The diversity of macroalgae epiphytes on the thallus surface of Kappaphycus Spp in Serewe Bay, East Lombok

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Abstract. Kappaphycus spp are seaweed that is widely cultivated by coastal communities. The community grows Kappaphycus spp because it has economically profitable. Although Seaweed cultivation often experienced failures caused by environmental, herbivorous, and epiphytic factors. This study aims to determine what type of epiphytes grow on the surface of the thallus Kappaphycus spp. Sampling was conducted at the seaweed cultivation location in Serewe Bay, East Lombok. The sampling stations were determined using the purposive sampling method. Data is displayed as a tabular form and analyzed descriptively. A total of 21 epiphytic species were found in K. alvarezii and K. striatum, namely Ulva compressa, Chaetomorpha crassa, Hypnea sp, H. valentiae, H. saidana, H. pannosa, Spyridia hypnoides, S. filamentosa, Heterosipnonia japonica, H. crispsella, Ceramium cingulatum, Ceramium flaccidum, Antithamnionella breviramosa, C. clarionensis, Acantophora spicifera, Bostrichia tenella, Polisiphonia sp., Polisiphonia foetidissima, Tolypiocladia glomerulata, Wrangelia gordoniae, W. tanegana, One species is found only in Kappaphycus alvarezii namely Padina minor. Five species are found only in K. striatum, namely Dictyota mayae, Ceramium cimbricum, Laurencia papillosa, Amphiroa sp. C. cimbricum is one species that found in two culture method. All environmental parameters are optimal, except for the brightness and water flow in the bottom culture method.

1. Introduction
Kappaphycus spp are seaweed that is widely cultivated by coastal communities. The community grows Kappaphycus spp because it has many benefits (including as a source of food, medicines, and industrial raw materials). Seaweed farming is an industry that can contribute significantly to the economy of the producing countries, providing foreign income and improving the socio-economic situation of the coastal people involved [1]. The Indonesian government is making efforts to meet the world's needs. One of the government's leading programs is the establishment of a cultivation centre. The NTB provincial government is more focused on developing seaweed through the 'PIJAR' program (cattle, corn, and seaweed) on Lombok and Sumbawa's islands. One of them is Serewe Bay cultivation in East
Lombok Regency [2]. Types of seaweeds that are cultivated are *Kappaphycus alvarezi* and *Kappaphycus striatum*.

*Kappaphycus* spp. cultivation is conducting throughout the year with the bottom, long-line, and raft methods. Seaweed cultivation often experienced failures caused by environmental, herbivorous, and epiphytic factors. The presence of epiphytes on the thallus surface can damage the physical condition, even causing the crop to fail. Epiphytes are plants that stave to other crops only as attached places [3]. Epiphytes usually appear when the quality of the environment decreases. The existence of epiphytes on the thallus causes competition to get sunlight. Thus, epiphytes indirectly affect the growth process of *Kappaphycus* spp. The presence of epiphytes also causes *Kappaphycus* spp. not to be used as a seed [4].

One effort of the community to avoid epiphytes is to use some planting seaweed methods and some types of *Kappaphycus*. Although it has been doing, the epiphytic population remains high. Therefore, research on epiphytes must be doing. The aims of this research are 1. To determine what kinds of epiphytes grow on the surface of thallus *K. alvarezi* and *K. striatum*, 2. The differences of epiphyte in *K. alvarezi* and *K. striatum*, 3. The differences of epiphyte at *K. striatum* in difference culture method.

2. Methodology
The research was conducted at the Serewe Bay seaweed cultivation centre, East Lombok (Figure 1.). Observation and identification of epiphytic samples were carried out at the immunobiology laboratory, Mataram University. Identification of epiphyte was carried out following the guidelines of [5]. The sampling method used in this research is the exploration method. Sampling was carried out on two species, namely *K. alvarezi* and *K. striatum*, with two cultivation methods: bottom and long-line. The sample taken is a sample of seaweed attacked by epiphytes. The collection sample was carried out three times during the study [6]. Besides, environmental parameter data collection is also carried out as supporting data. Environmental parameters taken are NH4, phosphate, temperature, pH, salinity, and dissolved oxygen (DO). The research data are presented in a tabular form and analyzed descriptively.

Figure 1. Epiphytic sampling location, Serewe Bay.

