Development of Biology Learning Media based on Echinoderm Diversity for Support Environmental Sustainability

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Abstract: Biodiversity was the important topic for biology learning to support environmental sustainability, especially in Echinoderms biodiversity. The purpose of this study was to identify Echinoderm species found on Pangumbahan Beach, Ujung Genteng, Sukabumi and develop e-booklet teaching materials for students. The research procedure is field observation with the exploration of transect methods at 3 stations representing 3 ecosystems, namely rocky sand ecosystems, coral ecosystems, and seagrass meadow ecosystems. Sampling was carried out by transecting a combination of plots with a plot size of 5 x 25 meters at three different stations and the develop the learning media with research and development method. The results of the study found 3 classes, 4 orders, 4 families, and 4 genera of Echinodermata consisting of 7 species, namely Ophiocoma scolopendrina, Ophiocoma erinaceus, Ophiomastix annulosus, Diadema setosum, Tripneustes gratilla, Synapta maculata, Euapta gedeffroyi, and Holothuria atra. The validation results of the booklet receive an average score of 88%, placing it in the category of very feasible for use in school learning activities. This media can empower students' knowledge about biology topic, expecially in Echinoderm to support environmental sustainability.

Keywords: Biology; Echinodermata; Environment; Learning; Media

Introduction

One of the strategic areas in Sukabumi Regency is Pangumbahan Beach, Ujung Genteng which takes the form of an archipelago and consists of several islands. The region is known for its high biodiversity. Mangrove ecosystems and extensive seagrass beds can be found around Pangumbahan Beach, Ujung Genteng Sukabumi. Echinoderms are one of the most important animals in the marine ecosystem and are useful as components in the food chain, eaters of organic waste, and other small animals. Echinoderms can be seston-eaters or destritus-eaters, so their role in an ecosystem is to remodel the remains of organic matter that other species do not use but that some Echinoderms can use (Hernández et al., 2006). Some species of the Echinodermata group, such as sea urchins and sea cucumbers, are usually sought after by the public

because they have high economic and protein values. Sea cucumbers are an important source for the food and medicine industries in Malaysia (Jontila et al., 2018). Meanwhile, sea urchins are traded for use by their gonads (Hammer et al., 2006). Echinoderms also play an important role in seagrass ecosystems as tier 1 consumers, which can reduce the possibility of blooming. Ecologically, the decline of seagrass ecosystems has an impact on biota, and seagrass beds have an important role as Echinoderm habitats which is that is important issue for maintain environmental sustainability. Seagrass ecosystems are essential for marine life. Physically, seagrasses act as sediment stabilizers as well as protect the coast from erosion Seagrasses serve as diverse habitats for many marine species. Seagrass beds also serve as protection and a source of nutrients that maintain a complex food chain (Uneputty et al., 2017). Echinoderms are biota that

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inhabits coral reefs that are quite prominent, the availability of feed on flat coral reefs is one of the factors for the abundance of Echinodermata biota on average coral reefs, according to Oktavia (2018), Echinoderms are marine animals that have prickly or fluorescent skin. These animals are divided into five main classes, namely: sea cucumbers (Holothuroidea), starfish (Asteroidea), snake stars (Ophiuroidea), sea urchins (Echinoidea), and sea lilies (Crinoidea). Ecosystem coral reefs fauna, Echinodermata, can occupy all sorts of habitats and zones. Especially at low tide, they occupy habitats that are constantly inundated with water. Triacha et al. (2021) state that the habitat of Echinodermata is in an intertidal zone whose circumstances are always changing.

