Molluscan assemblages associated with photophilous algae in the Alboran Sea (western Mediterranean Sea)

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Introduction

Vegetated habitats are highly productive systems harbouring rich associated faunal communities (Christie *et al*. 2009). Factors structuring these dense and diverse communities are, among others, habitat complexity, food availability, sediment stability and predator-prey relationships (Graham Lewis III 1984; Orth *et al*. 1984). Photophilous algae meadows are one of the most widespread types of vegetated bottoms in the Mediterranean Sea, with the amphi-Atlantic brown algae *Stypocaulon scoparium* as one of the dominant and common species in shallow waters of southern Spain (Ballesteros & Pinedo 2004).

Molluscs are one of the best represented and dominant taxa within the faunistic communities inhabiting macroalgae meadows, and are considered an important food source for higher trophic levels (Edgar 1983; Christie *et al*. 2009). Little attention has been paid to communities associated with photophilous algae meadows of the Alboran Sea (western Mediterranean Sea) (Sánchez Moyano *et al*. 2000), which is considered a hot-spot area for Mediterranean and European biodiversity (Coll *et al*. 2010).

The aims of this research are therefore (1) to study the composition and structure of the molluscan assemblage associated with photophilous algae meadows in the Alboran Sea; (2) to characterize and compare the molluscan assemblages associated with the different strata (algal fronds and sediment under fronds); (3) to analyse the seasonal variation of molluscan assemblages in each strata (algal frond *vs* sediment); and (4) to assess the influence of biotic (i.e. algal biomass, Chl *a*) and/or abiotic (i.e. seawater temperature, sediment characteristics) variables on the seasonal dynamics of the molluscan assemblage.

Material and methods

The study area is located between "Punta de Calaburras" (36º30.4´N 04º38.3´W) and "Calahonda" (36º29´N 04º44.3´W) (southern Spain), and within the Site of Community Importance "Calahonda" (Natura 2000). The community of photophilous algae was sampled in two sites, near the lighthouse of Calaburras and off the "Riviera de Calahonda" (7 km to the west) and in different seasons including July, November 2007, January and April 2008.

Faunistic samples were collected using Scuba-diving equipment. The distinct bionomic strata were sampled separately, first collecting the algal fronds within a 50 x 50 cm quadrat and enclosed them within <0.5 mm mesh bags, then the underlying substratum using an air-lift sampler with a <0.5 mm mesh bag. Five replicate samples were collected per site, stratum and season, resulting in a total of 40 samples, from which molluscs were separated and identified. Seawater temperatures and the concentration of Chlorophyll *a* were taken along several days in order to study the influence of these variables on the molluscan assemblages. Samples of sediment were also taken in order to estimate the percentage of organic matter. Macroalgae collected were also identified and quantified in order to study the influence of their characteristics (e.g. wet and dry weight, volume) on the molluscan assemblages.

Several ecological indices were calculated for the characterization of the molluscan assemblages at different times of the year, site and strata (sediment vs algae). Statistical differences of seasonal values of environmental variables, macroalgae characteristics and ecological indices were tested with a two-factor ANOVA, while one-factor ANOVA analyses were carried out for testing statistical differences in values of ecological indices according to season or strata (sediment vs. algae) within each location. Multivariate methods using the Bray-Curtis similarity index were used in order to identify similarities/dissimilarities according to the different factors (site, season, strata) in the composition and structure of the molluscan assemblage. The relationships between faunistic variables and environmental or macroalgae related variables were determined by the Pearson correlation and also contrasted by using the BIOENV analysis.

Results

A total of 193 molluscan species were identified, with gastropods dominating in terms of number of species and abundance. Twenty-two species displayed dominance values higher than 1%, with *Nodulus contortus* as the top dominant species (21.65%D), followed by *Bittium reticulatum*, *Musculus costulatus* and *Rissoa guerinii* (Figure 1). The bulk of dominant species on the algae and the sediment was quite similar in Calaburras and Calahonda, with the rissoid *Rissoa gerinii* and the mytilid *Musculus costulatus* dominating the algal stratum, and *Nodulus contortus* and *Bittium*

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reticulatum dominating the sediment stratum in both sites.

The species richness and abundance of the sediment assemblage was significantly higher than that of the algae (Kruskal-Wallis; $p<0.001$). On the sediment, S was maximal in summer and autumn, whereas on the algal fronds it was maximal in summer (one-factor ANOVA; $p<0.001$). Abundance displayed a similar pattern, with maximum values in summer. The evenness (J´) was similar in sediment and algal strata, with maxima in spring, summer and autumn.

The Shannon-Wiener diversity index (H´) was significantly higher on the sediment than on the algae, with maximum values in spring and summer.

Samples displayed groupings according to the type of stratum (sediment vs algae) based on both qualitative (presence/absence of species) and quantitive data (fouth root transformed abudance data) and according to ANOSIM analyses. Regarding quantitative data, the species that contributed to these inter-stratum differences were related to the lower abundance on: (1) the sediment of *Eatonina fulgida*, *Rissoa similis*, *M. costulatus* or *Flexopecten flexuosus* among others, and on (2) the algae of *N. contortus*, *Retusa truncatula*, *Diplodonta eddystonia* or *Kurtiella bidentata* among others.

