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Diets of peracarid crustaceans associated with the orange coral *Astroides calycularis* in southern Spain

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Abstract

The endangered and Mediterranean endemic orange coral (*Astroides calycularis*) hosts an important macrofaunal assemblage. The gut contents of the main peracarids associated with the orange coral were analysed. In total 161 specimens belonging to 11 species and 9 families were examined on the southern coast of the Iberian Peninsula. The gut content study was carried out introducing the specimens of each species in Hertwig's liquid. The analysis revealed that the peracarid species associated with *A. calycularis* had different feeding strategies and their main food source was detritus. The results highlight that peracarids may depend on the host and the detritus that the coral produces.

Keywords: *Astroides calycularis*, peracarid crustaceans, associated macrofauna, feeding, gut contents.

Introduction

Astroides calycularis (Pallas, 1766) is an azooxanthellate colonial scleractinian, with a calcium carbonate exo-skeleton (Zibrowius, 1980) that inhabits the rocky shores from the surface to a depth of 50 m (Rossi, 1971). It occupies both well-lit and dark habitats and appears to prefer environments with strong currents (Zibrowius, 1978; 1995; Kružic *et al.*, 2002). Its population density can be locally high, with colonies covering up to 90% of the sea bottom (Goffredo *et al.*, 2011). Populations of *A. calycularis* mainly have a limited geographical distribution in the Mediterranean Sea, restricted to the south-western area (Zibrowius, 1980; 1995; Bianchi, 2007). Though, the species has been also quoted in Adriatic Sea (Grubelic *et al.*, 2004). Andalusian rocky shores (southern Iberian Peninsula) host one of the highest densities of the orange coral populations (Terrón-Sigler *et al.*, 2015).

Terrón-Sigler *et al.* (2014) observed that peracarid crustaceans were the most prevalent species associated with the orange coral. Additionally, three of the peracarids associated with *A. calycularis* had a strong orange colour (i.e. *Janira maculosa*, *Sthenothoe cavimana*, and *Caprella penantis*) (Terrón-Sigler *et al.*, 2014). However, the nature of the association is unclear, whether it is obligate or facultative, and whether the coral is used as a substrate (e.g. refuge, spawning, brood care or protection by crypsis) or as a feeding source (partial or totally).

Amphipods are the most diverse group of crustaceans in terms of lifestyle, trophic types and habitats (De Broyer & Jazdzewski, 1996). Due to their population's characteristics, amphipods may play major roles in the ecology of their habitats (Conlan, 1994). Amphipods are known to have versatile feeding strategies (i.e. Sarvala & Uitto, 1991) and show a wide range of feeding habits (Conradi & Cervera, 1995). They also constitute an important food source for a large variety of marine predators (Vázquez-Luis *et al.*, 2013); hence playing a key role in energy flow through food webs (Guerra-García *et al.*, 2014). Consequently, the main objective of the present study is to explore if peracarids associated with *A. calycularis* feed on the host coral's tissues, in an effort to highlight the nature of the association.

Material and Methods

161 specimens of peracarids were collected from 23 colonies of *A. calycularis* from Marina del Este beach (Granada coast; Andalusia; Spain) in July 2011 (Figure 1). Colonies were covered *in situ* with plastic bags before they were removed in order to keep all the associated fauna. The samples were fixed in 4% formalin and subsequently placed in 70% ethanol in the laboratory. The colonies were washed, the macrofauna sieved using a 0.5 mm size mesh, and the specimens collected were sorted and identified at the species level, when possible.

Diet study was analysed following the methodology proposed by Bello & Cabrera (1999) with slight variations. Recently, this method was successfully used in amphipods (i.e. Navarro-Barranco *et al.*, 2013; Vázquez-Luis *et al.*, 2013; Guerra-García *et al.*, 2014).