In terms of ecology education, it can be used as a medium in biology learning to increase students' awareness of and concern for biodiversity. With the discovery of Echinodermata diversity, it is hoped that it can provide additional knowledge in the Kingdom Animalia material given in class X (ten) semester II. In Animalia material, which still requires additional knowledge or information because it has a wide scope, namely invertebrate animals and vertebrates, the large use of Latin causes students to have difficulty understanding the learning topic. Based on this issue, it is necessary to create biology learning media that can include student references and knowledge, as well as support material that has previously been studied, so that students can better understand the material. To support students in understanding the material, learning media are needed because learning media can be a solution to overcoming limited learning time. Learning media that can be used to overcome these problems are electronic-based (Susanti et al., 2020). The learning media are in the form of e-books can support students learning about Echinoderms biodiversity in context about environmental sustainability. E-booklet learning media is superior to print media because it is more practical, and besides that, e-booklets make the learning process easier to understand so that the objectives of learning will be achieved. Therefore, learning media in the form of e-books can be the right choice in this era of the "Industrial Revolution 4.0," where technological developments have affected many aspects, one of which is education (Rahim et al., 2020).

Method

Identification of Echinoderm will be held from September 2022 to October 2022. Echinoderm da106024' 09.3'' E.ta was collected in the intertidal zone of Cibuaya Ujung Genteng Beach. The study site is at c020' 51.5''S, point 106024' 09.3''E. The research location can be seen in Figure 1.

Figure 1. Location of research Cibuaya beach, Sukabumi, West Java, Indonesia

The research method uses the belt transect method, which consists of three stations based on the type of substrate. Each station will be transected perpendicularly from the coastline and spread over a distance of 100 meters, consisting of five 5x5-meter plots separated by 15 meters. The transect belt design can be seen in Figure 2.
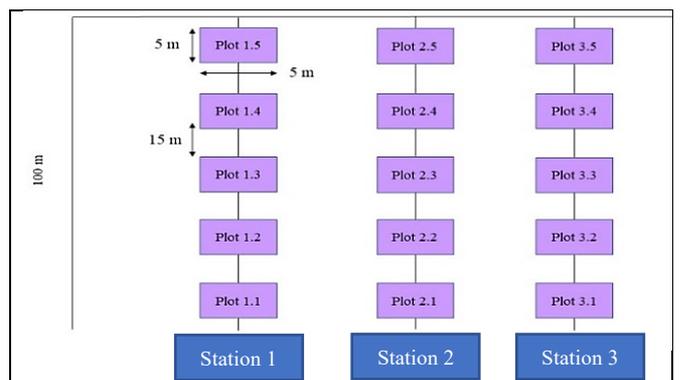

Figure 2. Transect Belt Design

After the identification of Echinodermata has been carried out, the next stage is the development of learning media. The method used to develop instructional media is the research and development method based on the ADDIE model. The stages of the development are Analyze, Design, Develop, Implement, and Evaluate. The stages of Echinoderm identification include the analysis stage, then the design and develop stages. Then do the implementation and evaluation of the media use of the media.

Result and Discussion

There are three dominant types of substrates at each station, namely rocky sand, seagrass beds, and corals, according to Gea et al. (2019). Echinoderms are commonly found in sand, mud, rock, seagrass, and coral substrates because in these substrates there is a lot of food available for gastropods. Data retrieval in the form

of primary data and environmental data Primary data taken are the number of Echinoderm species and individuals, while environmental data are taken at each station in the form of temperature, pH, salinity, humidity, current strength, and light intensity. This measurement aims to describe the physico-chemical conditions of the environment that can support the life of Echinoderms. Data collection is carried out at low tide, which is around 6.00 to 12.00 WIB. Each sample found on each plot is then taken and counted. The preservation process is carried out by storing specimens in closed jars containing a 70% alcohol solution. Jars containing specimens are then labeled with a description of the sample number, the name of the collector, the date of collection, the habitat found, and a color caption. The samples obtained will be identified in reference to the book "Identification," the identification key book, the Monograph of Shallow Water Indo-West Pacific Echinoderms by Clark and Rowe (1971), the website in the form of the WoRMS database (World Register of Marine Species, 2019), and other relevant journals.Results and Discussion 7 Species of Echinoderms at Pangumbahan Beach, Ujung Genteng Sukabumi (Table 1).

