Coral reefs substrate composition influence on nudibranch diversity

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Abstract. The substrate serves as a habitat and a source of food for Nudibranch. Therefore, it influences the existence of nudibranchs. This study examined the differences in the presence of nudibranchs at two locations with different substrate compositions on Lembeh Island and a flat island (Tunda Island). Data collection used a modified belt transect 50m long and 4m wide (200m²) with a depth of 5-7m along the coastline. A total of 86 individual specimens consisted of 12 families with 22 species were recorded. The largest group was the Phyllidiidae family (10 species). Chromodorididae and Polyceridae family represented by 3 species each, Facelinidae family represented by 2 species, and Dotidae, Flabellinidae, Discodorididae, and Myrrhinidae, each represented by one species. Nudibranch diversity was higher on Lembeh Island than Tunda Island. A total of 19 species were found on Lembeh Island while only 5 species were found on Tunda Island. The wealth of nudibranch is largely determined by the composition of the substrate. Based on hierarchical analysis 80.93% of determinants of nudibranch existence was a substrate category of DCA, sponges, and hard corals. Nudibranch’s diversity directly proportional to the percentage of DCA and sponge, and inversely proportional to the percentage of hard coral.

1. Introduction
Nudibranchs, known as the Sea Butterfly, is one of the most diverse morphologies and unique taxa in the mollusk phylum, having more than 6,000 species already known [1-2]. More than 3,000 already recorded in the Indo-Pacific region [1]. Some other forms of Metazoa life are virtually unknown, although they may consist of thousands of species, with undescribed high amounts of taxa. Lately, it has been displayed a variety of Heterobranchia groups, which were formerly known as "Opisthobranchia" [1]. Some marine slugs have developed chemical defenses to protect themselves from predators after the loss of their shell Evolution. Therefore, gentle-body mollusks have always been a favorite choice for natural product chemists because of the potential for the discovery of bioactive metabolites and the chemical ecology associations between nudibranchs and their prey [3]. Sea slugs can be found in a variety of habitats ranging from tropical to polar regions. Also, recent developments suggest that sea slugs can also be used as a climate change bioindicator [4-5]. The location difference is a very determined habitat; this also applies to marine animals in particular Nudibranch. These differences are not separated from geographical, marine dynamics, and substrate composition. Each island has a different substrate composition depending on the type of formation. Habitat in different locations is instrumental in Nudibranch’s diversity [6-7] Substrate composition as one of the seabed phenomena that
supports biota diversity directly associated with the substrate, if reduced substrate diversity, even loss of substrate because global warming accompanied by activities conducted on the coastal area will not only determine the composition of the life of this benthic biota [8]. To observe the changes in species composition, regardless of cause, knowing about the species diversity is indispensable [9-10]. Research on substrate relations as habitat and biodiversity nudibranch has been several times [11]. Nudibranch is closely related to the substrate as a place to stick, shelter, eat, and reproduce [12-13]. This research aims to analyze the factors that affect the presence of nudibranchs. The difference in both locations lies in the type of island formation, Lembeh island as the type of hill island and Tunda island as a type of flat island. And we also analyze the structure of Nudibranchia community in different locations.

2. Materials and methods

2.1. Study area

This research was conducted on Lembeh Island and Tunda Island in January and December 2019, data collection was carried out at 11 sites, namely eight sites on Lembeh Island and three sites on Tunda Island. Determination of the location for data collection was based on differences in island types, each of which was a hill island represented by Lembeh Island and a flat island represented by Tunda Island. Data collection sites on Lembeh Island using code L and Tunda Island with code T. The data collection stations on Lembeh Island and Tunda Island are named L1 (N 01°40'873", E 125°25'165"), L2 (N 01°39'637", E 125°22'087"), L3 (N 01°39'567", E 125°19'228"), L4 (N 01°39'885", E 125°20'977"), L5 (N 01°52'241", E 125°27'699"), L6 (N 01°45'468", E 125°24'163"), L7 (N 01°42'184", E 125°18'151"), L8 (N 01°43'892", E 125°21'358") dan T1 (S 5°48'29.00", E 106°15'48.72"), T2 (S 5°48'27.23", E.88”), T3 (S 5°49'0.32", E 106°17'18.98”).

