

SEAGRASS DETRITUS AS MARINE MACROINVERTEBRATES ATTRACTOR

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Abstract – Seagrasses colonise coastal areas worldwide. Despite their high primary production, a considerable proportion becomes detritus that can be used as food, physical habitat and occasional or permanent shelter by several benthic macroinvertebrates. In turn, macroinvertebrates can contribute to regulating seagrass decomposition, and represent an important trophic link between primary producers and higher consumers. Nonetheless, several factors could modify colonizer responses to this habitat.

In this study, we tested if colonisation of the seagrass detritus of *Zostera noltei* Hornemann, 1832 was related to substrate availability rather than food and whether the colonising assemblages were similar according to the structural complexity of the meadow. We used artificial seagrass detritus to mimic the physical structure of the natural detritus while disentangling the effect of food attractiveness vs. physical habitat availability. Litterbags were filled with natural or artificial detritus and deployed within a seagrass meadow in Thau lagoon (Étang de thau, France) in areas of different structural complexity. During two field experiments, detritus decomposition and litterbag colonisation were analysed.

A total of 11270 individuals belonging to 26 taxa were identified (including polychaetes, crustaceans, molluscs, and chironomids larvae). Habitat structural complexity shows no effects on the colonisation of the detritus, but there were clear differences between empty and filled litterbags, which had a higher number of species and individuals, but without a general preference for the natural or artificial detritus substrate.

In conclusion, colonisation appeared to be driven by the presence of debris material, and not by its type. The natural and artificial detritus acts as an attractor for macroinvertebrates, which use opportunistically one or the other type, with no differences according to the seagrass habitat complexity, probably indicating a supply of individuals from further distances.

These findings show that the detritus, acting as a faunal magnet, can be colonised by a rich and diverse benthic community, highlighting its important role in maintaining the biodiversity within the seagrass meadows.

Introduction

Seagrasses form underwater meadows colonising coastal areas worldwide [1]. Seagrass ecosystems contribute to fundamental ecosystem services, including carbon sequestration in marine sediments and coastal protection [2, 3]. Despite their crucial role, a worldwide decline of these species is well-documented as a response to numerous threats (e.g. eutrophication, invasive species, urbanization, etc) [4]. Seagrass biomass production is comparable to the aboveground production of mangroves and terrestrial forests [5], but a considerable proportion of seagrass production does not enter the green food web pathway [6]. The grazing pathway by some herbivorous fish and some invertebrates (e.g. *Sarpa salpa*), is highly variable [7]. The amount of primary production not directly used becomes detritus (defined also as litter) and can accumulate within the meadows, or can be exported to deeper water or to the shoreline where it is often referred as wrack or beachcast [6].

Seagrass detritus can be used as food, physical habitat and occasional or permanent shelter by several benthic invertebrates [8]. Small crustaceans and molluscs are often the main colonizers of the detritus [9, 10]. They can feed on the detritus itself, as reported for some detritivorous crustaceans (i.e. *Gammarella fucicola* and *Gammarus aequicauda*), or on the microbial community that colonizes the detritus during the decomposition process [9, 11]. Biotic and abiotic variables regulate seagrass decomposition, such as litter quality and hydrodynamics conditions [12, 13]. Additionally, benthic invertebrates, as direct detritus shredders and enhancers of microorganisms' activity, can contribute to regulating seagrass decomposition [14] and represent an important trophic link between primary producers and higher consumers. Nonetheless, several factors could modify invertebrate responses to this habitat.

In this study, we tested if the colonisation of the seagrass detritus of *Zostera noltei* Hornemann, 1832 by macroinvertebrates was related to the substrate availability rather than food and whether the colonising assemblages were similar according to the structural complexity of the meadow. In particular, we used artificial seagrass detritus to mimic the physical structure of the natural detritus while disentangling the effect of food attractiveness vs. physical habitat availability.

