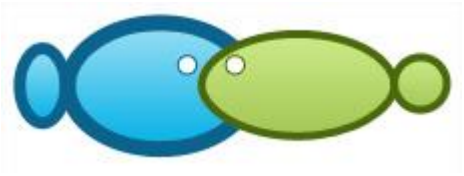

Day-night comparison of the number of *Drupella* sp. seen in the Semak Daun Island coral reef, Seribu Islands, Indonesia

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Abstract. Coral reef ecosystems are susceptible to harm from both natural and human-caused disturbances. Excessive predation by coral predators like *Drupella* sp. is one of the biological elements of nature that can harm an ecosystem. These aquatic creatures' sudden population explosions pose a serious threat to coral reefs. Identifying the presence of *Drupella*, a kind of coral predator snail, on coral reefs is crucial. This study aimed to assess and compare the day-night number of *Drupella* sp. seen in Semak Daun Island waters. One of the benefits of this study is that it can be used to estimate the total number of sea snails, even though observations are carried out during the day. Based on this study, *Drupella* concentration is higher at night compared to daytime. The *Drupella* species found are *Drupella cornus* and *Drupella rugosa*. The total number of *Drupella* was, at the east station, 61 individuals during the day and 88 individuals at night, while at the west station, it was 38 individuals during the day and 91 individuals at night. *D. rugosa* is the dominant species in the study area. The *Drupella* ratio at day versus night, at the east station was 1:1.78, whereas at the west station, it was 1:2.70. The relationship between the number of *Drupella* seen during the day and night meets the linear equation y=0.856x+3.2087 with a determination coefficient (R^2) of 0.3591.
Key Words: temporal abundance, corallivore, diseases, predator, scars, sea snail.

Introduction. Coral reef ecosystems are vulnerable to damage due to the impact of human disturbances and natural factors (Barber et al 2001; Halpern et al 2008; Hoegh-guldberg et al 2017; Mellin et al 2019; Roth et al 2018). One of the natural biological factors that can damage the ecosystem is excessive predation by coral predators such as *Drupella* sp. (Boneka & Mamangkey 2013; Cumming 2009; Hamman 2018). This type of sea snail lives in coral reef areas, which are included in the Mollusc phylum, Gastropod class, Prosobranchia sub-class, and the Muricidae family. The characteristic found in Prosobranchia is a single shell on the outside of the body. *Drupella* lives in groups and attaches to corals to consume coral polyps, leaving whitish, progressive marks called scars (Claremont et al 2011). These marine animals can severely threaten coral reefs through an event of population explosion (Barco et al 2010). If the phenomenon of population explosion occurs over a long enough time and a large area, it becomes a threat of damage to coral reef ecosystems (Bessey et al 2018; Bruckner et al 2017; Cumming 2009; Kita et al 2005; Koido et al 2017). Thus, *Drupella* can be classified as one of the coral destroyers, like *Acanthaster plancii* (Boneka & Mamangkey 2013). *Drupella* population outbreaks were ever recorded and caused significant damage to coral reefs in various locations such as in Japan (Fujioka & Yamazato 1983; Koido et al 2017), Australia (Bessey et al 2018; Cumming 2009; Turner 1994), Red Sea (Antonius & Riegl 1997; Shafir et al 2008), Thailand (Scott et al 2017), and India (Marimuthu & Tripathy 2018).

Drupella is a type of coral predator snail and it is important to detect its presence on coral reefs (Al-Horani et al 2011; Tsang & Ang 2015). Furthermore, coral mortality caused by outbreaks of predators can increase the occurrence of bioerosion and accelerate the degradation of coral reefs (Glynn 2001). In addition, coral predation by *Drupella* also helps spread other coral diseases, namely Brown Band disease (BrB) (Nicolet et al 2013) and has a relationship with White Band Disease (WBD) (Antonius & Riegl 1997,1998). *Drupella* will be found in areas that experience the most pressure, such as in utilization areas usually visited by tourists (Boneka & Mamangkey 2013), and will usually attack coral reefs under stress (Morton et al 2002; Schoepf et al 2010). *Drupella* snail is a nocturnal predator that usually hides at the base of branching corals, although some forage for food during the day (Cumming 1999; Turner 1994). So far, research on the abundance of *Drupella* in nature has always been carried out during the day, so the actual abundance cannot be said to be valid. According to Cumming (1999), sample data from a more detailed study is needed to detect the presence and concentration of *Drupella*. To provide a clearer picture of the presence of these sea snails between day and night, it is necessary to carry out this study, aiming to compare the abundance of *Drupella* during the day and at night by taking as an example the location of the coral reef ecosystem in the waters of Semak Daun Island, Thousand Islands, Jakarta. The study of the *Drupella* ratio during the day and night can be used to estimate the total number of these sea snails, even though the observation activities are carried out during the day.

