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Physical structure of artificial seagrass affects macrozoobenthic community recruitment

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Abstract. Seagrass ecosystems are important in supporting marine biodiversity. However, the worldwide decline in seagrass areas due to anthropogenic factors leads to a decrease in the marine biodiversity they can support. There is growing awareness of the need for concepts to conserve and/or rehabilitate seagrass ecosystems. One option is to create artificial seagrass to provide a physical structure for the marine organisms to colonize. The objective of this research was to analyze the effect of some artificial seagrasses and seagrass transplants on marine biodiversity, with a focus on the macrozoobenthic community. The experimental design compared two types of artificial seagrass (polypropylene ribbons and shrub-shaped plastic leaves), and seagrass transplants from nearby seagrass meadows. The experimental plots were 4 x 4 m^2 with 3 replicates. Macrozoobenthic communities were sampled fortnightly for 3.5 months. At the end of the experiment, makrozoobenthos were also sampled from a natural seagrass bed nearby. Of 116 macrozoobenthic species in the artificial seagrass plots, 91 were gastropods. The density of the macrobenthic fauna increased from the beginning to the end of the study in all treatments, but the increase was only significant for the artificial seagrass treatment (i.e. shrub-like plastic leaves). There was a distinct separation between the macrozoobenthic community structure found in the restoration plots (artificial seagrass and transplanted seagrass) compared to natural seagrass beds.

1. Introduction

Seagrass ecosystems are a shallow-water coastal marine ecosystem. In Indonesia, seagrass beds are often found adjacent to or between mangrove and/or coral reef ecosystems, and the importance of the multiple ecological interactions among these ecosystems is now universally recognised, if not yet fully understood. As the community structure and physical properties of the three ecosystems are mutually supportive, if one is disturbed, the other ecosystems will be affected [1].

On the one hand, seagrass beds provide valuable ecosystem services such as nursery grounds, beach protection, and water quality maintenance. On the other hand, industrial development and the growth of human population in coastal areas have placed severe pressures on seagrass ecosystems, resulting in the degradation or even loss of seagrass ecosystems in many locations [2]. A decline in marine biodiversity is likely as a result of the partial or total loss of ecological functions following damage to or loss of seagrass beds [3]. One measure to mitigate this impact is to plant artificial seagrass in areas where seagrasses have been severely damaged or eradicated.

Artificial seagrass has been shown to serve as habitat for some marine organisms; artificial seagrass units could therefore be used as a refuge by some marine organisms, especially epifauna, when natural seagrasses are in critical condition [4]. The results of this pervious study inspired a more in-depth study on the effects of different artificial seagrass types on the macrozoobenthic community.

The objectives of the research were: 1) to analyze the effect of two types of artificial seagrass on marine biodiversity, with a focus on the macrozoobenthic community; 2) to evaluate the ecological function of artificial seagrasses by comparing macrozoobenthic communities found in artificial and natural seagrass habitat.

2. Materials and Methods

2.1. Study site
The experiment was conducted in the waters surrounding Barrang Lompo Island, Makassar, Indonesia (5º03'S, 119º20'E). Artificial seagrasses were deployed in the sub-tidal zone (± 1.5 meters at low tide) on the west side of the island, in areas not covered by natural seagrass, but with seagrass *Enhalus acoroides* stands nearby.

2.2. Treatments
Three treatments were used in this study. The first artificial seagrass treatment (A) used ribbon-like leaves made from plastic rope (width 1.6 cm; length 50 cm). The second artificial seagrass treatment (B) comprised plastic floral decorations used to make shrub leaves. The third treatment (C) was transplants of natural seagrass *E. acoroides*. The artificial seagrasses and transplant were tied to or planted in 4 m x 4 m iron frames.

All treatments were randomly deployed on the substrate parallel to the shoreline. The three replicates of each treatment were tagged with symbols A1, A2, A3 (Treatment A); B1, B2, B3 (Treatment B); C1, C2, and C3 (Treatment C). The distance between the treatment levels was 50 m.

2.3. Sampling of macrozoobenthos
Macrozoobenthos samples were collected using a grab sampler with an area of 20 x 20 cm^2. The first sampling was one week after deployment, followed by sampling every fortnight for three months. During the final data collection, macrozoobenthos samples were also collected from a natural seagrass bed nearby to enable comparison between the restoration plots and a natural seagrass ecosystem. The samples were sieved using a mesh size of 1 mm to separate the benthic fauna from sediments. The benthic fauna found were then preserved in 70% alcohol, stored in small jars and labelled. The macrozoobenthic organisms were identified based on [5,6,7].

