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Seaweed (macroalgae) diversity on the Dikwella coast, Southern Sri Lanka

Seaweeds are photosynthetic and macroscopic eukaryotic organisms found in marine and brackish water environments (Nedumaran & Arulbalachandran 2015). They are one of the major primary producers in marine ecosystems (Harley *et al*. 2012). They are also important in maintaining coastal biodiversity by interacting with other organisms (Fulton *et al*. 2019). In addition to their biological and ecological importance, seaweeds are economically significant (Wijesinghe & Jeon 2011). Data from the Food and Agriculture Organization (FAO) shows that a total of 35 million tonnes of seaweed were produced through cultivation in 2019 and 97% of this was from East Asia. China was ranked as the top producer (Cai *et al.* 2021). In contrast to all the positives, there are a few negative impacts of seaweeds; including biofouling, habitat invasion, and unwanted beach drift (Chapman *et al.* 1998).

A variety of seaweeds occur in Sri Lanka's coastal waters and currently 440 taxa belonging to 148 genera have been identified (Premarathna *et al*. 2020). Because of the north and east coast's extensive sand beaches and protected coves, the majority of the Sri Lankan taxa described are restricted to the southern and western shoreline (Durairatnam 1961). Moreover, from June to November, the supralittoral and intertidal zones exhibit a particularly dense seaweed cover as a result of the seasonal monsoons, and during the dry season after November, the diversity of seaweeds declines, as many of them are subjected to desiccation (Coppejans *et al*. 2009). Large waves collide with the edges of reefs and rocks during the south-west monsoon, when the water is particularly turbulent and plenty of algae are torn off and thrown upon the coasts (Durairatnam 1961). However, after the monsoon, seaweeds are regularly flushed by waves, leading to an increase in their abundance and diversity (Coppejans *et al.* 2009).

In Sri Lanka, knowledge on the diversity of seaweeds is lacking. More research could establish a foundation for future, comprehensive ecological studies in this field and help manage and study seaweeds (Premarathna *et al*. 2020). The objective of this study is to contribute to that process by examining the diversity of seaweeds along the southern coast of Sri Lanka, as well as compare the diversity of the three major types of seaweed: red algae, green algae, and brown algae.

The study site was the south coastal area of Sri Lanka, with the geographical platform of Dikwella (5°57'35.8N, 80°41'06.9E). The first set of samples were collected in the first and last weeks of March and April 2019 (before the south-west monsoon), while the second set was collected in the first and last weeks of October and November 2019 (after the south-west monsoon). 30 quadrats (0.5 × 0.5m each) were randomly placed along a 30m stretch of the Dikwella coast for each sample period. Algal species were identified in situ using standard identification guides (Coppejans *et al.* 2009). Clear, high-resolution photographs of each quadrat were taken using a Canon 750D EOS digital camera. Algal samples that were difficult to identify in-situ were collected and placed in polythene bags containing seawater and taken to the laboratory for further identification.

The average total percentage cover of algal species was calculated. In addition, the relative abundance values for all three types of seaweeds were calculated separately. The Shannon Wiener diversity index (H) and Simpson’s diversity indexes (D) were calculated using R to assess the diversity of algae species. Since, percentage cover was used instead of individual numbers; Simpson’s original index was used. In order to convert probability into diversity, 1-D was used. The Shannon-Wiener diversity index assesses the difficulty of correctly predicting the species of the next individual collected, whereas the Simpson's diversity index assesses the likelihood that two randomly selected individuals belong to the same species.