Table 1. Echinodermata discovered in Pantai Pangumbahan Ujung Genteng

Class	Species name	Total of organism			Total
		St. 1	St. 2	St. 3	($\sum$)
Ophiuroidea	*Ophiocoma scolopendrina*	251	212	201	664
	Ophiocoma erinaceus	170	4	25	199
	Ophiomastix annulosa	-	-	1	1
Echinoidea	*Diadema setosum*	3	8	4	15
	Tripneustes gratilla	-	-	1	1
Holothuroidea	*Synapta maculata*	18	15	-	33
	Euapta gedeffroyi	3	5	-	8
	Holothuria sp.	-	5	-	5
Total of Organism/ station (St.)		445	249	232	

The most common species at station 1 is *Ophiocoma scolopendrina.* This species is also the most common species at the other two stations. According to Rompis et al. (2013), this is because the snake star has a fairly high regeneration power because its arms can regenerate at any point. Furthermore, snake stars prefer habitats that are difficult to defend against the impact of waves, so the substrate at this station strongly supports the existence of snake stars. The snake-star predator, the demersal fish, was also not found during the study.

This specimen is known to have a flattened shape as well as a disc that is clearly visible as the center of the body part. Internodes on the arm section are trapezoidal ventral and hexagonal dorsal 33 with curved corners

(Clark & Rowe, 1971). *Ophiocoma scolopendrina* has a dark-colored body on the dorsal part and a light body on the ventral part (Fatemi & Stöhr, 2019) with curved corners (Clark & Rowe, 1971). The details was *Ophiocoma scolopendrina* (Lamarck, 1816) Class Ophiuroidea; Order Ophiurida; Family Ophiocomidae; Genus Ophiocoma L. Agassiz, 1836.

Figure 3. *Ophiocoma scolopendrina*

The snake star scientifically named *Ophiocoma erinaceus* belongs to the class Ophiuroidea, which has characteristics such as a single body with a snake-like shape, a solitary life, and a fragile body structure. In addition, the body shape of this snake star is radially symmetric, with a body center diameter of 2.5 cm and an arm length of up to 8 cm, and has a slightly slippery body center surface while the arms are filled with thorns or tentacles. This type of snake star has a mouth at the bottom or that leads directly to the seabed, whereas the madreporite does not. This species does not have an anus because the rest of the food or metabolism in its body is removed through the mouth. The body color of this snake star is dark brown at the top and light brown at the bottom. *Ophiocoma erinaceus* has a mobile form of movement (moving), and the way it moves is by creeping. This species of snake star has tube legs, and its habitat is below the surface of the coastal base. A special feature possessed by *Ophiocoma erinaceus* is that it has many thorns that are tentacles and modifications of the tube legs on its arms. The taxonomy details was Ophiocoma erinaceus Star Snake (Ophiuroide) Ophiocoma erinaceus Taxonomy according to Triana et al., (2015), the classification of the star injure Ophiocoma erinaceus is as following: Kingdom : Animalia Phylum : Echinodermata Class : Ophiuroidea Order : Ophiurida Family : Ophiocomidae Genus : Ophiocoma Species : Ophiocoma erinaceus (Müller & Troschel, 1842).

Figure 4. *Ophiocoma erinaceus*

Ophiomastix annulosa's disc edges are protected by soft spines on the dorsal surface of the disc. has five arms with additional segments of scales on the dorsal part (Clark & Rowe, 1971). Devaney (1978) used part sleeves with modified spines. *Ophiomastix annulosa* has a modified part of the spines called the claviform, i.e., the part of the thorns where the tip is swollen. The species *Ophiomastix annulosa* has a characteristic on the arm: there is a light-colored plate that contrasts with the blackish color on the other part of the arm. The oral shields are surrounded by deep black and luminous spines, and there are blunt disc spines. There are two tentacle scales. For the self-defense of this species, there is room for bone spinelets in each skin, and there are one or two tentacle scales (Clark & Rowe, 1971). Ophiomastix is named after the discs that contain several spines, sometimes combined with granules, and some discs contain thorns, some of which are held back by maeginoir bones. There are a number of thorns on the arm that are rather conspicuous. Normally, there are five arms, and most arms reach a length of sometimes more than 25 mm (Clark & Rowe, 1971). The taxonomy details was Ophiomastix annulosa (Lamarck, 1816) Class: Ophiuroidea Order: Ophiurida; Family: Ophiocomidae Genus: Ophiocoma.

