropical marine resources (2nd ed.). ASEAN-Australia Marine Science Project.

Field, A. P. (2018). Discovering statistics using IBM SPSS statistics (5th ed.). SAGE Publications.

Graham, N.A.J., Nash, K.L. The importance of structural complexity in coral reef ecosystems. Coral Reefs 32, 315–326 (2013). https://doi.org/10.1007/s00338-012-0984-y.

Hill, J., & Wilkinson, C. (2004). Methods for ecological monitoring of coral reefs. Australian Institute of Marine Science.

Klau, F. R., Subagiyo, S., & Riniatsih, I. (2025). Bioekologi bulu babi (Echinoidea) pada ekosistem padang lamun di Kecamatan Kupang Barat. Jurnal Kelautan Tropis, 28(2), 185–194. https://doi.org/10.14710/jkt.v28i2.25627

Menge BA, Cerny-Chipman EB, Johnson A, Sullivan J, Gravem S, et al. (2016) Correction: Sea Star Wasting Disease in the Keystone Predator Pisaster ochraceus in Oregon: Insights into Differential Population Impacts, Recovery, Predation Rate, and Temperature Effects from Long-Term Research. PLOS ONE 11(6): e0157302. https://doi.org/10.1371/journal.pone.0157302