2.4. Data Analysis
The macrozoobenthos community structure parameters or indices calculated were species diversity, population density, diversity index, evenness index, and dominance index based on [8].

Macrozoobenthos density was calculated using the formula:

$$Y = \frac{100 \times a}{b} \tag{1}$$

where: Y = Density (ind/m^2)
a = Number of individuals (ind)
b = Area sampled by the grab sampler (cm^2)

Diversity Index was calculated as follows:

$$H' = -\sum pi \ln pi\,;\;\; pi = ni/N \tag{2}$$

where: H'= Diversity Index
ni = Number of individual for each species
N = Total number of individuals

Evenness Index was calculated as follows:

$$E = \frac{H'}{\ln S} \tag{3}$$

where: E = Evenness Index
H'= Diversity Index
S = Number of species

Index of Dominance was calculated using the formula:

$$C = \sum \left(\frac{ni}{N}\right)^2 \tag{4}$$

where: C = Index of Dominance
ni = Number of individuals for the ith species (i = 1 to S)
N = Total number of individuals

Macrozoobenthic community structure parameters/indices were calculated and grouped according to treatment (3 treatments) and then analyzed using One-Way Analysis of Variance (ANOVA) for each observation period. To evaluate the effect of the presence of artificial seagrass and natural seagrass transplants on the macrozoobenthic community structure, data from before and after the deployment of each treatment were compared using a t-student test. In addition, similarities in macrozoobenthic community structure were also analyzed between treatments and natural seagrass using Cluster Analysis (CA) [9].

3. Results and Discussion

Macrobenthic fauna found in the artificial seagrass treatment plots comprised 116 genera. Of these, the majority were molluscs, with 91 gastropod genera (21825 individuals) and 12 bivalve genera (1250 individuals). The remainder comprised crustaceans (2 genera, 63 individuals), asteroids (2 genera, 625 individuals), polychaetes (2 genera, 88 individuals), sipunculids (one genus, 100 individuals), scapopods (3 genera, 800 individuals), and echinoids (3 genera, 200 individuals). The macrozoobenthic community structure indices (diversity, evenness, and dominance) for each treatment are shown in Figure 1.

Macrozoobenthic diversity index values ranged from 2.03 to 2.47. Overall, the macrozoobenthos diversity in all treatments was in the high category (2.0 $<$H '$\leq$ 3.0). The Evenness Index was in the range of 0.83 to 0.96. This value indicates that the individuals of each genus or species were evenly distributed (0.75 $<$E $\leq$ 1.00) [8]. This result was further supported by the Dominance Index of around 0.09, showing no signs of dominance of certain species of macrozoobenthos under any treatment.The fortnightly sampling data showed no significant differences among treatments in macrozoobenthic species number or density during any sampling period (Fig. 2).

Macrobenthic fauna density tended to increase during the study. The highest density was obtained from the final sampling in week 14 (571 ind/m^2), and was approximately double the baseline (before planting) density (267 ind/m^2), as shown in Fig. 3. This indicates that artificial seagrass and seagrass transplants can both attract some macrozoobenthos to inhabit the area and use it as a refuge.

The increase over time in the number of species and the macrozoobenthos density present in the two types of artificial seagrass and transplanted natural seagrass plots is in line with previous findings, which indicated that the number of species and density of epifaunal organisms inhabiting artificial seagrass is more strongly correlated with the length of deployment period of the artificial seagrass than with the type of material used to construct it [4]. This suggests that artificial seagrass may possibly be used as a foraging site as well for protection; epiphytes are a food source for many types of macrozoobenthic organisms, and the biomass of epiphytes attached to the structure would seems to be determined by the time elapsed since the artificial seagrasses were deployed.

Macrozoobenthos density increased from the beginning to the end of the study in all treatments, but the increase was only significant for treatment B (shrub-like plastic leaves) (Fig. 3). Artificial seagrass with shrub-like leaves may provide a higher protection because its leaf structure is more complex [10]. However, the increase in macrozoobenthic species was not significant under any of the treatments.