Figure 1. The nudibranch site survey at Lembeh Island and Tunda Island. L shows site at Lembeh Island, T shows the site at Tunda Island 1-8 means number of observed site.
2.2. Data collection

Data collection using a modified belt transect with a length of 50m and a width of 4m (200m$^2$) with a depth of 5-7m along the coastline, identification of nudibranch type is directly made when capturing data and taking photos followed by looking at underwater photos. The identification of Nudibranch is made from the family, genus, to species by looking at colors on notum, rhinophores, gills, feet, and body size, with the help of several identification books [14,15] and scientific publications [16,17]. Nomenclature and species taxonomy following indications by WORMS (http://www.marinespecies.org). Substrate Data were taken using UPT (Underwater Photo Transect) method and processed using CPCe [18,19].

2.3. Analysis

To see the grouping from the substrate we use hierarchical clustering, cluster analysis is a set of methods used to group objects into a cluster based on the information found in the data. The values of the Shannon Diversity Index were obtained using the following formula [20] with five categories (table 1). The spatial distribution of reef fish based on coral lifeforms was analyzed using the correspondence analysis (CA).

\[
H' = -\sum \frac{N_i}{N} \log_2 \frac{N_i}{N}
\]

$H'$ : Value of diversity index
Ni : The number of individuals on the i-th type
N : Number of individuals in all types

| Diversity index ($H'$) | Community Structure | Categories |
|------------------------|---------------------|------------|
| < 0.60                 | Not Stable          | Very bad   |
| 0.61 – 1.2             | Fair Stable         | Bad        |
| 1.21 – 1.8             | Stable              | Fair       |
| 1.81 – 2.4             | More Stable         | Good       |
| > 2.41                 | Stable              | Very Good  |

Table 1. Category of shannon diversity index.

3. Results and discussion

3.1. Nudibranch community structure

22 nudibranch species was found in Lembeh Island and Tunda Island, including 12 genera and eight families (table 2). 10 species represent the Phyllidiidae family, three species represent each Chromodorididae family and Polyceridae family, two species represent Facelinidae family and one species represent each Dotidae family, Flabellinidae family, Discodorididae family, and Myrrhinidae family. The highest type of wealth is found in the L5 data retrieval site with eight species and the lowest type of wealth is found in the location of T1 on Tunda Island with one species. The highest nudibranch abundance is found in L6 locations with 18 individuals and locations with the lowest number of individuals at T1 with the number of one individual.
| Family                  | Species name                        | L1 | L2 | L3 | L4 | L5 | L6 | L7 | L8 | T1 | T2 | T3 |
|------------------------|-------------------------------------|----|----|----|----|----|----|----|----|----|----|----|
| Chromodorididae        | *Chromodoris annae* (Bergh, 1877)   | ✓  |    |    | ✓  | ✓  | ✓  | ✓  |    |    |    |    |
|                        | *Chromodoris lochi* (Rudman, 1982) | ✓  | ✓  |    | ✓  | ✓  | ✓  | ✓  |    |    |    |    |
|                        | *Goniobranchus reticulatus* (Quoy & Gaimard, 1832) |    |    |    | ✓  |    |    |    |    |    |    |    |
| Dotidae Gray, 1853     | *Doto ussi* (Ortea, 1982)           | -  | -  | -  |    | ✓  | ✓  | ✓  | -  |    |    |    |
| Flabellinidae          | *Coryphellina rubrolineata* (O'Donogue, 1929) | ✓  |    |    |    |    |    |    |    |    |    |    |
|                        | *Halgerda batangas* (Carlson & Hoff, 2000) | -  | -  | -  | ✓  |    |    |    |    |    |    |    |
| Discodorididae         | *Nembrotha cristata* (Bergh, 1877)  | -  | -  | -  | ✓  |    |    |    |    |    |    |    |
|                        | *Nembrotha purpureolineata* (O'Donogue, 1924) | -  | -  | -  | ✓  |    |    |    |    |    |    |    |
|                        | *Roboastra gracilis* (Bergh, 1877)  | -  | -  | -  |    |    |    |    |    | ✓  |    |    |
| Phyllidiidae           | *Phyllidia coelestis* (Bergh, 1905) | -  | ✓  | -  | -  |    |    |    |    |    |    |    |
|                        | *Phyllidia exquisita* (Brunckhorst, 1993) | -  | -  | -  |    | ✓  |    |    |    |    |    |    |
|                        | *Phyllidia ocellata* (Cuvier, 1804) | -  | -  | ✓  | ✓  | ✓  | ✓  | ✓  | ✓  |    |    |    |
|                        | *Phyllidiella pustulosa* (Cuvier, 1804) | -  | ✓  | -  |    | ✓  | ✓  | ✓  | ✓  |    |    |    |
|                        | *Phyllidiopsis xishaensis* (Lin, 1883) | -  | -  | -  | ✓  | -  |    |    |    |    |    |    |
|                        | *Pteraeolidia ianthina* (Angas, 1864) | ✓  | ✓  | -  |    |    |    |    |    |    |    |    |
|                        | *Pteraeolidia semperi* (Bergh, 1870) | ✓  | ✓  | -  |    |    |    |    |    |    |    |    |
| Myrrhinidae            | *Phylloidesium briareum* (Bergh, 1896) | -  | -  | ✓  | ✓  |    |    |    |    |    |    |    |
|                        | *Pteraeolidia ianthina* (Angas, 1864) | ✓  | ✓  | -  |    |    |    |    |    |    |    |    |
|                        | *Pteraeolidia semperi* (Bergh, 1870) | ✓  | ✓  | -  |    |    |    |    |    |    |    |    |
3.2. Substrate percentage