Faunistic variables displayed the highest correlations with seawater temperature (T), concentration of Chl *a* (Chl *a*), percentage of organic matter and parameters of the dominant macroalgae *S. scoparium* (dry weight, height, etc.).

Discussion

This study has shown that a rich molluscan fauna inhabits photophilous macroalgal meadows in southern Spain as found in other macroalgal meadows in the Strait of Gibraltar (Sánchez-Moyano *et al*. 2000) or in other types of habitats in the studied area (Urra *et al*., 2011; Urra *et al*. 2012). Its geographical location, in the confluence point of Mediterranean and Atlantic fauna, together with its oceanographic characteristics promotes a high invertebrate biodiversity (García Raso *et al*. 2010). The assemblage is remarkable by the presence of some subtropical African species, such as the bivalves *Ungulina cuneata* or *Modiolus lulat* with their only european populations in this area, enhancing the faunistic richness of this strecth of coastline.

Gastropods were the dominant group in the molluscan assemblage, as observed in other macroalgal meadows (Sánchez-Moyano *et al*. 2000; Rueda & Salas 2003), with some species only found as juvenile forms, mainly bivalves, probably indicating a preferred habitat for breeding and for settlement and development of larvae of many species, including those from surrounding habitats (Poulicek 1985). The higher number of species on the sediment could be related to an increase of different micro-habitats.

The molluscan assemblage displayed similar seasonal changes than those of other macroalgal meadows (Sánchez-Moyano *et al*. 2000; Rueda & Salas 2003), with a high influence of dominant species (*N. contortus*, *B. reticulatum, R. guerinii* and *Musculus costulatus*) in the values of ecological indexes. On the contrary, maximum values of diversity during summer may be related to high abundance and species richness. Extrinsic factors related to the canopy stratum such as algal biomass, play an important role in the abundance of some dominant epifaunal grazers, which has been attributed to a higher availability of microhabitats and feeding strategies, but also to reproductive cycles of the species (Sánchez-Moyano *et al*. 2000; Rueda & Salas 2003).

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References

Ballesteros, E., S. Pinedo, 2004. Los bosques de algas pardas y rojas. In: Luque ÁA y Templado J. (Coords.) *Praderas y bosques marinos de Andalucía*, pp. 199-222. Consejería de Medio Ambiente, Junta de Andalucía, Sevilla, 336 pp.

Christie, H., K.M. Norderhaug, S. Fredriksen, 2009. Macrophytes as habitat for fauna. Marine Ecology Progress Series, 396: 221-233.

Coll, M., C. Piroddi, J. Steenbeek, K. Kaschner, F. Ben Rais Lasram, *et al*., 2010. The Biodiversity of the Mediterranean Sea: Estimates, Patterns and Threats. PloS ONE 5(8): e11842. doi: 10.1371/journal.pone.0011842

Edgar GJ. 1983. The ecology of South-East Tasmanian phytal animal communities. I. Spatial organization on a local scale. Journal of Experimental Marine Biology and Ecology, 70: 129-157.

García Raso, J.E., S. Gofas, C. Salas Casanova, M.E. Manjón-Cabeza, J. Urra, J.E. García Muñoz, 2010. El mar más rico de Europa: Biodiversidad del litoral occidental de Málaga entre Calaburras y Calahonda. Junta de Andalucía, Consejería de Medio Ambiente, Sevilla, 138 pp.

Graham Lewis III, F. 1984. Distribution of macrobenthic crustaceans associated with *Thalassia*, *Halodule* and bare sand substrata. Marine Ecology Progress Series, 19: 101-113.

Orth, R.J., K.L. Heck Jr., J. van Montfrans, 1984. Faunal communities in seagrass beds: A review of the influence of plant structure and prey characteristics on predator-prey relationships. Estuaries, 7 (4A): 339-350.

Poulicek, M., 1985. Les mollusques des biocénoses à algues photophiles en Méditerranée: II. Analyse du peuplement. Cahiers Biologie Marine, 26: 127-136.

Rueda, J.L., C. Salas, 2003. Seasonal variation of a molluscan assemblage living in a *Caulerpa prolifera* meadow within the inner Bay of Cádiz (SW Spain). Estuarine, Coast and Shelf Science, 57: 909-918.

Sánchez-Moyano, J.E., F.J. Estacio, E.M. García-Adiego, J.C. García-Gómez, 2000. The molluscan epifauna of the alga *Halopteris scoparia* in southern Spain as a bioindicator of coastal environmental conditions. Journal of Molluscan Studies, 66: 431-448.

Urra, J., S. Gofas, J.L. Rueda, P. Marina, 2011. Molluscan assemblages in littoral soft bottoms of the Alboran Sea (Western Mediterranean Sea). Marine Biology Research 7: 27-42.