Figure 5. *Ophyomastix annulosa*

Diaderma setosum This species of sea urchin, scientifically named *Diaderma setosum,* belongs to the class Echinoidea. This individual has a single number with a spherical shape and lives colonially. The structure of the body is strong, and the shape of the body is radial symmetry with a diameter of 4.5 cm and a prickly body surface with a length of thorns that can reach 12 cm or more. This sea urchin has a mouth located at the bottom and a madreporite and anus located at the top, or apex. Then the last one has a black body color with blue and white spots on the ambulakral groove, and on the anus there is an orange color. This species of sea urchin has a mobile (moving) form of movement with a creeping movement based on water. This species of sea urchin has a tube leg. Meanwhile, it lives on the surface. A special feature possessed by this sea urchin is that it has long, brittle spines. Then in the amburakaral grooves, there are blue and white spots, and there is an orange color around the anus.

Diadema setosum has a pentagonal and flattened round body shape; it is black in color; the spines are longer than the body; they have a sharp surface and a pointed and brittle tip; and the secondary spines are short as a means of movement. It has five white dots on the top and is located in each segment; the shape of the tubercle is crenulate. The size of this species usually reaches 70 mm; however, those found at the time of the study ranged from 20 to 40 mm, weighing 4.91 to 6.3 grams, and the length of the primary spines ranged from 18 to 22 mm. This type usually lives in groups, but during research, this sea urchin was found to be relatively small in size and lived alone in coral crevices in very small numbers (Suryanti et al., 2020). The details was Diaderma setosum, (Leske, 1778). Class: Echinoidea, Ordo: Cidaroidea; Family: Diadematidae; Genus: Diadema.

Figure 6. *Diadema setosum*

Tripneustes gratilla is a species of sea urchin belonging to the class Echinoidea. This species has a single body number, has a spherical shape, lives solitary, and has a strong body structure. In addition, the body

shape of this sea urchin has radial symmetry with different body sizes, and besides that, this species has a prickly body surface with different lengths of thorns as well. This sea urchin has a mouth located at the bottom facing the seabed; the madreporite is located at the top or peak adjacent to the anus; and the body color is striped with a variation of two colors. This sea urchin has a mobile (moving) form of movement, and the way it moves is by creeping. This species of sea urchin has tube legs, and its habitat is on the surface of the coastal bottom. A special feature possessed by the *Tripneustes gratilla* species is that it has a very clear ambulakral groove that is shown in different colors while the number of stripes in each amounts to 10 stripes in each color. *Tripneustes gratilla* has a circular or oval-shaped disc and is covered by very soft spines. There is a vertical area that is dark in color on each interambulal area, while the rest of the area is light with white spines (Clark & Rowe, 1971). On the soft covering spines, the color varies between orange, purplish, and whitish (Filander & Griffiths, 2017). Spines extending from the disc were discovered on specimens with a dark color that runs vertically downward and the rest is white. The details was Tripneustes gratilla (Lamarck, 1816), Class: Echinoidea, Ordo: Camarodonta; Family: Toxopneustidae, Genus: Tripneustes