Material and Method

Time and study area. The survey of data collection was conducted in April 2017 and is located on Semak Daun Island, Seribu Islands, Jakarta.

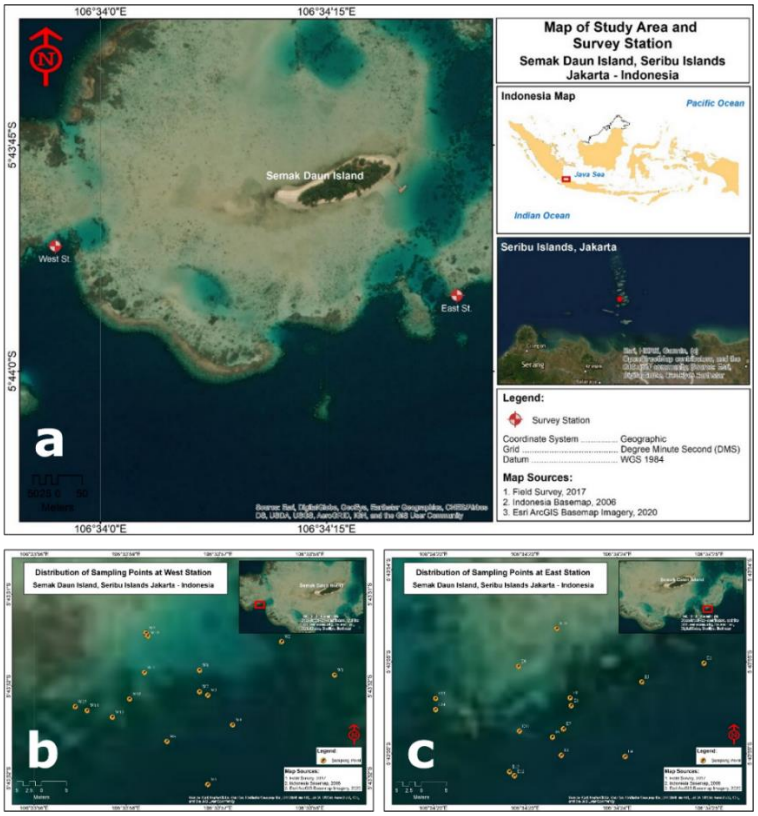

Figure 1. Map of the study area (a) location of Semak Daun Island and position of observation stations, (b) distribution of sampling points for *Drupella* observation at the west station, (c) distribution of sampling points for *Drupella* observations at the east station.

Geographically, the Island is located at coordinates 5.955833° South and 106.575833° East. The stations chosen to conduct observations are located at coordinates 5.731024° South and 106.565833° East on the western side and at coordinates 5.731932 °South and 106.573232 °East on the eastern part of the Island. At each station, there are 15 sampling points which are determined based on the presence of *Drupella* (Figure 1). The coordinates of each sampling point are presented in Table 1.

