First occurrence of the alien large benthic foraminifera *Parasorites orbitoloides* (Hofker, 1930) and *Euthymonacha polita* (Chapman, 1900) in the Western Mediterranean: their effects on the large-benthic foraminifera community.

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Introduction

In recent years, the number of marine alien species in the Mediterranean Sea is increasing. Due to the opening of the Suez Canal (1869), the number of species from the Indo-Pacific has been increasing in this basin, including symbiont-bearing foraminifera (Mouanga and Langer, 2014). Foraminifera are protozoa which, mostly of them, form calcium carbonate shells and, therefore, contribute to the formation and composition of marine sediments. These sediments, such as epiphytic foraminifera tests, can partially feed beaches. The entry and settlement of species of foreign foraminifera can lead to a strong modification of the composition of this sediment as well as to the displacement of native species (Mouanga and Langer, 2014). Therefore, detecting and determining the entry paths for new species of tropical origin in the Mediterranean basin is important for two reasons. Firstly, in order to determine how these species could affect other organisms with whom they could establish competitive relationships and, in the second place, to determine if they can have the ability to alter the environment. *Parasorites orbitoloides* and *Euthymonacha polita* are two species of large-benthic foraminifera from the Indo-Pacific region (Figure 1). *P. orbitoloides* presents chlorophyte symbionts. This symbionts bring them the greenish coloration characteristic of the subfamily Archaiasinae. Its presence in the Mediterranean Sea had not been documented yet. *Euthymonacha polita* belongs to the Peneroplidae family, a group that presents red algae symbionts. So far, in the Mediterranean, this species has only been cited in the Aegean Sea, Turkey (Meriç et al., 2010). The mechanisms of arrival to the Western Mediterranean Sea are unknown. One of the main objectives of this work has been to determine if these exotic species could compete or displace the autochthonous symbiont-bearing foraminifera species, as well as, if they could modify the composition of the foraminifera community.

Materials and Methods

The geographical area sampled corresponds to the Balearic archipelago. From each of the three main islands, samples of sediment of the littoral have been collected in different beaches: 15 of Mallorca, 8 of Ibiza and 4 of Menorca. From each beach three subsamples have been collected. Of each subsample, 60 specimens belonging to the seven different species of symbiont-bearing foraminifera of the Western Mediterranean have been counted. The abundance of each specie in each beach have been calculated with the mean of the

tree subsamples. Moreover, to see the effects on the whole community of foraminifera have been used the morphotypes described by Langer (1993) and modified by Mateu-Vicens et al. (2014). Due to each shell morphotype corresponds to a specific autoecological condition, the proportion of each morphotype in the community are indicative of the community conditions. Thus, from each sample, the first 60 foraminifera found were counted and classified under the corresponding morphotype: A, SB, B, C or D. Morphotype A is formed by incrusting sessile forms with long term life span (1 year), SB forms correspond to the symbiont-bearing foraminifera, temporary motile foraminifera with a short-term life span (2-5 months) belong to the morphotype B, morphotype C is formed by motile foraminifera which feed on particle in suspension and have a short-term life span (3-4 months) and, finally, morphotype D is composed by little opportunistic forms with a very short life span (1-2 months). In order to analyse the effects into the symbiont-bearing community as well as in all autochthonous foraminifera community have been built abundance graphics. Furthermore, in order to see if there is a correlation between the different kinds of symbiont of each specie with the morphotypes, a Principal Component Analysis has been made.