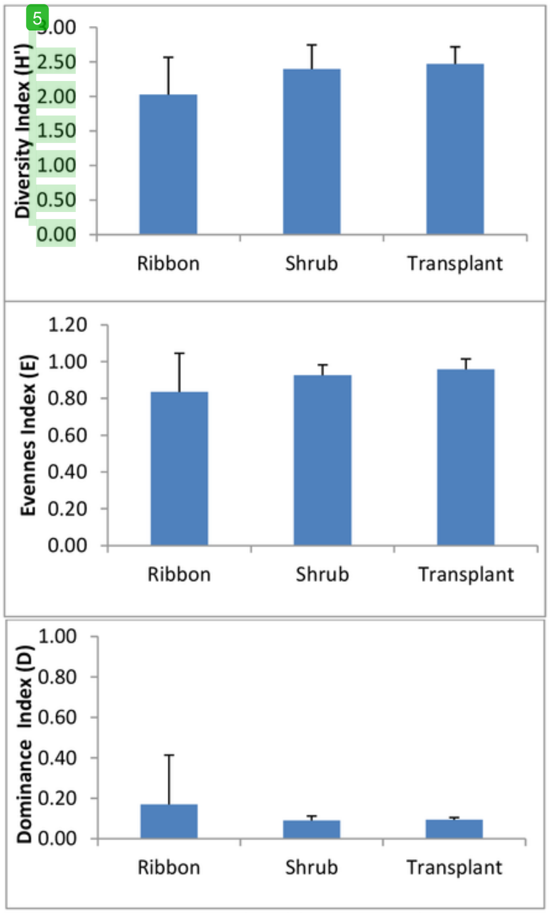

Figure 1. Macrozoobenthic community structure indices (diversity, evenness, and dominance) for each treatment (mean values over time and between replicates).

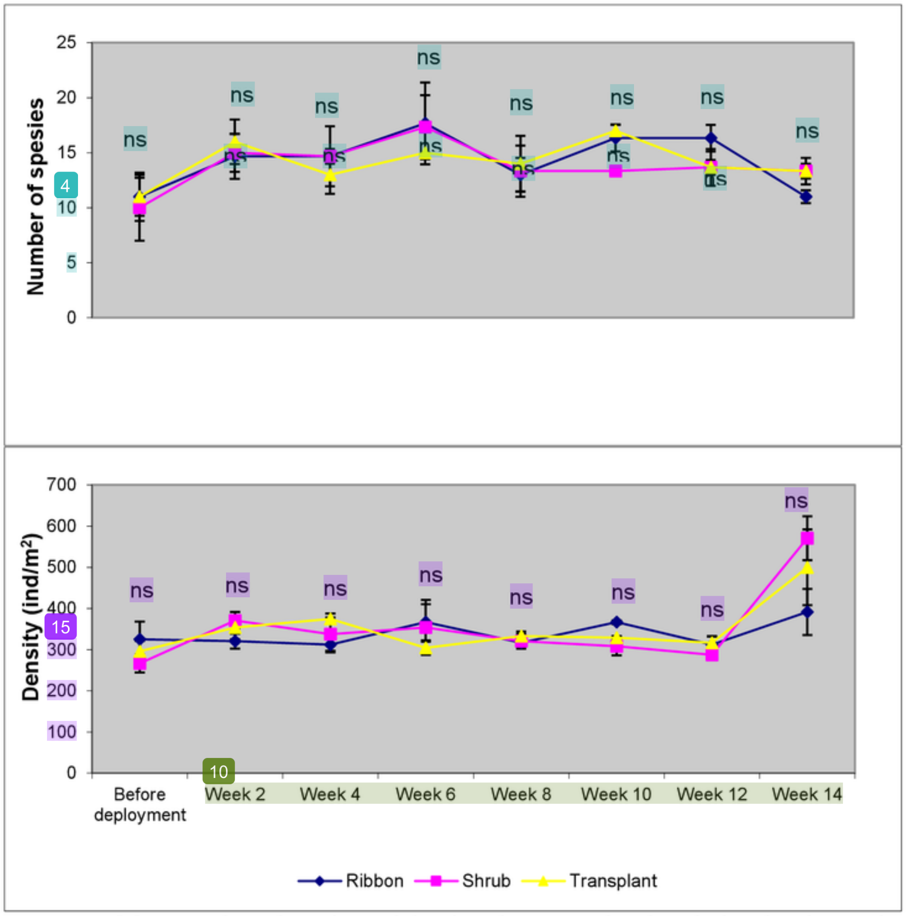

Figure 2. Mean number of species and density of macrozoobenthos during the observation period for each treatment.