Table 1

The list of sampling points coordinates at each west station and east station

West station sampling point	*Coordinate location*		*East station sampling point*	*Coordinate location*	
	Longitude (°E)	*Latitude (°S)*		*Longitude (°E)*	*Latitude (°S)*
W1	106.56605	5.73098	E1	106.57325	5.73191
W2	106.56595	5.73092	E2	106.57349	5.73184
W3	106.56582	5.73102	E3	106.57338	5.73187
W4	106.56586	5.73107	E4	106.57335	5.73201
W5	106.56582	5.73118	E5	106.57323	5.73200
W6	106.56574	5.73110	E6	106.57322	5.73197
W7	106.56580	5.73101	E7	106.57324	5.73196
W8	106.56580	5.73097	E8	106.57325	5.73190
W9	106.56570	5.73090	E9	106.57315	5.73184
W10	106.56571	5.73091	E10	106.57322	5.73177
W11	106.56570	5.73098	E11	106.57316	5.73196
W12	106.56567	5.73102	E12	106.57315	5.73204
W13	106.56564	5.73106	E13	106.57314	5.73203
W14	106.56560	5.73104	E14	106.57300	5.73192
W15	106.56557	5.73104	E15	106.57300	5.73190

Material and Method. The data taken in the current study include data on the number and types of *Drupella* both during the day and at night. These marine organisms are usually found on the bottom of the substrate and between coral, crevices to hide, or on the coral surface when looking for food (Figure 2). Because the observations are carried out below the surface of the water, diving equipment and some special equipment are needed to record and record activities carried out underwater. The equipment used for data collection in this study can be seen in Table 2.

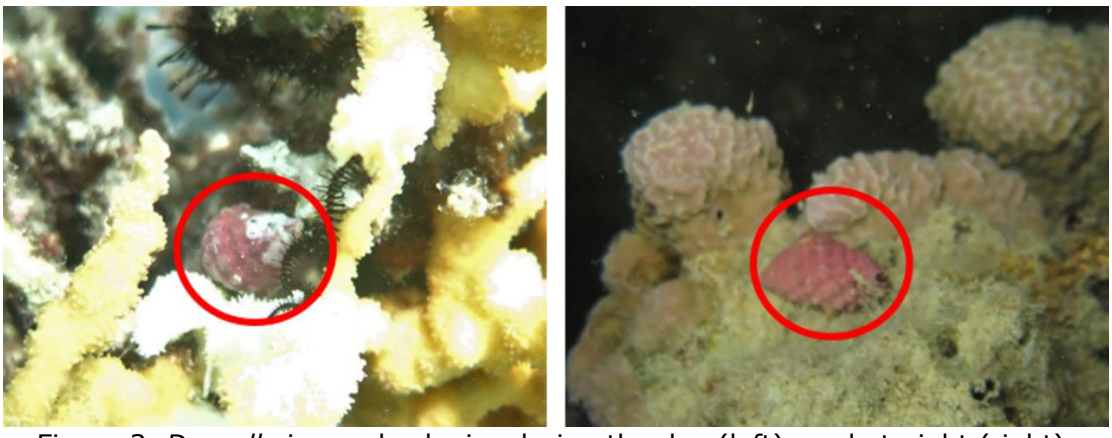

Figure 2. *Drupella* in coral colonies during the day (left); and at night (right).

The method used in this research is a field survey by direct observation at the study site. A random technique determines sampling points by diving at a depth of 1 to 7 m to look for the presence of *Drupella* in coral colonies. It should be remembered that when carrying out this activity, divers need knowledge of the methods and objects being

observed and good diving knowledge and skills because safety is essential in carrying out activities in the field.

Table 2

Equipment used in data collection

No.	*Equipment*	*Utilities*
1	SCUBA (Self-Contained Underwater Breathing Apparatus) equipment	Diving equipment for underwater observation
2	GPS (Global Positioning System)	Determine location/station coordinates and observation points
3	Underwater Camera	Documenting activities during underwater observations
4	Depth Gauge	Tool for measuring water depth
5	Boat	As a vehicle to the observation location
6	Pencil	Stationery to record observations
7	Underwater slate	Media for recording observations
8	Underwater torch	As a light source when diving at night
9	Quadrat transect 1x1 meter	Used in sampling and counting the number of *Drupella* at an observation point

Furthermore, after *Drupella* was found, a 1 x 1 m quadratic transect was placed on top of the coral colony, and its location was plotted using GPS as the sampling and observation point (Figure 3). Observations and recordings were carried out at the predetermined sampling point during the day and at night. Observations involved counters and recorders of the type and number of *Drupella* contained at each sampling point.