3. Results and Discussion
Algae can survive in various ecological conditions by sticking to multiple substrates, even very often found clinging as epiphytes on the surface of other organisms, including on other algae that are generally over-sized [4].

3.1 Type of Epiphyte at *Kappaphycus* spp. in Serewe Bay

Based on the collection and identification results, we found 27 species of epiphytes at the *K. alvarezi* thallus. The most widely discovered epiphytes are the Florideophyceae class, consisting of 22 species. The Ulvophyceae class consisting of 3 species, and the least epiphytes are the Phaeophyceae class with two species (Table 1).

Epiphytes are plants that attach to other plants to support growth and life [3]. Epiphytic algae are competitors in absorbing nutrients for host growth. Epiphytic algae can be a nuisance because it covers
the surface of the host. Furthermore, it prevents the process of absorption of nutrients and photosynthesis [7]. Aside from being a competitor of epiphytic algae, this is also one of the initial causes of bacterial infection that causes ice-ice disease. Based on the normal range, epiphyte size is divided into microepiphytes (length <1 mm) and macro-epiphytes (length> 1 mm). Several microepiphytes species infect Kappaphycus spp by integrating with the host to directly obtain nutrients, causing the host's growth to be disrupted [8]. Macro-epiphytes sometimes flourish to exceed the size of Kappaphycus spp or its host so that it can become a competitor during the photosynthesis process. [9], macro depressives with sufficiently strong attachment can penetrate the cell wall, and cortical cells tend to stick to more substantial and more prolonged. This accident hurts seaweed growth while the type of epiphyte that attaches weakly and does not penetrate the cell wall tends to be easily detached and does not significantly impact seaweed.

Identification was carried out on epiphytic macroalgae attached to Kappaphycus spp. in the study site's existing cultivation area. Based on the identification results, obtained 27 species of epiphytic macroalgae. The species collected are members of the class Ulvophyceae, Phaeophyceae, and Florideophyceae. All species were found epiphytes both in K. striatum and K. alvarezii, which were planted using the bottom planting method and the long-line planting method. The most dominant epiphytic algae species are species from the Florideophyceae class of 22 species, Rhodophyta divisions. Ceramium and Hypnea are the most prevalent genus of epiphytic algae at the genus level, with four species of the genus Ceramium and four species of the genus Hypnea. When sampling, it was seen that the number of individuals from both types of algae was relatively high. Almost every sampling location found epiphytes on Kappaphycus spp.

| Class          | Ordo       | Family           | Genus   | Species          |
|----------------|------------|------------------|---------|------------------|
| Ulvophyceae    | Ulvales    | Ulvaceae         | Ulva    | U. compresa Linnaeus |
| Cladophorales  | Cladophoraceae | Cladophora         | C. dalmatica Kutzing |
|                |            | Chaetomorpha     | C. crassa Kutzing |
| Phaeophyceae   | Dictyotales | Dictyotaceae     | Padina  | P. minor Yanada |
|                |            |                  | Dictyota | D. mayae Lozano & Sentíes |
| Florideophyceae| Gigartinales| Cystoclioniaceae  | Hypnea  | H. valentiae Montagne |
|                |            |                  |         | H. saidana, H. |
|                |            |                  |         | H. pannosa J. Agardh |
|                |            |                  |         | S. hypnoides (Bory) Papenfuss |
|                |            |                  |         | S. filamentos (Wulfen) |
|                |            |                  |         | Harvey |
|                |            |                  |         | H. japonica Yendo |
|                |            |                  |         | H. crispella (J.Agardh) M. J. Wynne |
| Ceramiaceae    | Spyridiaceae| Spyridia          |         | Ceramium cingulatum Weber- |
|                |            |                  |         | van Bosse |
| Dasyaceae      | Heterosiphonia |                  |         | C. flaccidum (H.E.Petersen) G. |
|                |            |                  |         | Furnari & Serio |
| Ceramiaceae    | Ceramium    |                  |         | C. cimbricum H.E.Petersen |
|                |            |                  |         | C. clarionensis Setchell & N |
|                |            |                  |         | L.Gardner |
| Antithamnionella|           |                  |         | A. breviramosa (E.Y.Dawson) |
| Rhodomelaceae  | Laurencia  |                  |         | Wollaston |
| Acanthophora   |            |                  |         | L. papillosa Zanardini |
| Bostrychia     |            |                  |         | A. spicifera (M.Vahl) |
| Polisiphonia   |            |                  |         | Børgesen |
|                |            |                  |         | B. tenella (J.V.Lamouroux) |
|                |            |                  |         | J.Agardh |
|                |            |                  |         | P. foetidissima |
Based on [10], epiphytes growing on the surface of the seagrass *Enhalus acroides* dominated by the Rhodophyta division. The result is also consistent with the research results by [3] that the Rhodophyta division is one of the most commonly found divisions attached to *Kappaphycus spp*. The Rhodophyta class Morphology has a medium to small cylindrical shape so that the types grow faster on the talus *Kappaphycus spp* than other types. With the small size of the epiphytic species, the possibility of space increasing on the thallus *Kappaphycus spp* will be higher. On the other hand, if algae species' size is large, then the area to grow will be less because only one species has exceeded the host thallus's capacity. Red algae group or Rhodophyta is a type of algae that has a habitat in the sea. This algal group dominates along the coast and tropical continental shelf and sub-tropics.