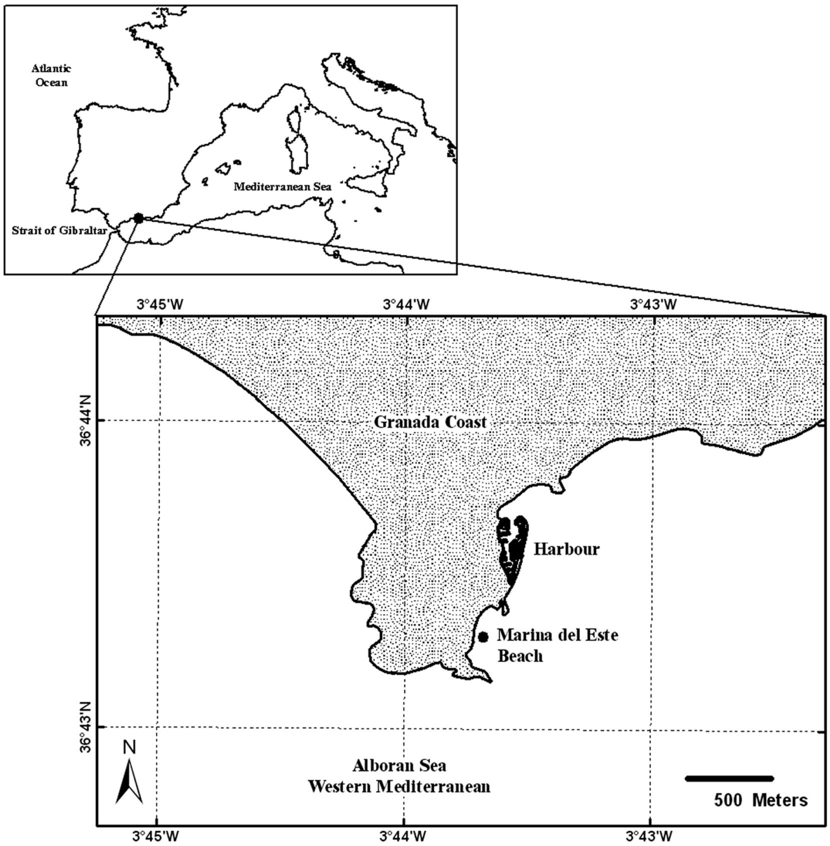

Fig. 1: Map of the study site showing Granada coast (Andalusia, Spain) and Marina del Este beach, where the colonies of *Astroides calycularis* were collected (* = 36º43'15" N; 3º43'43" W).

Specimens of each species were introduced in vials with Hertwig's liquid (consisting of 270 g of chloral hydrate, 19 ml of chloridric acid 1 N, 150 ml of distilled water and 60 ml of glycerine) and oven-heated at 65 °C for 4 to 6 hours depending on the cuticle thickness of the specimens. After this, samples were mounted on slides for microscope study. The percentage of absolute gut content (i.e. total area occupied by the content in the whole digestive tract) and the relative gut content (i.e. area occupied by each component within the total gut content) were estimated using a microscope equipped with an ocular micrometer (at 40× or 100×). Mean and standard error of the mean were calculated.

Results and Discussion

The collected peracarid specimens belonged to 11 species and distributed in 9 families (Table 1), representing the dominant peracarids associated with *A. calycularis* in the south Iberian Peninsula. Gut contents of the studied amphipod species included detritus, crustaceans and macroalgae (Table 1). The dominant component was detritus, followed by crustacean pieces and macroalgal tissues. In a diet analysis of marine amphipods around the Iberian Peninsula, Guerra-García *et al.* (2014) concluded that detritivorous species had fuller guts than carnivorous species, where empty guts predominated. Nevertheless, trophic classifications may be subjective. In our study, three species namely *Liljeborgia psaltrica*, *S. cavimana* and *Eusiroides dellavallei*, presented empty guts. Although, these three species might be considered carnivorous, the amphipods associated with *A. calycularis* colonies presented the majority of the gut content occupied by detritus, highlighting the importance of detritus for the amphipods already noted in the Iberian Peninsula by Guerra-García *et al*. (2014).

Gut content ranged from 16% in *Leucothoe spinicarpa* to 64.3% in *J. maculosa*. In general, species with detritus had a higher area occupied by content in the digestive tract than other species.