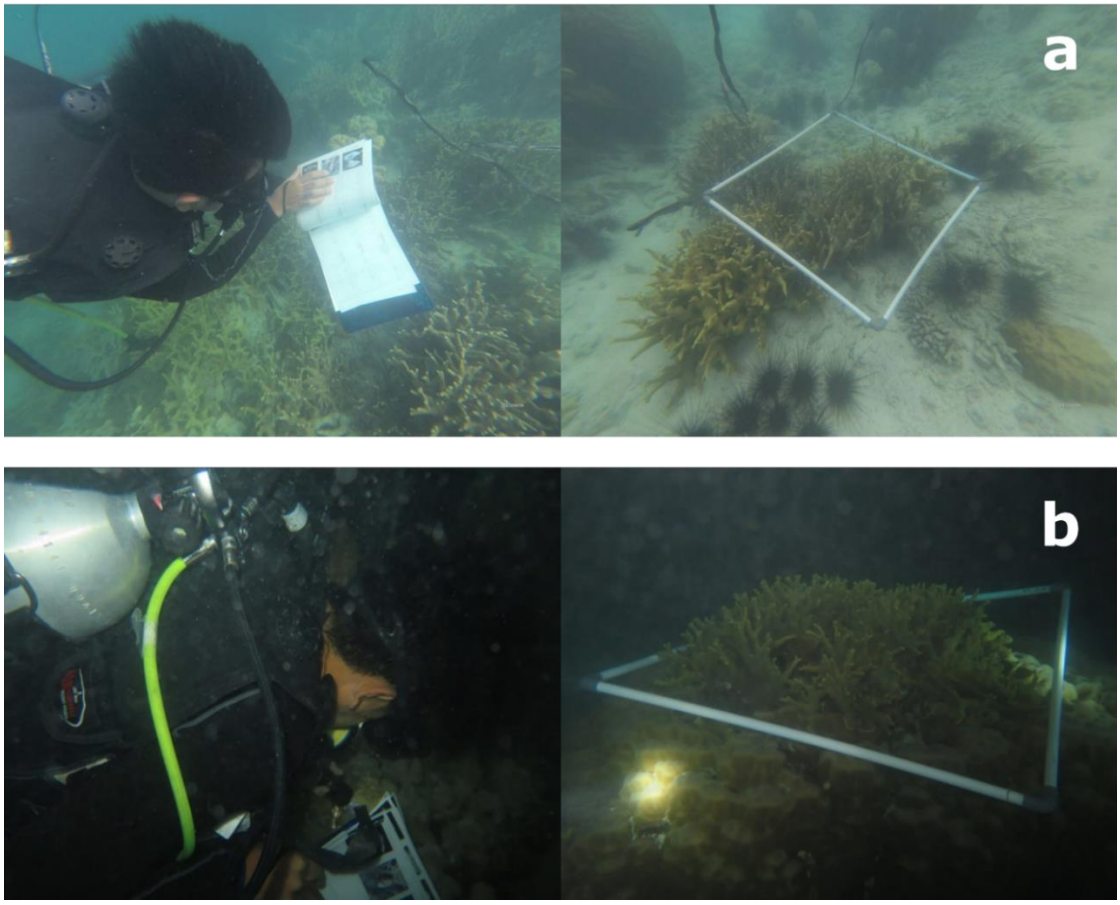

Figure 3. *Drupella* observations and quadratic transects during the day (a) and night (b).

Furthermore, the observational data were analyzed descriptively in a comparative manner to get an overview of the number of *Drupella* during the day and night at each observation station. Data were processed using Microsoft Office Excel with a statistical calculation approach. First, the ratio is used to find out the ratio of the amount during the day and night. When examining the relationship between two quantities or numbers, we apply the ratio formula. According to Encyclopaedia Britannica (2023), the relationship between the quantities of two or more objects is known as a ratio, and it shows how much of one object is contained in the other. Based on that statement then the day-night ratio of the number of *Drupella* is the ratio of the number of individuals found during the day with the number found at night using the following equation:

$$\boldsymbol{R_{D,N} = \frac{nD}{nN}}$$

Where:
$R_{D,N}$ - day-night ratio of the number of *Drupella*;
nD - the number of *Drupella* in the daytime;
nN - the number of *Drupella* at the night.