Thirty-three algal species belonging to 19 families were found (Appendix). Green algae were the most abundant seaweed type (45%). Although species richness was greatest in red algae (19 species), they had the lowest total abundance (19%; Table 1). Brown algae had the lowest species richness (4 species) (Appendix). Overall, *Sargassum* sp. (33.1%) had the highest relative abundance, followed by *Ulva lacuta* (21.4%). The most prevalent species of brown algae by relative abundance was *Sargassum* sp. (93.2%). Further, *Ulva lacuta* (47.1%) showed the highest relative abundance among green algae, while *Pterocladiella caerulescens* (24.3%) showed the highest relative abundance among red algae. Red algae had the highest diversity of the three algal types (H = 2.4; 1-D = 0.88). Green algae (H = 1.6, 1-D = 0.72) was more diverse than brown algae (H = 0.3, 1-D = 0.13) (Table 1).

Table 1. Relative abundance, Shannon Wiener and Simpson's diversity index values for brown, green and red algae recorded in this study

Algae (Number of species)	Relative abundance	Shannon Wiener index	Simpson's diversity index
Brown algae (4 species)	36%	0.32	0.13
Green algae (12 species)	45%	1.60	0.72
Red algae (19 species)	19%	2.43	0.88

Red algae had the highest diversity, although their relative abundance was the lowest. It can be assumed that *Sargassum* sp. outcompeted other species in this habitat. This species is able to limit other algal species in marginal environments (Ali *et al*. 2017). The large intertidal area and habitat homogeneity might be the reason behind the mono-specific stands of *Sargassum* sp. The same effect of *Sargassum* sp. has been reported in previous studies (Britton-Simmons 2004, Thakur *et al*. 2008). Not only *Sargassum* sp. but also other species like *Ulva* sp. and *Prophyra* sp. can be opportunistic and cause these types of blooms (Imchen & Anil 2017).

Competition is the most important factor determining plant diversity and distribution in the absence of stresses such as herbivory (Edwards & Connell 2012). This competition can occur for light, nutrients, and space. Variations in the availability of light and variations in water quality parameters such as different nutrient levels, water temperature, pH, transparency, conductivity, and amounts of dissolved gases such as dissolved oxygen and dissolved carbon dioxide can result in variations in the seaweed community structure (Mir *et al*. 2010, Roy 2020). Not only environmental factors, but also biological factors, such as dispersal ability, can influence variation in the abundance and richness of algal species (Worm *et al*. 2001). However, in this study, environmental and biological factors were not considered. In future studies, these factors should be taken into account in order to get more accurate correlations with water quality parameters.

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Appendix. Checklist of marine macroalgae found in Dikwella, southern Sri Lanka

Family	Species
Red algae	
Bonnemaisoniaceae	*Asparagopsis taxiformis*
Ceramiaceae	*Centroceras clavulatum*
Corallinaceae	*Amphiroa foliacea* *Amphiroa fragilissima* *Jania ungulata.* *Porolithon* sp.
Cystocloniaceae	*Hypnea pannosa*
Gelidiaceae	*Gelidium* sp.
Gracilariaceae	*Gracilaria canaliculata* *Gracilaria corticata.* *Gracilaria hikkaduwensis*
Halymeniaceae	*Carpopeltis maillardii* *Polyopes ligulatus*
Liagoraceae	*Dermonima viruns*
Lomentariaceae	*Gelidiopsis repens* *Gelidiopsis variabilis*
Pteocladiaceae	*Pterocladiella caerulesceris*
Rhodomelaceae	*Laurencia natalensis* *Natelensis* sp.

Family	Species
Green algae	
Bryopsidaceae	*Bryopsis pennata*
Caulerpaceae	*Caulerpa lentilifera* *Caulerpa recemosa* *Caulerpa sertulariodies* *Caulerpa verticillata*
Cladophoraceae	*Chaetomorpha antennia* *Cladopora* sp.
Halimedaceae	*Halimida opuntia*
Ulvaceae	*Ulva faciata* *Ulva lactuca*
Valoniaceae	*Valoniopsis fasifata* *Valoniopsis pachynema*
Brown algae	
Dictyotaceae	*Canistrocarpus crispatus* *Padina minor*
Sargassaceae	*Sagassum crassifolium* *Sargassum* sp.