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Trophic ecology of the sea urchin *Spatangus purpureus* elucidated from gonad fatty acids composition analysis

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A B S T R A C T

Irregular sea urchins such as the spatangoid *Spatangus purpureus* are important bioturbators that contribute to natural biogenic disturbance and the functioning of biogeochemical cycles in soft sediments. In the coastal waters of the Balearic Islands *S. purpureus* occurs in soft red algal beds, and can reach high densities. The diet of *S. purpureus* is unknown and it is particularly difficult to analyze the stomach contents of this group; therefore, we analyzed the fatty acid (FA) composition of the gonads and potential food resources in order to assess the trophic relationships of this species. The FA profiles of the gonads of *S. purpureus* agree well with the FA composition of the potential trophic resources (algae and sediment) and reveals changes between localities with different available resources. Three polyunsaturated FAs mainly contributes in the composition in the *S. purpureus* gonads: eicosapentaenoic acid (C20:5*n*-3) and arachidonic acid (C20:4*n*-6), both abundant in the macroalgal material, and palmitoleic acid (C16:1*n*-7), which is characteristic of sediment samples. Trophic markers of bacterial input and carnivorous feeding were significantly more abundant in sea urchins caught on bottoms with less vegetation. The current study demonstrates that the FA content of *S. purpureus* gonads is a useful marker of diet, as differences in the profiles reflected the variations in detritus composition. The results of this study show that this species has omnivorous feeding behavior; however, viewed in conjunction with available abundance data the results suggest that phytodetritus found within algal beds is an important carbon source for this species.

1. Introduction

Sea urchins are an important benthic megafaunal group, and play a significant ecologic role in the community structure. Regular sea urchins are generally herbivores and feed on micro- and macroalgae (Lawrence, 1975, 2007; Jangoux and Lawrence, 1982; Verlaque, 1987; Carpenter, 1981), while urchins with a burrowing life trait are generally considered detritivorous deposit feeders (Lawrence, 2007). Irregular urchins are common in subtidal soft sediments around the world, and play an important role in the biogenic disturbance (bioturbation) and biogeochemistry cycles in soft sediment systems (Ghiold, 1989; Widdicombe and Austen, 1999; Widdicombe et al., 2004; Lawrence, 2007; Lohrer et al., 2004, 2005, 2008). Large burrowing species such as spatangoids (heart urchins) are particularly important for these processes due to their abundance, size and mobility (Chiold, 1989). Large-scale losses of benthic bioturbators due to fishing disturbances could impair the functioning of marine ecosystems (Thrush and Dayton, 2002). Despite the obvious ecological importance of burrowing urchins, relatively little is known about the ecology of individual species, including their precise dietary requirements (Lawrence, 2007; Jangoux and Lawrence, 1982). This is due to the difficulties involved in traditional methods of stomach content analysis in which ingested material is often unidentifiable due to digestion processes. Fatty acids have recently been advocated as qualitative markers for tracing or confirming predator–prey relationships in the marine environment (Grahl-Nielsen et al., 2003; Iverson et al., 2004; Budge et al., 2006), identifying key processes in the dynamics of pelagic ecosystems (Brett and Müller-Navarra, 1997; Dalsgaard et al., 2003; Käkelä et al., 2005; Fernandez-Jover et al., 2007), and examining trophic interactions within benthic ecosystems (Ginger et al., 2000; Budge et al., 2002). The principle of this method is relatively simple. Consumers derive their lipid requirements either

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from their diet or by endogenous lipogenesis from dietary protein and carbohydrate precursors. Dietary lipids are broken down into their constituent FAs and are incorporated relatively unchanged into the tissues of the consumer (Lee et al., 1971; Stryer, 1995). Animals receive a considerable amount of lipid via their diet, and thus the diet type alters the FA composition of the organism (e.g. Sargent and Whittle, 1981; Sargent et al., 1987; Hughes et al., 2005; Hyne et al., 2009). Some polyunsaturated fatty acids (PUFAs) are considered essential. These are FAs that are necessary but cannot be synthesized by the organism, and thus must be consumed in the diet (Lenningher, 1984). Certain FAs, or their ratios, have specific known sources and can therefore act as "trophic markers", providing a more precise indication of an organism's diet than gut content analysis (Sargent et al., 1987; Dalsgaard et al., 2003; Howell et al., 2003). In addition, the sea urchins' diet varies locally and depends on food availability (Vadas, 1977; Ayling, 1978; Beddingfield and Mc Clintock, 1999). Diet quality has also been found to influence somatic and gonadal growth and development in urchins (Emson and Moore, 1998; Cook et al., 2000; Liyana-Pathiranaa et al., 2002; Liu et al., 2007a,b), and probably fecundity, as has been demonstrated in crustaceans (Hyne et al., 2009).

The spatangoid *Spatangus purpureus* (Müller, 1776) is widely distributed throughout the Mediterranean and northwestern Atlantic (from the north of Africa to the north of Europe and the Azores). This species has generally been described to be associated with clean gravel or sandy substrata with low algal cover (Holme, 1966; Kanazawa, 1992); however, around the Balearic Islands this species occurs in high abundances in *Peyssonnelia* beds (between 30 m and 100 m depth) (Ordines and Massutí, 2009) where its creates clearly visible furrows (Fig. 1). The present study aimed to elucidate the trophic ecology of *S. purpureus* on sandy bottoms of the Balearic Islands with FA composition analysis, and had three main objectives: a) to elucidate the potential food sources of *S. purpureus* (algae and/or sediment) by comparing the FA profiles; b) to compare the FA profiles of the gonads from locations with different macroalgal communities; and c) to analyze the changes in FA composition with respect to size and gonad biomass, as changes in the diet are thought to affect individual growth and gonad development.