Secondly, further analysis is done through a simple linear regression. This analysis shows the relationship between the number of individuals during the day and night. The number of snails at each sampling point at the western and eastern stations is plotted into a scatter diagram. The relationship between the number of days and nights follows a linear equation:

$$y = ax + b$$

Where:
y - the number of *Drupella* at night (dependent variable);
x - the number of *Drupella* during the daytime (independent variable);
a - intercept coefficient;
b - regression coefficient (slope).

Results

The number of species. *Drupella* is a genus of marine gastropods in the tropics, often found on coral reefs in the Indo-Pacific Ocean, onsisting of four species, *Drupella cornus* (Röding 1798), *D. eburnea* (Küster 1862), *D. fragum* (Blainville 1832) and *D. rugosa* (Born, 1778) (Claremont et al 2011). Meanwhile, during field observations carried out at the study site, only two species of *Drupella* were found, namely *D. cornus* and *D. rugosa*. Figure 4 shows that the presence of *D. rugosa* predominates, especially at night, at the west station, with a total of 56 individuals. Meanwhile, *D. cornus* can be found in higher numbers at the east station during the day, with as many as 33 individuals. The increased number of *D. cornus* can be influenced by excessive macroalgae growth in coral colonies (Kaullysing et al 2016). *D. cornus* has a high genetic diversity among populations and a significant genetic differentiation between regions and zone levels (Mbije et al 2019).

Day-night comparison. Furthermore, the comparison of the number of *Drupella* during the day and night, at each sampling point and at each station, can be seen in Figure 4. A breakdown based on sampling points showed that at the west station the presence of *Drupella* is higher at night than during the day. In total, the highest number of *Drupella* found at the west station at night was 93 individuals, while only 38 individuals were found during the day. Meanwhile, at the east station, the patterns of appearance of *Drupella* during the day and night were not too different. Meanwhile, at the east station, the number of *Drupella* found at night was 88 individuals and as many as 61 individuals during the day. If it is averaged between the day and night, then the east station has more *Drupella*. This result is in line with the study conducted by Harahap et al (2021), which illustrates that coral predation by snails is more commonly found in the east of Semak Daun Island.

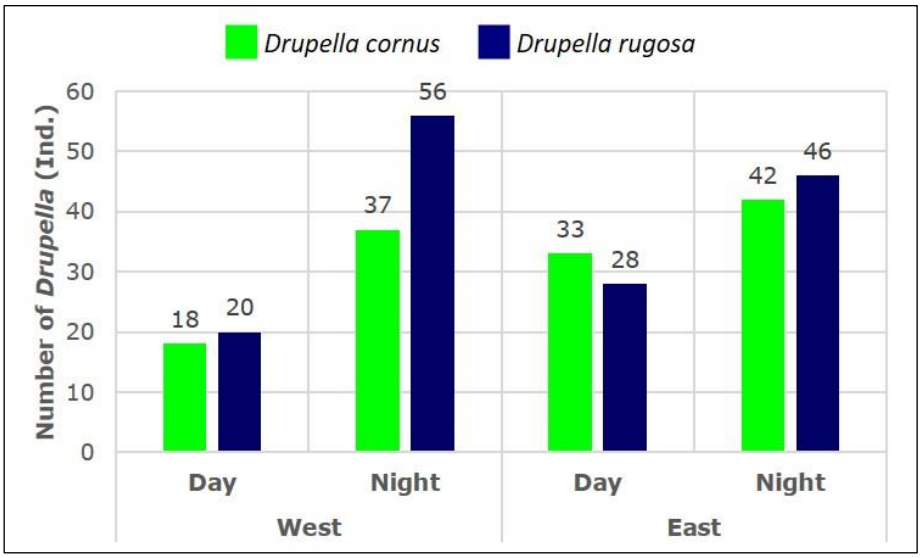

Figure 4. The number of *Drupella* found for each species during the day and night.