The epiphytes from the Chlorophyta division in this study were found from the Ulvophyceae class consisting of two orders, two families, two genera, and three species: *Ulva compressa* *Chaetomorpha crassa*, and *Cladophora dalmatica*. Research [11] stated that the competing algae species that dominated the observed rafts were species from *Chaetomorpha crassa*. The species have cylindrical thallus resembling hair or form lumps like tangled threads and are green in colour. This type of algae can sometimes be abundant and becomes a problem in conducting *Kappaphycus spp*.

The Phaeophyta Division is found in at least two species: *Dictyota mayae* and *Padina minor*. Both types of algae were found as epiphytes in the cultivation of *Kappaphycus striatum*, which was planted using the bottom planting method. *Dictyota* genus is quite commonly found in intertidal regions [12]. It is firmly attached to rocky substrates, even some that live attached or as epiphytes in other algae. This type of algae also has a large size of the thallus, and holdfast is too large, so it is less likely to stick to other algae types.

### 3.2 Type of epiphyte on *Kappaphycus alvarezii* and *Kappaphycus striatum* in different cultural methods

The epiphyte species found in the *K.alvarezii* and *K. striatum* are different (Table 2). Species *Padina Minor, Dictyota mayae, Ceramium cimbrispring, Laurencia papillosa*, and *Amphirhoa sp*. Not found epiphytes on *K. alvarezii*. *Ceramium flaccidum* found epiphytes on the *K. striatum* planted using bottom methods. Other epiphyte algae species are found epiphytes on *K. alvarezii* and *K. striatum*. Differences in the type of epiphytic algae found in this study occurred because planting long-line was carried out by the cultivation of *K. alvarezii* and *K. striatum*. While on the bottom planting method is done cultivation *K. striatum* only. So the possibility of epiphytic algae will be more found in the cultivation of *K. striatum*.

Cultivation methods affect epiphytic algal species in *Kappaphycus spp*. in Serewe Bay, East Lombok Regency. Epiphytic macroalgae found in *Kappaphycus spp*. Those planted in the bottom planting method are more likely to be found than those grown in the long-line planting method. The bottom planting method is carried out in intertidal areas where the area is affected by tides. There are critical environmental factors, such as temperature fluctuations, salinity, brightness, dissolved oxygen, etc. This zone is inhabited by organisms that are all marine organisms, including higher plants and lower plants such as algae. The types of algae have relatively high diversity because this area has high solar irradiation.

Furthermore, this area has several substrates ranging from sandy to rocky substrates. So the algae can survive due to photosynthetic process activities that are running smoothly. The bottom planting method
is located in a zone very close to the mainland so that it affects high nutrient intake, which can increase the rate of epiphyte growth.

Whereas the long-line planting method carried out in the middle of the sea, which is more in-depth and is not affected by tides, has high current strength and high enough sun exposure. The difference in environmental parameters is undoubtedly a determining factor for differences in epiphytic algae in *Kappaphycus spp*. Most of the macroalgae in waters have habitats in intertidal areas to a certain depth. One example is *Acanthophora spicifera*, a Rhodophyceae alga with a wide distribution throughout the tropics and subtropics. This distribution occurs on various substrates, from a hard bottom, some epiphytes in other algae, or free-living algae. In the long-line planting method, the distance to the land is far enough to reduce the nutrient content, causing the epiphyte growth rate below.