2. Materials and methods

2.1. Study area

The study areas were located at depths between 50 m and 100 m around Mallorca and Menorca (Balearic Islands, western Mediterranean) (Fig. 2). The seabed is composed of soft sediments with or without vegetation. Rhodoliths (corallinaceas) and red algae (*Osmundaria volubilis*, *Phyllophora crispa*, *Peyssonnelia* spp.) dominate this depth range. *S. purpureus* is generally more abundant in coastal soft sediments with red algae (Ordines and Massutí, 2009).

2.2. Sampling method

Samples for the FA composition analysis of gonads were collected over four days (11/13/19/21 May 2009) during the MEDITS0509 survey (Data Collection Framework for the Common Fisheries Policy) on board the R.V. Cornide de Saavedra. A 2-m beam trawl was used to collect the sea urchins and algae. A box-corer was used to obtain sediment samples. Four locations with sandy substrata but with different macroalgal communities were selected (Fig. 2): bare sand (L1) and algal beds on sandy bottoms dominated by rhodoliths and other soft red algae such as *Peyssonnelia* spp., *O. volubilis* and *P. crispa* (L2, L3 and L4). Information on the communities' distribution was based on a previous study (Ordines and Massutí, 2009). At each of the four locations three beam trawl samples were taken 100 m apart and the sea urchin abundances were recorded. General information on the algal and faunal composition was obtained from the same beam trawl samples (Table 1). The sampling design incorporates two factors: location (L1, L2, L3 and L4) and site (each beam trawl sample). A subsample of ten to fifteen individuals was taken at each location and site, and the specimens were measured. The gonads of each individual were removed and weighed. Five gonads of different individuals were randomly selected from each location and site for FA analysis (between approximately 1 and 2 g of the gonad were extracted) (4 locations × 3 sites × 5 replicates). Three subsamples of the three dominant soft algae, *O. volubilis*, *Peyssonnelia* spp. and *P. crispa*, were also obtained from the beam trawl samples at three different sites of vegetated locations (5–6 g) (3 species × 3 sites × 3 replicates). At each location three grabs of sediment were collected, from which two sediment subsamples were taken consisting of 5–6 g of sediment from the first 4 cm of the surface (4 locations × 3 sites × 2 replicates). All samples were frozen in glass tubes with Teflon-lined screw caps, and conserved at −80 °C until FA analysis in the laboratory.

2.3. Laboratory methods

After individual sample/tissue homogenization, the FA composition of the total lipid fraction was determined by fat extraction

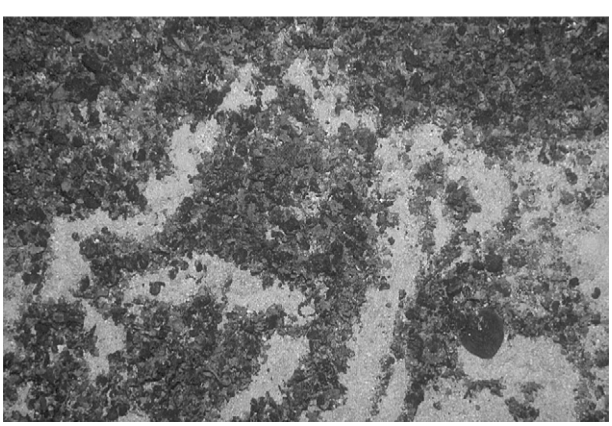

Fig. 1. Photograph taken from a sledge mounted camera showing the tracks made by *Spatangus purpureus* on a vegetated bottom dominated by *Peyssonnelia* spp. and rhodoliths (Corallinacea). Son Bou, SE Menorca, 60 m depth. Photo: F. Sánchez.

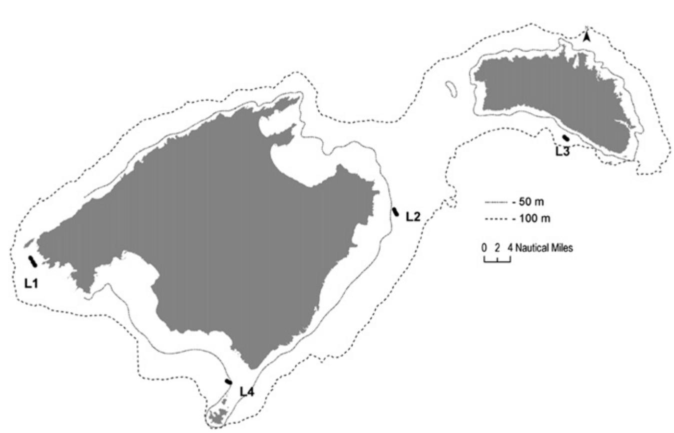

Fig. 2. The selected locations in the study area, circalittoral bottoms around Mallorca and Menorca Islands, between 50 and 100 m.