In addition to the results of the descriptive approach that has been presented above, the results of a statistical approach have also been produced to provide an overview of the comparison of the number of *Drupella* snails. Table 3 shows that the average day-night ratio of the number of *Drupella* seen on coral reefs in the waters around Semak Daun Island ranges from 1 versus 1.78 for the east station to 1 versus 2.70 for the west station. Next, an analysis was performed with a linear model, reflecting the influence of the number of *Drupella* during the day on the number of *Drupella* during the night. Based on the data on the number of *Drupella* available in Table 3, the scatter diagram was illustrated in Figure 5. The linear equation model obtained is y=0.856x+3.2087 with a determination coefficient (R^2) of 0.3591.

Table 3

The day-night ratio is based on the presence of *Drupella* during the day and night at each sampling point and at each observation station

West Station sampling point	*The number of Drupella (ind.)*		*Day-night ratio*	*East Station sampling point*	*The number of Drupella (ind.)*		*Day-night ratio*
	Day	*Night*			*Day*	*Night*	
W1	4	13	3.25	E1	2	4	2.00
W2	3	5	1.67	E2	5	9	1.80
W3	3	10	3.33	E3	1	3	3.00
W4	2	4	2.00	E4	4	5	1.25
W5	3	8	2.67	E5	5	4	0.80
W6	1	4	4.00	E6	6	9	1.50
W7	4	11	2.75	E7	8	9	1.13
W8	1	4	4.00	E8	8	8	1.00
W9	3	4	1.33	E9	2	2	1.00
W10	1	3	3.00	E10	4	6	1.50
W11	2	6	3.00	E11	1	5	5.00
W12	5	9	1.80	E12	2	4	2.00
W13	2	2	1.00	E13	5	6	1.20
W14	1	5	5.00	E14	4	6	1.50
W15	3	5	1.67	E15	4	8	2.00
Total number	38	93			61	88	
Average of day-night ratio			2.70				1.78

The correlation analysis results show that the number of *Drupella* seen during the day (variable x) can affect the number seen at night (variable y) by 35.91%, the remaining influence being related to other factors. This equation model can be used to estimate the number of *Drupella* that will appear at night (y), based on daytime observations (x).

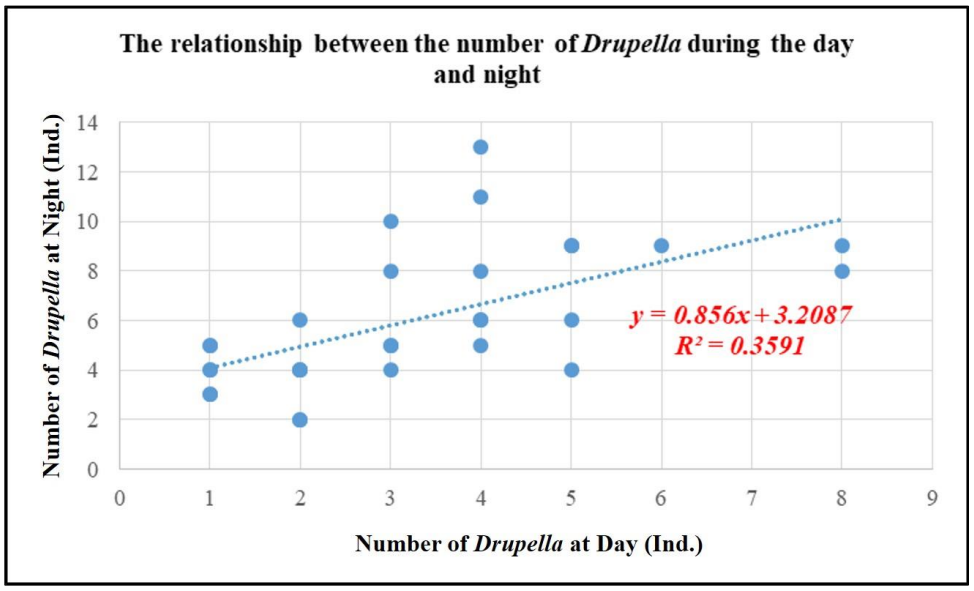

Figure 5. The relationship between the number of *Drupella* during the day and night and the formed linear equation.