Figure 7. *Tripneustes gratilla*

Euapta gedeffroyi has transparent skin and a visible body surface, and it is sticky to the touch. There is a red stripe and a light brown body, with tentacles numbering ± 7 pieces. The length of his body is about 20 – 50 cm. Members of the class Holothuroidea are gonochoric and have only one gonad. Spawning and fertilization are both external, and some exhibit brooding. Life cycle: Embryos develop into planktotrophic larvae (auricularia), then into doliolaria (barrel-shaped stage), which later metamorphose into juvenile sea cucumbers. *Euapta godeffroyi* inhabits the intermareal zone to about 80 m depth (Solís-Marín et al., 2009), and is associated with sand, seagrass beds, rock (pebbles), calcareous material, coral rubble, and coral reefs (Wenzhi et al.,

2006). The organism was actively feeding on deposited particles. This living specimen was approximately 60 cm in length, frequently contracting and expanding. It is color was creamy-white with transversal and brownish, regularly spaced stripes on the dorsal side and uniformly light creamy-white (lighter than the general body color) on the ventral side. Five bright yellow longitudinal bands with a middle black line ran along the whole body's length (Costache et al., 2013). The details was Eupta godeffroyi. Class: Holothuroidea; Ordo: Paractinopoda; Family: Synaptidae; Genus: Euapta.

Figure 8. *Euapta gedeffroyi*

Synapta maculata has a worm-like body shape and has no papillae or tube legs. The walls of the body are thin, sticky, or attached to the touch, as well as having a length of 30 cm. The dorsal and ventral bodies have the same color, namely the gray base color, and there is a black primary bar that stretches horizontally around the body. There are also five light brown transverse stripes. In the anterior, there is a mouth that has pinnate-shaped tentacles that number 15. *Synapta maculata* is found in a fine sand substrate that is overgrown with seagrass at a temperature of 28 °C and a pH of 7 (Hisam et al., 2022). *Synapta maculata* has a skin of brown and black stripes. Snake sea cucumber, also known as king belt sea cucumber, The color is yellow with brown stripes and can reach a length of 2 meters. It is found in seagrass beds. The body is sticky to the touch, with a body length of 30 to 80. The number of tentacles amounts to >10 pieces with a pinnate shape. The details was Synapta maculata. (Chamisso & Eysenhardt, 1821) Class: Holothuroidea, Ordo: Apodida; Family: Synaptidae; Genus: Synapta.

Figure 9. *Synapta maculate*

One species of Holothuriida sea cucumber was discovered at station 2. This order was discovered by only one species because it was very difficult to find at the time of the study, possibly requiring one to immerse oneself in the sand. The species found is *Holothuria atra*. Holothuria atra has an elongated and cylindrical shape with a smooth body surface. There is red in the ventral and black in the dorsal. *Holothuria atra* is one of the species of the class Holothuroidea that has features such as a single body count, a cylindrical shape, is usually solitary, and has a strong body structure. In addition, the body shape of this sea cucumber species is radially symmetric, with a body diameter of 5.5 cm and a length of 16 cm. Then, its rough body surface is covered with sand, and it has a mouth and madreporite located in the anterior part, while the anus is located in the posterior part. This sea cucumber has a pitch-black body color all over the outside of its body. This species of sea cucumber, scientifically named *Holothuria atra,* has a mobile (moving) form of movement, and the way it moves is by creeping. In addition, this species has tube legs, and its habitat is on the surface of the coastal bottom. A special feature possessed by this sea cucumber species is that its body is often covered with sand. The details was Holothuria atra Class: Holothuroidea; Or:Holothuriida; Family: Holothuriidae; Genus Holoturia.

Figure 10. *Holothuria atra*

Based on the results of identification of echinoderm as a first step of ADDIE, next step was designing the media. Learning media design in pdf format with content of echinoderm biodiversity. Development of media based on design step in previous step, development of learning media in the form of e-books was carried out through several stages until validation by expert. The result for media development can be seen in Figure 11.

Figure 11. Product development of Booklet for learning media

Then such results are presented in the form of descriptions and drawings. As for the feasibility test stage until revision, it is carried out by testing three aspects, namely, material aspects, language aspects, and media aspects, by six validators consisting of three lecturers and three high school biology teachers. This stage of the feasibility test seeks to determine the viability of learning media that have been made good and viable in order for them to be used effectively in the world of education. The result of validation by experts is in the form of a percentage that will be presented in the Table 2.