Table 2. Differences in Algae Epiphytic *Kappaphycus* spp types are planted with the Basic Planting Method and Longline.

| No | Epiphyte Species | Culture/Planting Method | K. alvarezii | K. striatum | K. striatum |
|----|------------------|-------------------------|--------------|-------------|-------------|
| 1. | Ulva compresa Linneaus | Longline | + | + | + |
| 2. | Cladophora dalmatica Kutzin | Longline | + | -- | -- |
| 3. | Chaetomorpha crassa Kuetzing | Longline | + | + | + |
| 4. | Padina minor Yanada | -- | -- | + |
| 5. | Dicyota mayae Lozano-Orozco &Senties | -- | -- | + |
| 6. | Hypnea sp. | Longline | + | + | + |
| 7. | Hypnea valentiae (Turner) Montagne | Longline | + | + | + |
| 8. | H. saidana Holmes | Longline | + | + | + |
| 9. | H. pannosa J. Agardh | Longline | + | + | + |
| 10. | S. hypnoides (Bory) Papenfuss | Longline | + | + | + |
| 11. | S. filamentosos (Wulfen) Harvey | Longline | + | + | + |
| 12. | H. japonica Yendo | Longline | + | + | + |
| 13. | H. crispella (C.Agardh) M.J.Wynne | Longline | + | + | + |
| 14. | Ceramium cingulatum Weber-van Bosse | Longline | + | + | + |
| 15. | C. flaccidum H. E. Petersen) G. Furnarii & Serio | Longline | + | + | + |
| 16. | A. breviramosa (E.Y.Dawson) Wollaston | Longline | + | + | + |
| 17. | C. cimbricum H.E.Petersen | -- | + | + |
| 18. | C. clarionensis Setchell&NL.Gardner | Longline | + | + | + |
| 19. | L. papillosa Zanardini | -- | -- | + |
| 20. | Acantophora spicifera (M.Vahl) Børjesen | Longline | + | + | + |
| 21. | Bostrichia tenella (J.V.Lamouroux) J.Agardh | Longline | + | + | + |
| 22. | Polisiphonia sp | Longline | + | + | + |
| 23. | Polisiphonia foetidissima | Longline | + | + | + |
| 24. | T. glomerulata (C.Agardh) F.Schmitz | Longline | + | + | + |
| 25. | Wrangelia gordoniae | Longline | + | + | + |
| 26. | W. tanegana Harvey | Longline | + | + | + |
| 27. | Amphiroa sp. | -- | -- | + |

Description: -- (not found; + (found).

The type of *Kappaphycus spp* cultivation also affects the species of epiphytic algae found. In the cultivation of *K. striatum*, found more types of epiphytic macroalgae compared with *K. alvarezii*. However, the number of epiphytic on *K.alvarezii* is much higher than *K. striatum*. It is related to the sampling area, where *K. alvarezii* samples are only planted in the long-line planting method. At the same time, *K. striatum* is cultivated in the long-line and bottom planting method. So, it indeed results in the high diversity of epiphytic algae found in *K. striatum*. The structure of the *K. alvarezii* thallus and *K striatum* is also different. *K. striatum* talus is much more slippery and hard than *K. striatum* talus. So, the possibility of attaching epiphytic algal spores will be more comfortable on *K. alvarezii*. 


Macroalgae generally live as epiphytes on the surface of seagrass leaves or the talus macroalgae's larger. The presence of epiphytes in K. alvarezii talus has been detected in various countries with cultivation centres. The research result found epiphytes in K. alvarezii talus cultivated on Balambangan, Sabah[5]. The results of the study revealed that Neosiphonia savanna was the most dominant epiphyte infecting K. alvarezii. The dominance rate ranges from 80-85% of the epiphytes found. Apart from N. savatieri, Neosiphoniaapiculata, Ceramium sp., Acanthophora sp., and Centroceras sp., were observed in smaller numbers. This epiphyte was also found in Semporna, Malaysia [13], on Songo-Songo Island, Madagascar [14].