Urra, J., J.L. Rueda, S. Gofas, P. Marina, C. Salas, 2012. A species-rich molluscan assemblage in a coralligenous bottom of the Alboran Sea (Southwestern Mediterranean): Intra-anual changes and ecological considerations. Journal of the Marine Biological Association of the United Kingdom 92 (4): 665-677.

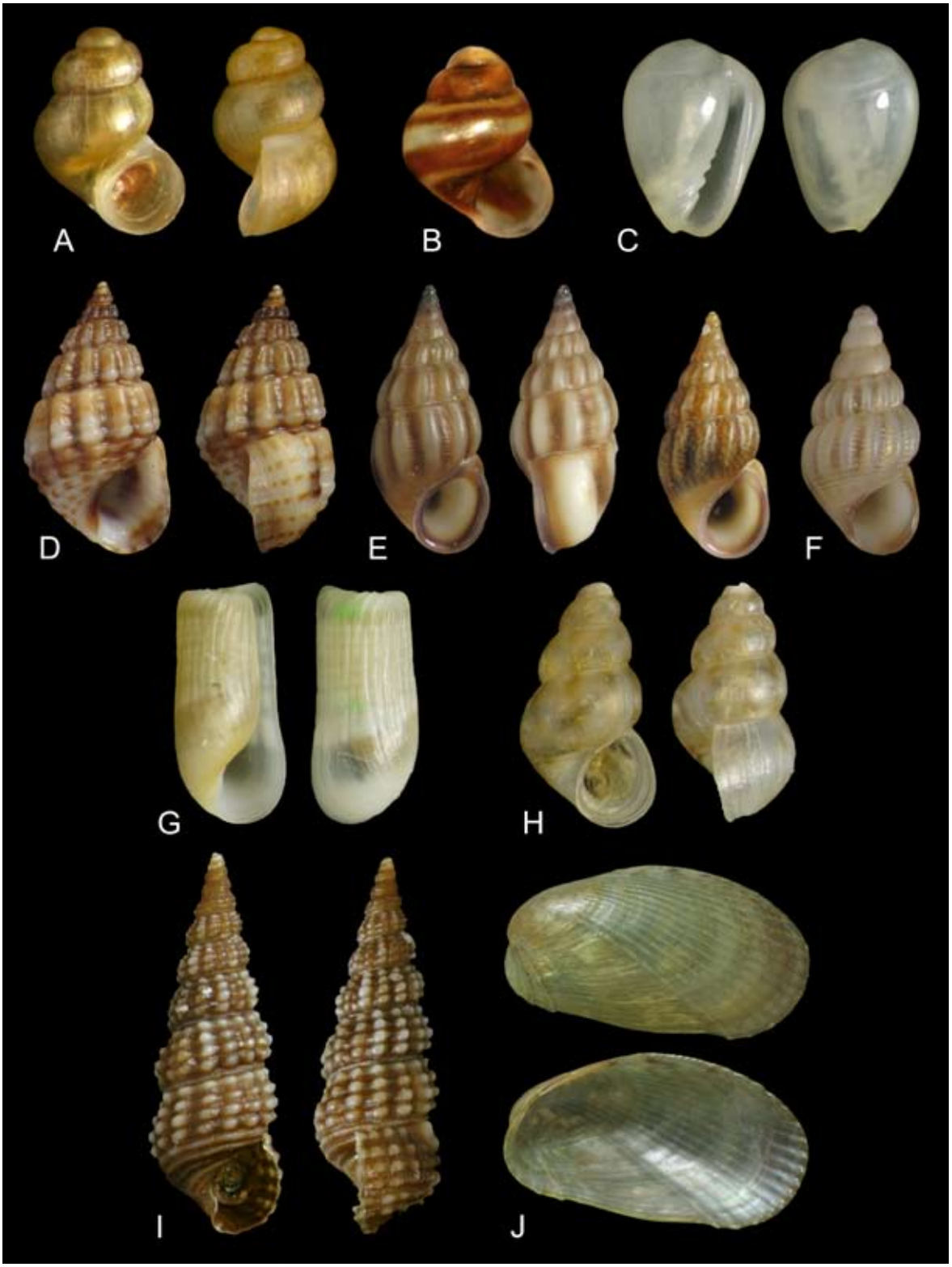

Figure 1. Characteristic molluscan species associated with photophilous algal meadows in the north-western Alboran Sea: A, *Nodulus contortus* (Jeffreys, 1856) (2.5 mm); B, *Eatonina fulgida* (Adams J., 1797) (1.8 mm); C, *Gibberula philippii* (Monterosato, 1878) (3.1 mm); D, *Alvania montagui* (Payraudeau, 1826) (4.5 mm); E, *Rissoa guerinii* Récluz, 1843 (5.1 mm; 4.7 mm); F, *Rissoa similis* Scacchi, 1836 (2.8 mm); G, *Retusa truncatula* (Bruguière, 1792) (2.3 mm); H, *Setia amabilis* (Locard, 1886) (1.8 mm); I, *Bittium reticulatum* (da Costa, 1778) (4.9 mm); J, *Musculus costulatus* (Risso, 1826) (8 mm).