Table 2. Validation result of learning media

Validators	Score Percentage	Category
Expert 1	70	valid
Expert 2	72	valid
Expert 3	83	valid
Expert 4	94	valid
Expert 5	97	valid
Expert 6	86	valid

The results obtained in the material aspect get an average score of 89%, which is included in the "very decent" category with the largest score on the indicator of material suitability with basic competence because the material in the e-booklet is in accordance with basic competence so that it can help students achieve learning goals. This is in accordance with the statement by Wahyuni & Ibrahim (2012), which states that basic competence is the minimum ability that students must have in the learning material. In line with the opinion by Sarip et al. (2022) that explains the suitability of material concepts in learning media, they must be in accordance with learning objectives in order to achieve the expected competencies. The language aspect scored an average of 84%, which is a very decent category with the highest score on the grammatical element indicator. This is because the language used in the e-booklet learning media is easy to understand. This is in line with the opinion by Kariska et al. (2019), which says simple language can make it easier for readers to understand the information in the writing. It is also supported by Inderasari et al., (2021), who explain how to use appropriate stylistics to draw the reader's attention.

The media aspect gets an average score of 90%, which is included in the very decent category with the largest score on design indicators. This is in accordance with the opinion of Fadli et al., (2017), who explained that a good e-booklet media will consider the font size so that the writing is easy to read and the clarity of the image to attract readers. In addition, Paramita et al., (2019) also explained that good e-book media must be systematically arranged so that its role as a learning medium can be achieved and run effectively.

Based on the results obtained, an overall average score of 88% was obtained, which is included in the "very decent" category. By using e-booklet learning media, it is hoped that the learning process will no longer be only teacher-centered. so that the teacher can function as a facilitator who can certainly apply the learning atmosphere by involving students directly to be more active in the learning process. This is in accordance with the statement by Putri & Sylvia, (2021), which said students will be more active if they are in a learning process that can create a pleasant atmosphere and carry out activities such as reading, writing, speaking, expressing opinions, and interacting with school friends and teachers. This is also reinforced by a statement by Violla & Fernandes (2021) that states that using multimedia in the learning process can make students think critically, solve problems, be more active in seeking information, and be more motivated in the learning process.

The development of biology learning media related to the topic of Echinoderms is very important to continue to be developed with various innovations (Nugraini et al., 2013; Sahronih et al., 2019; Suryanda et al., 2016). Content related to Echinoderms that attracts students will foster students' sense of concern for environmental sustainability issues (Díaz et al., 2020; Ibáñez-Rueda et al., 2020; Janakiraman et al., 2021; Thorburn, 2017; Wang et al., 2022). Biology learning media makes students' insights increase because of the activities in the media. The integration of Echinoderms learning media for environmental sustainability topics will be very good if combined with learning strategies such as problem based learning and project based learning (Barber et al., 2015; Derevenskaia, 2014; Fitriati et al., 2021; Lou et al., 2017; Muzana et al., 2021; Yurniwati & Soleh, 2020).

Conclusion

Echinoderms found on the coast of Pangumbahan Ujung Genteng Sukabumi consist of seven species with a total of 926 individuals. The species found belong to 3 classes of Echinodermata, consisting of the class Ophiuroidea (*Ophiocoma Scoropendrina*, *Ophiocoma erinaceus, and Ophiomastix annulosa*), the class Echinoidea (*Diadema setosum*), and the class Holothuria (*Synapta maculata*, *Eupta gedoffroyi, and Holothuria atra*). The results of the feasibility test of e-books that have been validated by material, language, and media experts on average by 88% show that Echinodermata diversity e-books are very feasible to be used as a medium for learning biology in schools. This media was supported for students knowledge about biodiversity for environmental sustainability.

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