Materials and Methods

The data presented in this paper form part of a project presented in Costa *et al.*, (2021) with further remarks [15]. The study was conducted in Thau lagoon (Étang de Thau, France) (Figure 1). The lagoon, located on the French Mediterranean coast, has a surface area of 75 km² and an average depth of 3.8-4.5 m [16]. Two seagrass species, *Zostera marina* and *Z. noltei*, form monospecific or mixed meadows representing about 22 % of the macrophyte biomass of the lagoon [17]. Seagrass detritus accumulates within the meadows, in adjacent bare sediment and on the lagoon shores.

Seagrass detritus Litterbags (15 x 10 cm) were filled with natural (NSD) or artificial seagrass detritus (ASD) or left empty (EMPTY). Seagrass detritus was collected in the lagoon, epiphytes were removed, and leaves were cut in fragments of 10 cm, as well as for the green plastic strips used for the ASD. The litterbags were deployed within a seagrass *Z. noltei* meadow in 3 areas of different structural complexity: Low Complexity (LC), Medium

Complexity (MC) and High Complexity (HC) (Figure 1). The structural complexity, based on shoot density and canopy height, was estimated on five plots per area.

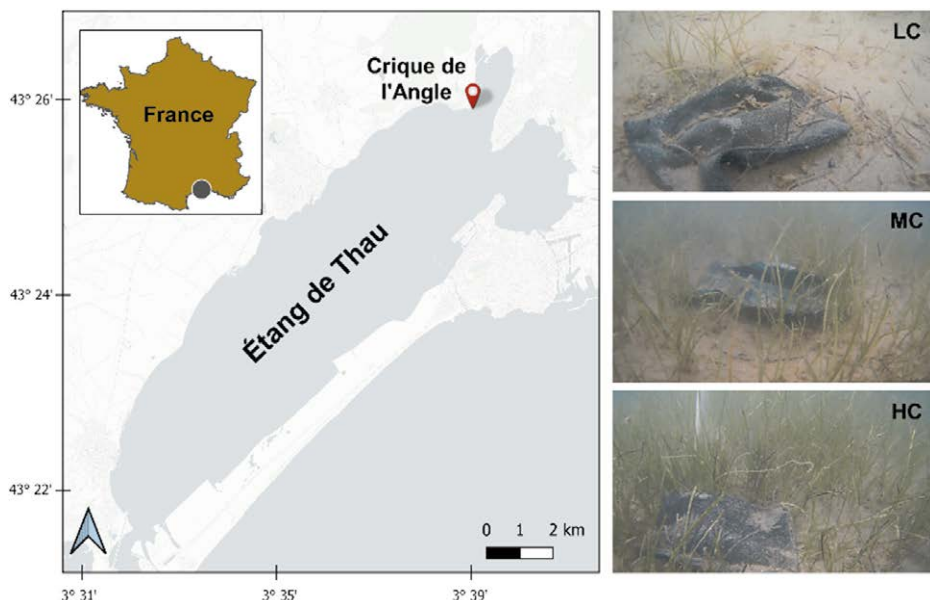


Figure 1 – Left side: map of the study area Crique de l'Angle, Thau Lagoon (Étang de Thau, France). Right side: litterbags in the three Habitat Complexity levels, Low Complexity (LC), Medium Complexity (MC) and High Complexity (HC).

During two field experiments, carried out in April and May 2018 (22 and 19 days, respectively), the detritus decomposition and the colonisation by invertebrates of 5 litterbags per substrate per area were analysed.

At the end of each experiment, each litterbag was singularly collected, put in plastic bags, and transported chilled to the laboratory. Each litterbag was gently rinsed with water and leaves and invertebrates were carefully separated. The seagrass detritus was rinsed, dried at 60 °C for 24 and weighed, while the colonizers were identified at the lowest possible taxonomic level and counted.

Diversity of the epifaunal assemblages, in terms of Number of Individuals (N), Number of Species (S) and Shannon-Wiener index of diversity (H'), was estimated. The R environment (version 4.2.0) in RStudio (2022.02.3 Build 492) was used for data analysis and visualization using the packages *tidyverse* [18] and *vegan* [19].