Regarding caprellid species, these findings are in agreement with other studies, where the detritus was the dominant food source in seaweed-associated caprellids (Guerra-García & Tierno de Figueroa, 2009; Guerra-García *et al*., 2014). In the present study, the two caprellids collected from orange coral colonies showed more than 98% detritus composition in their gut contents.

There is scarce information about the feeding habits of marine isopods (e.g. Navarro-Barranco *et al*., 2013). In this study, *Paragnathia formica* showed 100% detritus gut content, while *J. maculosa* had a diverse gut content (Table 1).

Table 1. Gut contents of the studied peracarid species. N: number of specimens of each species examined, n: number of specimens with detected digestive contents. % Abs: total area occupied by the content in the whole digestive tract. Det: detritus, Crust: crustaceans, Malg: Macroalgae. Mean values with standard errors of the mean (in parentheses) are included.

PERACARIDS	N/n	% Abs	% Det	% Crust	% Malg	Feeding group
Isopods						
Janira maculosa Leach, 1814	22/22	64.3 (19.1)	93.9 (8.6)	5.7 (3.1)	0.5	Omnivorous
Paragnathia formica Hesse, 1864	12/10	27.5 (15.5)	100	--	--	Detritivorous
Amphipods						
Lembos sp. Bate, 1857	23/22	50.2 (30.7)	92.7 (6.3)	7.3 (5.2)	--	Omnivorous
Autonoe spiniventris Della Valle, 1893	9/8	59.4 (39)	100	--	--	Detritivorous
Leucothoe spinicarpa Abildgaard, 1789	19/17	16 (9.1)	98.1 (3.1)	1.9 (0.8)	--	Omnivorous
Liljeborgia psaltrica Krapp-Schickel, 1975	20/0	--	--	--	--	Carnivorous
Sthenothoe cavimana Chevreux, 1908	20/0	--	--	--	--	Carnivorous
Eusiroides dellavallei Chevreux, 1899	3/0	--	--	--	--	Carnivorous
Caprella acanthifera Leach, 1814	14/14	61.1 (3.7)	100	--	--	Detritivorous
Phtisica marina Slabber, 1769	11/8	19.4 (13.9)	98.7 (3.5)	1.3	--	Omnivorous
Tanaids						
Tanais dulongii Audouin, 1826	8/7	55.7 (28.7)	98.8 (3.7)	1.2	--	Omnivorous

The tanaid *Tanais dulongii* associated with *Fucus spiralis* in the south Iberian peninsula is herbivorous with fucoid algae its primary diet source (Torrecilla-Roca & Guerra-García, 2012). The specimens associated with *A. calycularis* did not show this feeding habit; more than 98% of the gut content was detritus and the remaining was composed of crustacean fragments. This finding highlights the plasticity in the feeding habits of peracarid species depending on the host or habitat where they inhabit.

Scleractinian corals function as structural engineers (Jones *et al.,* 1994), contributing to an increase in habitat complexity and surface topography, which promotes biodiversity by mediating competition or predation (Hixon & Menge, 1991; Coker *et al*., 2009). Corals provide a large surface area where invertebrate assemblages can live, as well as refuges from predator, food source in the form of coral tissue, mucus and its associated detritus, and a hard skeleton used as a substratum by specialized burrowers (Castro, 1988). Taking all these factors into account, the peracarids associated with *A. calycularis* might use the coral skeleton as a refuge against potential predators (by hiding or as crypsis) or as food source of detritus that the colonies generate. Commensalisms between amphipods and cnidarians has been documented worldwide (e.g. Vader & Krapp-Schickel, 1996; Esquete *et al*., 2014), but there is little information about this association with corals. Therefore, more studies are necessary in this regard with scleractinian corals. The analysis of gut contents of peracarids associated with the intertidal algae *F. spiralis* revealed that the assemblage is dominated by species feeding mainly on this algae (Torrecilla-Roca & Guerra-García, 2012), in contrast with other crustaceans inhabiting different seaweed assemblages which mainly feed on detritus (Guerra-García & Tierno de Figueroa, 2009; Alarcón-Ortega *et al*., 2012). This could highlight that, depending upon the host with which the peracarids are associated, the relationship could be host-dependent or not, but further research needs to be carried out in this regard.

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