The substrate category is divided into ten categories namely hard coral (HC), Dead Coral (DC), Dead coral algae (DCA), a soft coral (SC), Sponge (SP), algae (A), Other (OT), rubble (R), Sand (S), and silt (SI). The L3 station is a station with the highest biotic substrate of 71.9% with a percentage of hard corals of 51.5%, and the lowest biotic substrate at the T1 station is 26.6% and a percentage of hard corals of 13.5%, on the biotic substrate of the highest SP category is located at L7 Station with a percentage amount of 23%. The T1 station is the highest abiotic percentage among the other 73.4% stations with DCA and R highs, which amounted to 32% and 29.9%.

Figure 2. Substrate percentage. HC- Hard Coral; DC - Dead Coral; DCA - Dead Coral Algae; SC - Soft Coral; SP – Sponge; A – Algae; OT – Other; R – Rubble; S - Sand, and SI – Silt.

Figure 3. Ascending hierarchical classification of the substrate. Divided into three category DCA- dead coral with algae (represent with black); SP-Sponge (represent with red); HC-hard coral (represent with green).
In hierarchical clustering analysis data retrieval stations divided into three clusters, the character substrates found in all three clusters are DCA, Sponge, and Hard coral. The proximity of the substrate composition of the L2, L3, L6, and T2 stations is influenced by the HC category substrate, where the stations are the highest HC percentage stations in each location. Nudibranch on Lembeh Island is more diverse and has a broader percentage of hard corals, and there are 19 species in Lembeh Island and five species on Tunda Island (table 2). Similarities in both locations are also influenced by the presence of nudibranch species found in both locations, *Phyllidia Varicosa* and *Phyllidiella pustulosa*. Both species of Nudibranch can be found in many locations other than Lembeh Island and Tunda Island [21]. Nudibranch belongs to a cosmopolite animal that has a wide distribution [22].

It is indicated that these two species of Nudibranch have an excellent adaptation to the environment. The sponge substrate availability significantly affects the richness of the Nudibranch, on the L3, T1, and T2 observation stations with the lowest percentage of sponge compared to the straight with the low type of Nudibranch as well as the station. Nudibranch is closely related to its feed since all three stations have a species of Sponge eaters that can be found on observation stations with more sponge availability. It is shown on a station with a combination of high-quality Sponge and DCA substrates with the highest type of richness, namely on the L5 and T3 observation stations. At both stations found the highest nudibranch diversity of both locations (table 3).

