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POSIDONIA OCEANICA SHOOT MICRO-DISTRIBUTION PATTERNS IN A 13 YEAR OLD TRANSPLANT SITE

PATTERN DI DISTRIBUZIONE DEI FASCI DI POSIDONIA OCEANICA *IN UN SITO DI TRAPIANTO DI 13 ANNI*

Abstract - Posidonia oceanica *meadows host a huge number of shoots and their dynamics is strictly related to the spatial distribution patterns of those shoots. Spatial distribution of shoots was recorded by cutting all the leaves and by digitizing shoot location from pictures of square frames (1600 cm*^{2}*) that were positioned in seemingly uniformly dense stands. We investigated shoot micro-distribution patterns in a 13 year old* P. oceanica *transplant site (Santa Marinella, Latium, Italy) and in an adjacent control meadow. Preliminary results highlight similarity of nearest neighbour statistics between transplanted and natural meadows. Nevertheless, the spatial point patterns of transplanted shoots differed from those of the control meadow.*

Key-words: Posidonia oceanica*, transplantation, shoot distribution, nearest neighbor analysis, monitoring.*

Introduction - While seagrass meadows often appear as uniform landscapes, their inner structure, and, therefore, their dynamics, can be very complex (Den Hartog, 1971). Seagrass meadows, at any one time, consist of a nested structure of clones, possibly fragmented into different ramets, each supporting a variable number of shoots (Duarte *et al.*, 2006). Research on *Posidonia oceanica* (L.) Delile, 1813 meadow structure is usually carried out at different spatial scales. At larger spatial scales, the focus is on the way meadows cover the substrate, while shoot density measurements are the main goal of studies at smaller spatial scales (Pergent-Martini *et al.*, 2005). However, density measurements are based on shoots counts and the spatial distribution of shoots is not uniform. Therefore, at very small spatial scales, density estimates become highly variable, depending on point patterns of shoot position (Panayotidis *et al.*, 1981; Bacci *et al.*, 2015). Recent studies on the structure of *P. oceanica* meadows at a very small spatial scale have related the observed spatial patterns of shoot micro-distribution to ecological processes (Bacci *et al.*, 2017). Here we report the preliminary results collected in the framework of the monitoring activities of the LIFE S.E.POS.S.O project on the micro-distribution patterns of *P. oceanica* shoots in a 13 year old transplant site.

Materials and methods - Field activities were carried out in September 2018 off S. Marinella (Central Mediterranean, Italy) in a shallow *P. oceanica* meadow at 8 m depth. Three 40×40 cm quadrats were randomly positioned in two sites: 1) the area where a rhizome transplant had been carried out in 2005 (32 shoots m^{-2}) by means of concrete frames, and 2) the adjacent natural meadow grown on *matte*. In the transplant area quadrats coincided with the concrete frames. In each quadrat all leaves were cut right above the ligule (thus allowing regrowth) and a picture was subsequently taken by an operator. The exact position of the apical portion of each rhizome (*i.e.*, at the leaf insertion) was then digitized *sensu* Bacci *et al*. (2017). Nearest neighbor statistics was computed. In addition, the Clark and Evans (1954) aggregation index R was calculated as the basis for a crude test of clustering or ordering of the shoot spatial distribution patterns in each quadrat. All the statistical analyses were performed using the package *spatstat* 1.47-0 in R Project for Statistical Computing, version 3.3.1.

Results - Shoot density revealed a high variability among quadrats both in the transplant area (min 65 shoots, max 96 shoots) and in the natural meadow (min 72 shoots, max 138 shoots). Spatial point patterns were analyzed in the six quadrats for a total of 535 shoots (Fig. 1). The frequency distribution of nearest neighbor distances (NNd) of shoots resulted unimodal and positively skewed both in the transplant area (227 shoots overall) and in the natural meadow (308 shoots overall). The median NNd values were 2.11 for the natural meadow and 1.97 for the transplant area and 99% of the measured shoot distances ranged between 1.04 and 5.77 cm and 0.92 and 5.12 cm respectively at the two sites. Kolmogorov-Smirnov test detected no significant statistical differences in shoot NNd between transplanted and natural meadow ($D=0.11$ $p>0.05$). The shoot NNd are also shown separately by means of box plots (Fig. 2). All the spatial point patterns observed in the natural meadow showed Clark and Evans index values significantly >1 (a: $R=1.21$ $p<0.0001$; b: $R=1.11$ $p<0.05$; c: $R=1.18$ $p<0.01$) indicating a regular pattern. Differently, spatial point patterns observed in the transplanted area showed values significantly <1(e: $R=0.79$ $p<0.01$) or not significantly ≠ 1 (d: $R=1.05$ $p>0.05$; f: $R=0.95$ $p>0.05$), indicating aggregated shoot distribution or suggesting a random pattern respectively (Fig. 1).