Results

Habitat complexity, in terms of shoot density and canopy height, was higher in HC, followed by MC and LC (Figure 2). Seagrass detritus decomposition was not significantly affected by the Habitat Complexity ($0.0218 \pm 0.0103 \text{ day}^{-1}$).

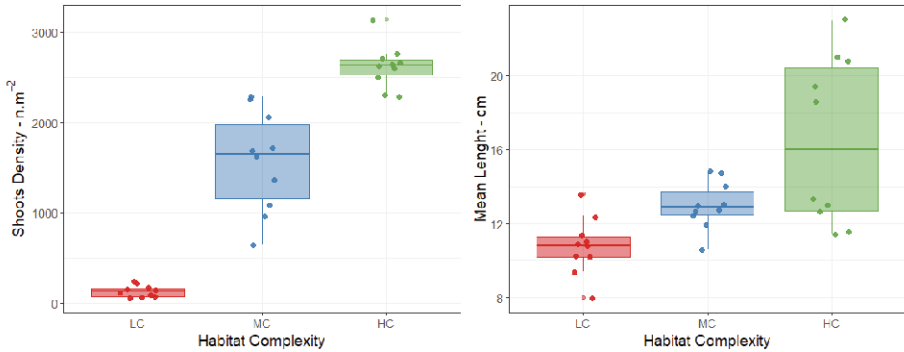


Figure 2 – Box-Plot (bounds from 25th to 75th percentile, median line and whiskers ranging from 5th to 95th percentile) and single points data of Shoot Density (n. of shoot per m⁻²) and Canopy height (mean length in cm) calculated for the three Habitat Complexity levels (LC, MC and HC).

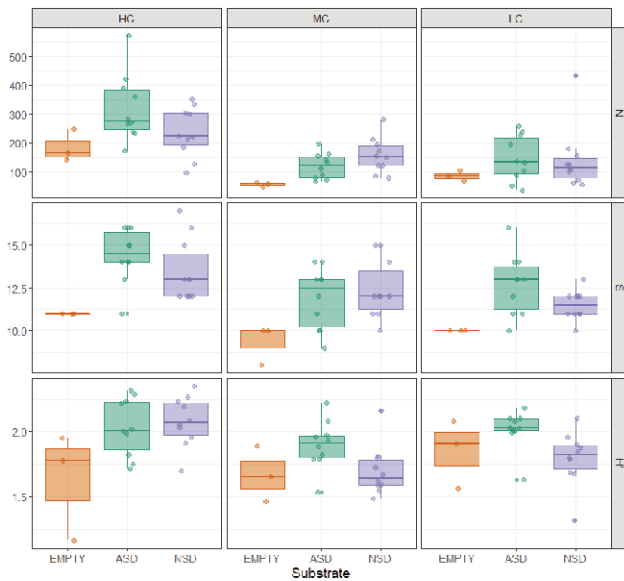


Figure 3 – Box-Plot (bounds from 25th to 75th percentile, median line and whiskers ranging from 5th to 95th percentile) and single points data of Diversity Indices (N, S, H') calculated for the Empty and filled litterbags (ASD and NSD).

More than 11 000 individuals ($n = 11270$) belonging to 26 taxa (including polychaetes, crustaceans, molluscs and chironomids larvae), were identified during the experiments. The number of individuals and species was significantly higher in the filled litterbags compared to the Empty ones ($p < 0.001$), and a slightly more diverse assemblage was associated with the Artificial substrate (Figure 3).

PERMANOVA analysis did not identify significant differences for the *Habitat Complexity x Substrate* interaction ($p > 0.001$), but a clear segregation is shown between empty and filled litterbags (Figure 4).