The nudibranch community structure with the highest diversity index is found at L5 stations with sponge-character substrates and the lowest diversity index is found on T1 stations that have DCA-character substrates. Stations with DCA-rated substrates have a good diversity index, but there are exceptions to T1 stations, which is because T1 stations have rubble substrate cover that dominates 30% of the total area. Rubble is one of the indicators of damage to coral ecosystems and one indication of strong currents at the site. Nudibranchs are marine animals attached to the base substrate and need a sturdy substrate to survive when there are strong currents, there are many rubbles that can be one of the reasons why very few nudibranchs are found at such locations.

### Table 3. Shannon diversity index.

| Stasiun | Substrate | H'  | C     | S  | A     | Category |
|---------|-----------|-----|-------|----|-------|----------|
| L1      | DCA       | 2.25| 0.21875| 5 | 8     | Good     |
| T1      | DCA       | 0   | 1     | 1 | 1     | Very bad |
| T3      | DCA       | 2.11749| 0.263889| 5 | 12    | Good     |
| L4      | SP        | 1.58496| 0.1875| 3 | 3     | Fair     |
| L5      | SP        | 2.53415| 0.231834| 8 | 17    | Very Good|
| L7      | SP        | 1.72957| 0.347222| 4 | 12    | Fair     |
| L8      | SP        | 2.25163| 0.222222| 6 | 6     | Good     |
| L2      | HC        | 0.9183| 0.555556| 2 | 3     | Bad      |
| L3      | HC        | 0.81128| 0.625| 2 | 4     | Bad      |
| L6      | HC        | 2.10541| 0.283951| 6 | 18    | Good     |
| T2      | 1         | 0.5  | 2     | 2 | 2     | Bad      |

Note: H' = Diversity index, C = Dominance index, S = Species Richness, A = Abundance/200m².

Stations with HC-character substrates generally have a poor diversity index, but there is one station that has a good diversity index of L6. This condition is followed by a low percentage of algae which is 4%, where the other location has a percentage of algae above 10%. Algae is one of the health indicators of coral reef ecosystems [23].
3.3. Nudibranch distribution

The results of the correspondence analysis showed that there were three main groups of associations between the substrate group and the nudibranch species. Group HC consists of the species *Dotto ussi*, *Goniobrachus reticulatus*, *Halgerda batangas*, *Phyllidia coelestis*, *Phyllidiopsis xishaensis*. In the DCA group there are species *Coryphellina rubrolineata*, *Phyllidia exquisita*, *Phyllidiella zeylanica*, *Roboastra gracilis*, *Pteraeolidia semperi*. The most common species was the SP group *Nembrota cristata*, *Nembrotha purpureolineata*, *Phyllidiella granulata*, *Phyllidiella lizae*, *Phyllidiella rudmani*, *Phyllidia ocellata* and *Phylloidesmium briareum*. There are three species found in both HC and SP groups, namely *Chromodoris annae*, *Chromodoris lochi*. Nudibranch species is found in the DCA and SP groups is *Pteraeolidia ianthina*. There are also nudibranch species found in the three groups namely *Phyllidiella pustulosa* and *Phyllidia varicosa* (figure 4).

![Figure 4. Correspondence analysis map showed distribution species of nudibranch. Blue means determinant substrate category (DCA-dead coral with algae; SP-sponge; HC-Hard coral). Red means founded species (C.ann-Chromodoris annae;C.loc-Chromodoris lochi; G.ret-Goniobrachus reticulatus; D.us-Doto ussi; C.rub-Coryphellina rubrolineata; H.bat-Halgerda batangas; N.cri-Nembrota cristata; N.pur-Nembrotha purpureolineata; R.gra-Rboastra gracilis; P.coe-Phyllidia coelestis; P.exq-Phyllidia exquisita; P.occ-Phyllidia ocellata; P.pus-Phyllidiella pustulosa; P.var-Phyllidiella varicosa; P.gra-Phyllidiella granulate; P.liz-Phyllidiella lizae; P.rud-Phyllidiella rudmani; P.zey-Phyllidiella zeylanica; P.xis-Phyllidiopsis xishaensis; P.bri-Phylloidesmium briareum; P.ian-Pteraeolidia ianthina; P.sem-Pteraeolidia semperi).](image)