3.3 Environmental Parameters

The ecological parameters measured in this study include temperature, pH, dissolved oxygen, current strength, brightness, salinity, NO2, and PO4 (Table 3.). Epiphytes at Kappaphycus spp, most of the cultivated plants come from the seeds used, because according to the residents of the bay of East Lombok Regency. The Kappaphycus spp, sometimes, have been infected by epiphytes first. Besides, the water quality is healthy, and it is still reasonably fertile for macroalgae survival. Water fertility is influenced by the dynamics of the sea, such as tides. The water input from the sea directly will make the seas' condition maintained with a nutrient content for the algae survival. The temperature of the waters at 27-28.1°C is the optimal temperature for macroalgae life. The average temperature range for macroalgae survival is in 26-33 °C. So, the water temperature is possible for the epiphytic algae to survive. In the long-line, the weather is lower than the temperature in the bottom planting method. Sampling factors caused the difference in water temperature because sampling was conducted in intertidal and mid-ocean areas. It is related to the cultivation method of Kappaphycus spp. The weather will be higher in the intertidal than in the subtidal zone. The intertidal region is much closer to the mainland. Land cooling in the rainy season causes the coast's temperature to be lower [15]. Based on these data, in general, the waters' condition is excellent to support macroalgae growth. Water temperature is very important for macroalgae metabolism because the speed of metabolism increases with increasing water temperature.

| Environmental Parameters | Culture/Planting Method |
|--------------------------|-------------------------|
|                          | Longline | Bottom |
| Temperature (°C)         | 27-27.3  | 28-28.1 |
| pH (%o)                  | 7.0-7.5  | 7.8-8.0 |
| DO (m/s)                 | 7.8-8.0  | 7.6-7.7 |
| Water Current (m/s)      | 0.04-0.05| 0.01   |
| Brightness (m)           | 10-11    | 3-4    |
| Salinity (ppt)           | 4.0      | 4.0    |
| NO2 (mg/L)               | 0.1      | 0.1    |
| PO4(mg/L)                | 0.03     | 0.03   |

The development of macroalgae is related to the movement of waves, wind, and currents. The large waves and strong winds caused macroalgae to escape from the substrate. Besides, it can release attached macroalgae spores. The water movement has a huge role in nutrient availability, light penetration, and temperature and salinity changes. Water movement that is too high causes pressure on macroalgae to be high, even causing spores to fail to stick to the substrate. Meanwhile, if the water movement is too low, it will impact diffusion pressure and interfere with nutrient uptake [16]. A steady current of 0.5 m / s is optimal for macroalgae.

Nitrate content for marine biota is 0.0080 mg / L. Nitrate is needed by seaweed for development and production and food reserves [17]. Phosphate analysis results ranged from 0.03 mg / L both on the long-line and bottom planting method. The average level of phosphate in the sea is 0.070 mg / L, while the phosphate for waters with high fertility rates ranges from 0.201–0.1 mg / L. According to [1], there are no primary nutrients such as nitrates and phosphates that can support the growth of seaweed. The high and low phosphate levels in water are an indicator of water fertility [18]. The range of salinity values
for macroalgae growth ranged from 2.8 to 3.4 ppt. Increasing or decreasing water temperature and salinity drastically caused the dominance and infection on seaweed thallus towards macro-epiphyte [8].

Water conditions that are very acidic or very alkaline will endanger the organism's survival because it will cause metabolic and respiration disorders[19]. Data from the measurement of water pH shows that the pH of Serewe Bay waters in the East Lombok Regency is ideal for algal survival.

DO concentration at sea level is affected by temperature; the higher the temperature, the lower the gas's solubility. DO levels obtained during research in Serewe Bay's waters ranged from 7.0 to 8.2 ppm. This condition is a reasonable condition for macroalgae survival [20]. Dissolved oxygen (DO) is also impactful on growth and macro-epiphyte parasitism [8].

4. Conclusion
Twenty-one species were found in Kappaphycus spp, namely Ulva compressa, Chaetomorpha crassa, Hypnea sp, H. valentiae, H. saidana, H. pannosa, Spyridia hypnoides, S. filamentosa, Heterosipnonia japonica, H. crispella, Ceramium cingulatum, Ceramium flaccidum, Antithamnionella breviramosa, C. clarienensis, Acantophora spicifera, Bostrichia tenella, Polisiphonia sp., Polisiphonia foetidissima, Tolypiocladia glomerulata, Wrangelia gordoniae, W. tanegana. One species is found only in Kappaphycus alvarezi namely Padina minor. Five species are found only in K. striatum, namely Dictyota mayae, Ceramium cimbricum, Laurencia papillosa, Amphiroa sp. C. cimbricum is one species that found in two culture method. All environmental parameters are optimal, except for the brightness and water flow in the bottom culture method.

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