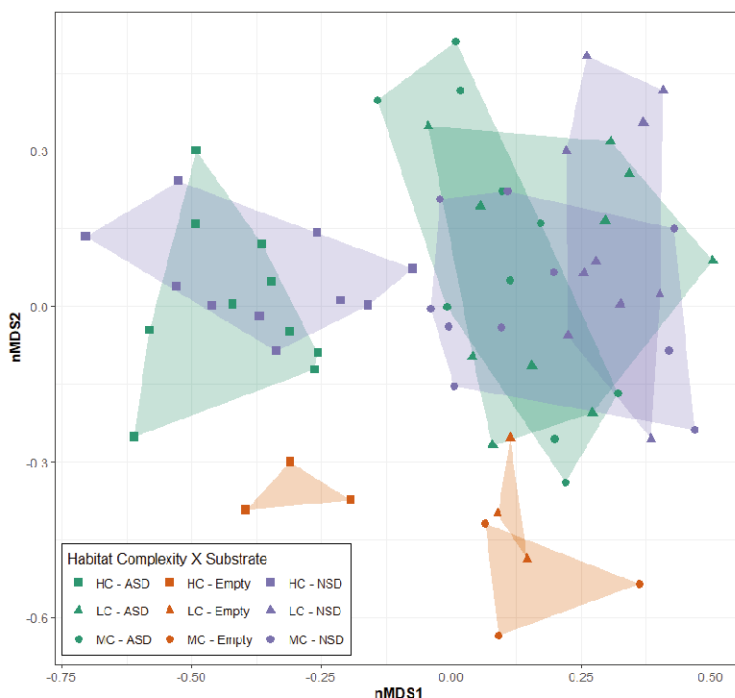


Figure 4 – nMDS ordination and convex hull areas calculated for the Empty and filled litterbags (ASD and NSD) for the three Habitat Complexity levels (LC, MC and HC).

Discussion

The aim of this study was to investigate the role of seagrass detritus as an attractor of invertebrates and the importance of the meadow habitat complexity in shaping the detritus colonising assemblages. To control for possible biases in the experimental procedures, we assess seagrass decomposition rates in the three habitat complexity areas and we used empty litterbags to control for the potential artefact effect due to the structure of the bag itself.

Seagrass decomposition showed no differences related to the complexity of the habitat, with results comparable to those reported for *Z. noltei* and *Z. marina* in other Mediterranean areas (0.015 ± 0.002 and 0.019 ± 0.001 d⁻¹; respectively) [20]. The empty litterbags were colonised only by very few taxa, showing that the detritus was the real faunal magnet [8, 11].

During the colonisation experiments, we deployed the litterbags within the seagrass meadow at different levels of Habitat Complexity and we found a decrease in the number of individuals and species from high to medium complexity treatment, where however few species were still present. In general, there was not a clear effect of the habitat complexity on the epifaunal colonisation of detritus, probably indicating a supply of larvae and juveniles from a further distance.

The artificial substrate was used to mimic the structure of the natural seagrass detritus while disentangling the effect of food attractiveness vs. physical habitat availability, and in our experiments both natural and artificial detritus attracted a diverse and variable epifaunal community with the epifauna not selecting one substrate more often than the other. Rather, some species opportunistically used either one or the other type of detritus, probably feeding also on the microbial biofilm growing on senescent leaves. Several mesograzers can show a low level of host-specificity and, rather, adaptability to different substrates, as found in two coexisting seagrass species, *Zostera caulescens* Miki, 1932 and *Z. marina* in northeastern Japan meadows [21].

On the whole, epifaunal distribution regardless of the substrate type showed that eelgrass detritus can be used uniquely as physical habitat by some species and also as a food source by others.

Conclusion

In conclusion, the colonisation appeared to be driven by the presence of detritus itself, with similar assemblages in the natural and artificial substrate, but with more individuals than the empty bags, used as controls. Using a seagrass meadow in Thau lagoon (France) as a case study area, this study provides new information about the role of habitat complexity in shaping the colonisation of seagrass detritus. It also shows that eelgrass detritus does not always attract invertebrates directly, letting us hypothesize that microbial biofilm growing on senescent leaves could be more important as a food attractor/resource for some epifauna species. These findings show that the detritus, acting as a faunal magnet, can be colonised by a rich and diverse benthic community, even in a short period of time, highlighting its important role in maintaining the biodiversity within the seagrass meadows.

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