Discussion. Future research directions can also be highlighted to describe the role of *Drupella* in coral reef ecosystems in more detail. Most of the research that has been conducted related to *Drupella* and its ecological dynamics in several Indonesian seas has focused more on abundance, disease, predation preferences and how they are linked, and also on their impact on coral reef ecosystems. (Boneka & Mamangkey 2013; Istiqomah et al 2019; Kanela et al 2018; Luthfi & Januarsa 2018; Subhan et al 2011).

Moreover, this study illustrates that *Drupella* is more commonly found in the waters around Semak Daun Island at night compared to during the day, at both the west and east stations. This behavior is due to this snail being a nocturnal animal actively engaged in predation on corals during nighttime(Turner 1994). Furthermore, based on the comparison of the day-night ratio and on the obtained linear equation (Table , Figure 5), the abundance of *Drupella* can be estimated more accurately, even though data collection is done during the day. *Drupella* is an active predation at night because fatty acids in corals increase, causing a significant attractant effect for *Drupella* to eat these corals. These fatty acids influenced by light, water temperature, food availability, and coral conditions so that at night the total fatty acid amount will increase (Oku et al 2003). The specific fatty acids that can attract *Drupella* to prey on coral reefs are montiporic acid, alpha-linolenic acid, arachinodic acid, and betaine (Kita et al 2005).

Ecologically, this snail can play an essential role as an indicator and balancer of the ecosystem integrity. However, there is an assumption that the influence of *Drupella*, especially on coral reefs, is relatively small. For example, studies on coral disease have been carried out, and it was found that *Drupella* contributes only 5-8% of the total coral diseases found in this area (Harahap et al 2021). In general, several factors can affect the presence of *Drupella* on coral reefs, namely the depth, substrate, and growth form of the coral itself (Schoepf et al 2010), where *Drupella* prefer to eat *Acropora* species with branched growth and are also found in the coral genera *Porites* and *Pocillopora* (Kanela et al 2018). However, it is necessary to monitor its population's evolution, which is directly related to its feeding activity, since it can threaten the ecological balance, especially the coral reefs (Armstrong 2009). *Drupella*'s feeding aggregation is abundant in corals that have suffered damage due to anthropogenic influences (human activities) and overfishing

of natural predators of these snails, thereby reducing coral cover and hindering coral reef recovery (Armstrong 2009; Saponari et al 2021).

Temporarily, the *Drupella* population at a particular time can increase, then in a matter of years, it can decrease. Food sources and other environmental factors can influence these fluctuations. For example, the abundance of *Drupella* decreases with the coral colonies decrease (Johan 2009). The presence of *Drupella* in a coral colony also depends on the choice and quality of food, as explained by Morton et al (2002), meaning coral tissue accessibility, nutritional value, mucus production, and coral stinger cell defense (Nematocyt), which greatly determine the position of *Drupella* on the coral branches. These gastropods are primarily found in areas with a high percentage of live coral cover, among other environmental factors (Kanela et al 2018; Saponari et al 2021). Periodic monitoring is needed because coral reef cover, especially in the Seribu Islands core zone, shows an increase (Harahap et al 2021). *Drupella* densities are generally homogeneous in certain species, and species variations depend on coral cover conditions (Saponari et al 2021). Low temperatures can cause higher coral predation by these sea snails (Tsang & Ang 2019). The number of biota populations in an area can also be related to the physical connectivity within and between geographic areas, mainly based on larval dispersal (Carpenter et al 2011).

Conclusions. Based on the results of this study, it can be concluded that two species of *Drupella* are found in the waters of Semak Daun Island, namely *D. cornus* and *D. rugosa*. It can be said that *D. rugosa* predominates, especially at the west station. The number of *Drupella* found at night is more than the number found during the day with a ratio ranging from 1: 1.78 to 1:2.70. If analyzed by linear regression, the data on the number of *Drupella* during the day (x) and at night (y) resulted in the equation model $y = 0.856x + 3.2087$ with a determination coefficient (R^2) of 0.3591.

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Conflict of interest. The authors declare no conflict of interest.

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