The minimal separation in the cluster analysis (Fig. 4) shows a high degree of similarity in community structure between the three treatments. However there was a clear separation between the macrozoobenthic community structure of the three treatments and that of the nearby natural seagrass bed. One reason for this difference is the number of species found; whereas the treatment plots contained 116 species, there were 118 species in the natural seagrass area. The two distinct species found only in natural seagrass areas were *Nereis pelagica* and *Asterias astrubs*. Starfish of the class Asteroidea (*A. astrubs*) require seagrass habitats that contain a large amount of litter as food. While *N. pelagica* (class Polychaeta) require seagrass roots as a place to attach.

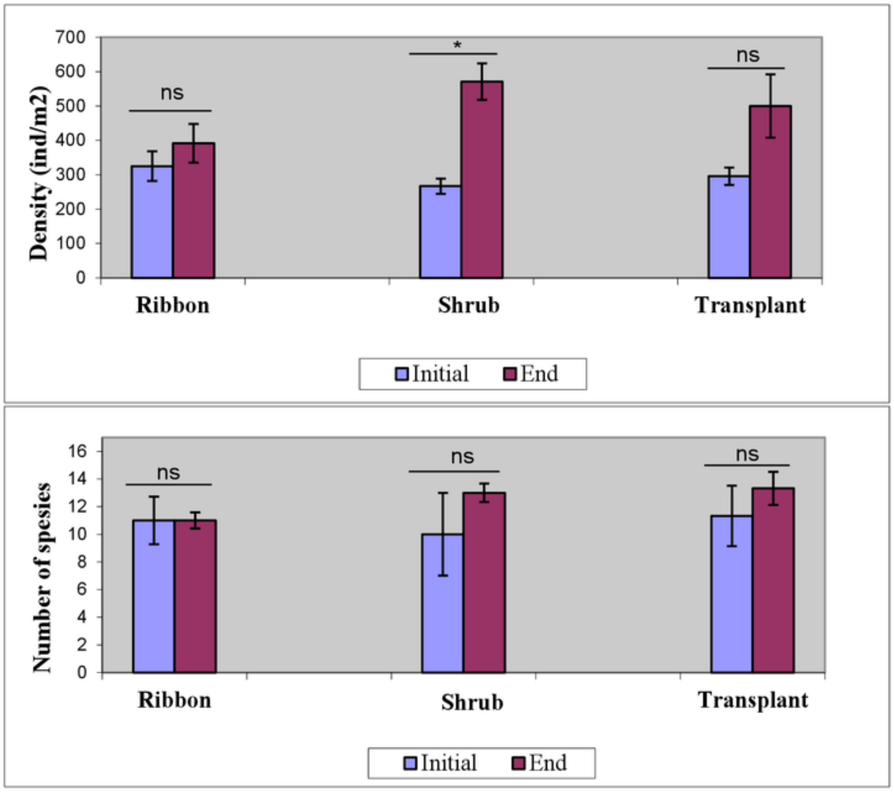

Figure 3. Comparison of initial and final mean macrozoobenthos density and species number by treatment.

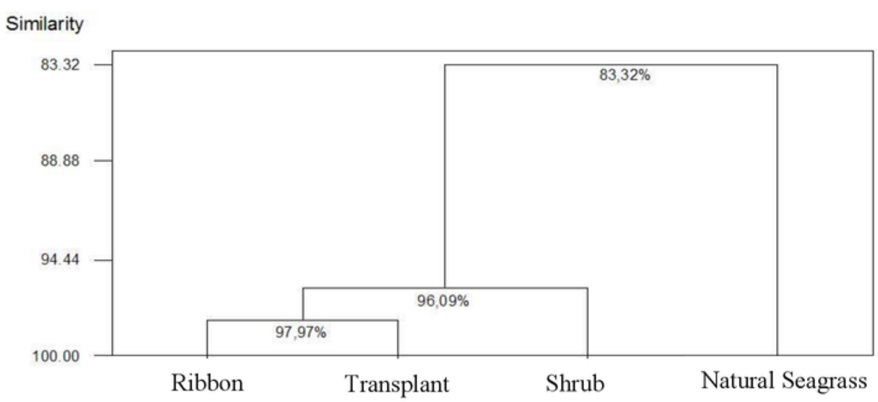

Figure 4. Similarity of macrozoobenthic community structure of the three treatments and natural seagrass bed.

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