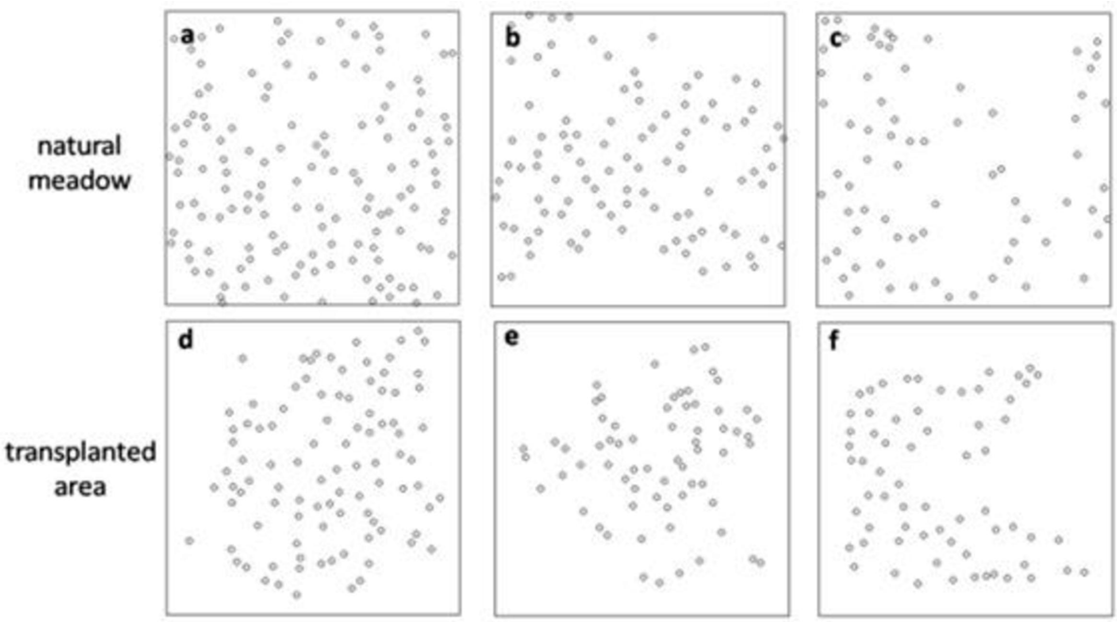

Fig. 1 - Shoot distribution of *P. oceanica* within 40x40 cm quadrats: a-c) natural meadow; d-f) transplanted area.
Distribuzione dei fasci fogliari di P. oceanica *in quadrati 40x40 cm: a-c) prateria naturale; d-f) area di trapianto*.

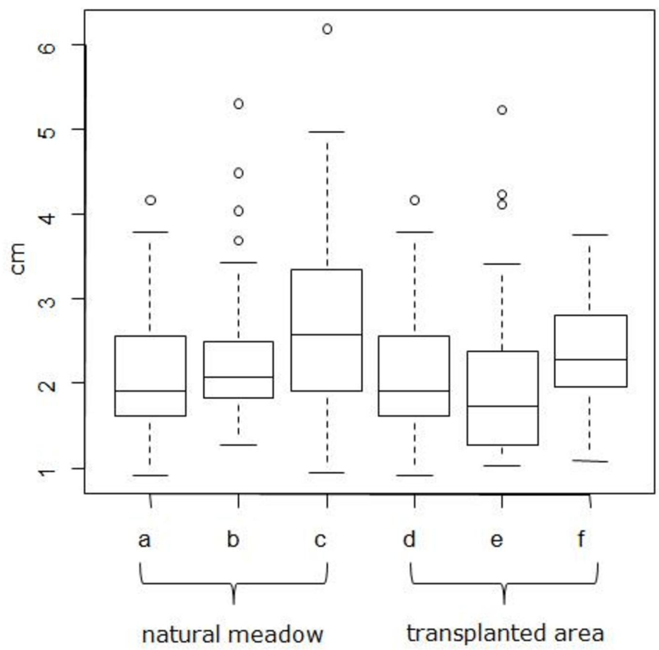

Fig. 2 - Box-plot of nearest neighbour distances (NNd) for each of the quadrats: a-c) natural meadow; d-f) transplanted area.
Box-plot *delle distanze al vicino più prossimo (NNd) per ciascuno dei quadrati: a-c) prateria naturale; d-f) area di trapianto.*

Conclusions - Although the quadrats analyzed were placed in sites that looked uniformly dense, shoot distribution highlighted a high patchiness both in natural meadow and transplanted area. Despite the comparison of nearest neighbor statistics did not show significant differences, the spatial point patterns observed showed that transplanted shoots have different dynamics compared to those of the natural meadow investigated in this study and of other natural and mature meadows investigated in Bacci *et al*. (2017). Although Spatial Point Pattern Analysis (SPPA) has become increasingly popular in terrestrial ecological research over the last two decades (Velázquez *et al*., 2016), most of these techniques are almost unknown in aquatic environments (Bacci *et al*., 2017). In the framework of *P. oceanica* transplantation activities within restoration projects, the analysis of shoot micro distribution turned out to be a useful tool for comparing transplanted areas to surrounding natural meadows, in order to reveal something more if compared to shoot density.

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