Results and Discussion

In the Balearic coast there is no relationship between the presence of these two exotic species and the presence and abundance of the autochthonous symbiont-bearing foraminifera species (Figure 1). *P. orbitoloides* is present in all the islands but with low abundances as well as *Laevipeneroplis laevigatus* (Cushman, 1930), the other species with green algae. Due to the kind of symbiont, *L. laevigatus* is the only species which could be affected by the entrance and settlement of *P. orbitoloides*. That is not observed. Indeed, both have very low abundances so it is unlikely that they compete for resources. Moreover, it is very likely that these two species present different strategies due to their different morphology (Hohenegger, 2009) They present higher abundances in those environments where morphotypes C and B are abundant. So these organisms are mobile and linked to high organic matter environments. Thus, the symbiosis in these cases probably is not so linked to the obtaining of sugars but rather to other advantages such as the enhancement of the calcification. *Euthymonacha polita* is the rarest. Their abundances are generallyvery low, below 5% of the symbiont-bearing foraminifera. Because it has red algae symbionts, their settlement could affect the species of the genus Peneroplis. However, there is no decrease in the abundances of these species in response to the presence of *E. polita*. This lack of response could be due to two factors. First, *E. polita* has very low abundances so it could hardly affect the rest of the species. Second, similar shells are usually a sign of very similar niches or strategies (Hohenegger, 2009) and *E. polita* presents a very different shell compared to the rest of the symbiont-bearing foraminifera. So the niche it occupies has to be different and it does not compete with peneroplids. Analysing the abundances and not the presence of these species with the Principal Components Analysis (PCA), very interesting groupings have been shown (Figure 1). The different species are grouped coinciding with the type of symbiont they harbour, the morphology of their shell and with the abundance of some of the morphotypes. Although all these species belong to the SB morphotype, not all of them show a positive correlation with it. Only those with red algae, specifically the genus Peneroplis, are positively correlated. *Peneroplis planatus* (Fichtel and Moll, 1798) is the most correlated due to its morphology adapted to the epiphytic behaviour (Hohenegger, 2009) while *Peneroplis pertusus* (Forsskal in Niebuhr, 1775) and *Peneroplis arietinus* (Batsch, 1791) would be better adapted to be part of the epifaunal community of the sediment among this vegetation. *E. polita* shows a positive correlation with high abundances of the morphotype D, so it is a more opportunistic species. Both its morphology and its small size are consistent with this strategy (Langer, 1993; Mateu-Vicens et al., 2014). Finally, the abundance of *Sorites orbiculus* (Forsskal in Niebuhr, 1775), the only one with dinoflagellates, is positively correlated to the abundance of morphotype A. *S. orbiculus* is a sessile epiphyte of hard substrates as sea-grass leaves. Due to it does not move in search of food, it depends on photosynthesis. This sessile strategy is similar to that of morphotype A specimens. To conclude, these two exotic species are present throughout the Balearic archipelago. Their abundances are very low. Being the principal reason why they will hardly imply problems for the autochthonous benthic foraminifera community or for the ecosystem structure. Finally, this work shows that not all foraminifera with symbionts show the same trophic strategies. This group is heterogeneous, the ecology and trophic strategy of each of these species will depend on the kind of algae they harbour.

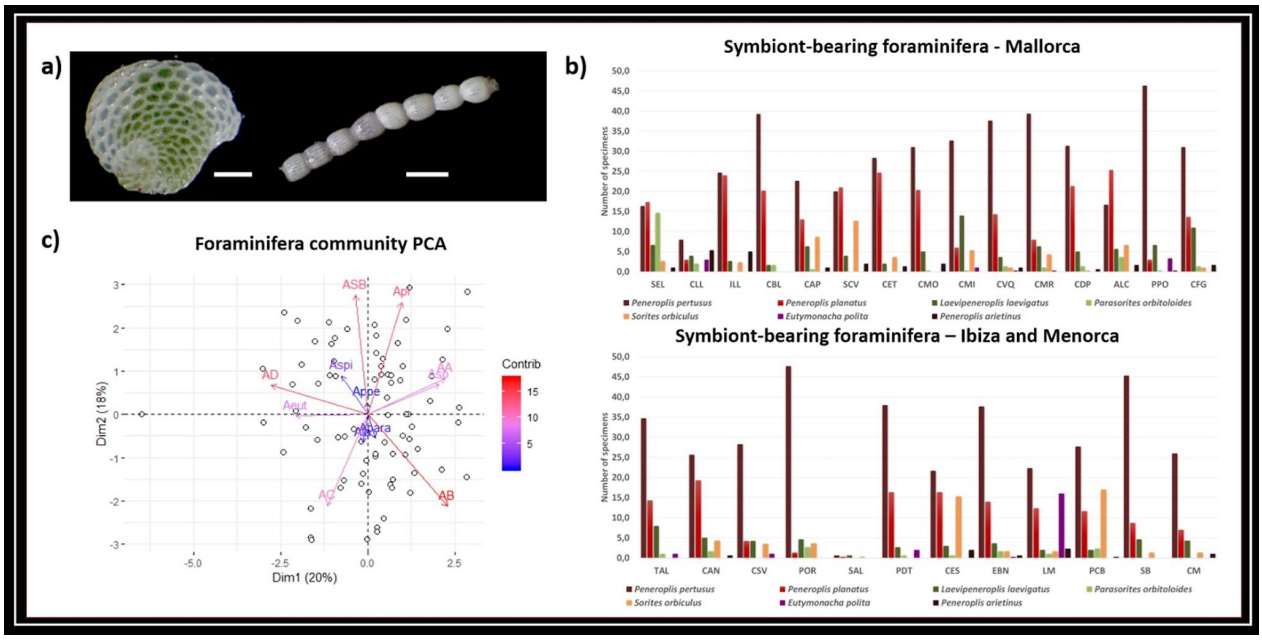

Figure 1: a) Alive *Parasorites orbitoloides* (left) and alive *Euthymonacha polita* (right). The white bar means 300/*mu*m. (b) Abundances of the different species of symbiont-bearing foraminifera of the Western Mediterranean in each sampled beach of the Balearic archipelago. (c) PCA of the abundances of each symbiont-bearing species (*Parasorites orbitoloides* = Apara; *Laevipeneroplis laevigatus* = Ala; *Euthymonacha polita* = Aeut; *Peneroplis pertusus* = Appe; *P. planatus* = Apl; *P. arietinus* = Aspi; *Sorites orbiculus* = Aso) and each morphotypes (morphotype A = AA; morphotype SB= ASB; morphotype B= AB; morphotype C= AC and morphotype D = AD).

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