The factor affecting Nudibranch's existence is the substrate that becomes the place of sticking and food availability. [24] that the DCA is the most widely found substrate nudibranch, but it can not be a
reference of habitat that corresponds to the existence of Nudibranch because the results of the study showed that the T1 station has the dominant substrate DCA found only one species nudibranch \textit{Phyllidia varicosa}. Nudibranch Habitat based on substrate composition greatly determines diversity and abundance, it is worth seeing other substrate categories to be a reference to the diversity nudibranch.

![Image](image_url)

**Figure 5.** Nudibranch attaches to the substrate, a) the \textit{Chromodoris Lochi} attaches to the substrate sponge, b) \textit{Doto Ussi} attaches to the hydroid substrate, c) \textit{Phyllidia exquisita} attached to the substrate DCA, d) \textit{Nembrotha cristata} attaches to the ascidians substrate.

The nudibranch is found to be attached to several categories of substrates, on substrates of DCA, hydroid, Ascidian, sponge (Figure 4). If referring to the feed of any family (Table 4), Nudibranch consuming sponge from family Chromodorididae, Phyllidiidae, Discodorididae, found above DCA substrates, sponge, algae, and ascidians as a place to stick. Family Polyceridae who ate Ascidians and nudibranch-eaters stick to the DCA and ascidians substrates, for soft coral eaters of the Phyllodesmium briareum of the family Myrrhinidae attached to the DCA substrate, then the Hydroid eater of the family Dotidae, Flabellinidae [25]. Sponge eaters have more alternative substrates than other nudibranchs, the Chromodorididae family, namely the \textit{Chromodoris lochi} and \textit{Chromodoris anae} species, like DCA as a sticking place because the Nudibranch of this family like habitats with a reasonably shallow depth, have more active movement, and have currents. when attached to the DCA, they can withstand the current [11]. Nudibranchs that are found attached to sponges may be found while they are eating. \textit{Doto ussi} species from the Dotidae family tend to stick to the substrate they feed on, namely hydroid species \textit{Aglaoepenia cupressina} Lamouroux, 1816 [16], Other than as food and place to stick, the hydroid becomes the place to reproduce and attach eggs (Figure 5d). Nudibranchs attached to the substrate use it as a shelter, a source of food, and a place to live [13,17].
Table 4. Pray of nudibranch.

| Family                  | Sponge | Ascidian | Hydroid | Soft Coral | Opisthobranch |
|-------------------------|--------|----------|---------|------------|---------------|
| Chromodorididae Bergh, 1891 | ✓      |          |         |            |               |
| Dotidae Gray, 1853      |        |          | ✓       |            |               |
| Flabellinidae Bergh, 1889 | ✓      |          |         |            |               |
| Discodorididae Bergh, 1891 |       |          | ✓       |            | ✓             |
| Polyceridae Alder & Hancock, 1845 |     | ✓        | ✓       |            |               |
| Phyllidiidae Rafinesque, 1814 |       |          |         | ✓          |               |
| Myrrhinidae Bergh, 1905  |        |          |         | ✓          |               |
| Facelinidae Bergh, 1889  |        |          |         | ✓          |               |

Source: [25].

4. Conclusions

This study identified 22 species, including 12 genera and 8 families. The composition of the substrate greatly determines the richness of the nudibranch, the substrate category that determines the existence of Nudibranchs is DCA, Sponge, and Hard Coral. The high percentage of DCA and sponge is directly proportional to the diversity of Nudibranch, and Hard Coral is inversely proportional to the diversity of Nudibranch. The existence of Nudibranch is determined by the availability of food and places to stick.

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