# Feeding habits of the peracarid crustaceans associated to the alga *Fucus spiralis* in Tarifa Island, Cádiz (Southern Spain)

## Alimentación de los crustáceos peracáridos asociados al alga *Fucus spiralis* en la Isla de Tarifa, Cádiz (sur de España)

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**Palabras clave:** Crustáceos peracáridos, alimentación, contenidos estomacales, variación estacional, *Fucus spiralis*.

**ABSTRACT**

The intertidal alga *Fucus spiralis* (Linnaeus, 1753) hosts an important mobile associated macrofauna, composed mainly of peracarid crustaceans such as the amphipod *Hyale perieri* (Lucas, 1849), the isopods *Dynamene bidentata* (Adams, 1800) and *Ischyromene lacazei* Racovitza, 1908 and the tanaid *Tanais dulongii* (Audouin, 1826). In the present study, we explored the feeding habits of these peracarid crustaceans associated to *F. spiralis* in Tarifa Island. The analysis of gut contents revealed that the community of *F. spiralis* is dominated by herbivorous, feeding mainly on the own algae along all year round. As expected, taking into consideration that *F. spiralis* inhabit the upper levels of the intertidal and it is emerged most of the day, detritus collected from the water column was very scarce in the gut of examined species. The amphipod *H. perieri*, the dominant species, fed also on crustaceans besides the fucoid algae, especially during the warmer season. Dinoflagellates, diatoms and vorticellids were also present in lower proportions. Further experimental studies are needed to better understand the strong effect of associated herbivorous on the growth and dynamics of *F. spiralis*.

**RESUMEN**

El alga intermareal *Fucus spiralis* (Linnaeus, 1753) alberga una macrofauna móvil asociada importante, constituida fundamentalmente por crustáceos peracáridos como el anfípodo *Hyale perieri* (Lucas, 1849), los isópodos *Dynamene bidentata* (Adams, 1800) e *Ischyromene lacazei* Racovitza, 1908 y el tanaidáceo *Tanais dulongii* (Audouin, 1826). En el presente estudio, exploramos la alimentación de los peracáridos asociados a *F. spiralis* en la Isla de Tarifa. El análisis de los contenidos estomacales reveló que la comunidad de *F. spiralis* está dominada por herbívoros, que se alimentan del alga durante todo el año. Como cabría esperar, teniendo en cuenta que *F. spiralis* vive en los niveles superiores del intermareal en emersión la mayor parte del día, se encontró poco detrito procedente de la columna de agua en las especies examinandas. El anfípodo *H. perieri,* la especie dominante, se alimentó también de crustáceos además de alga, especialmente durante la estación cálida. Los dinoflagelados, diatomeas y vorticélidos también estuvieron presentes, aunque en proporciones menores. Se requieren estudios experimentales para comprender mejor el fuerte efecto de la presión de herbivoría sobre el crecimiento y dinámica de *F. spiralis*.

## INTRODUCTION

Species of fucoid algae have proven to be an important habitat-forming substrate, supporting many epiphytes as well as sessile and mobile associated fauna, mostly peracarid crustacean (Kersen *et al*., 2011; Guerra-García *et al*., 2011a, 2011b). However, there are few reports about the feeding habits of their mobile fauna (Vázquez-Luis *et al*., 2012; Alarcón-Ortega *et al*., 2012; Guerra-García & Tierno de Figueroa, 2009). Rocky intertidal zonation patterns of marine algae and marine invertebrates have been intensively studied, occurring at specific levels along a height axis, from the lower to the upper shore (Underwood, 1981; Araújo *et al.,* 2005; Martins *et al.,* 2008). Zonation patterns of macroalgal assemblages in general are recognized to be the result of the effects of biological factors such as competition and grazing as well as physical factors such as wave action, aerial exposure, irradiance, temperature ranges and time available for nutrient exchange (see Lobban & Harrison, 1994; Choi & Kim, 2004). *Fucus* is found in the upper level of the intertidal area; therefore, it is exposed to serious desiccation during periods of falling tide, resulting in a tissue water loss, measured in other Atlantic areas, of about 90% (Schagerl & Möstl, 2011). Guerra-García *et al.* (2011b) showed that seasonal fluctuations of *Fucus spiralis* (Linnaeus 1753) correlated with its associated peracarid crustacean abundance. Thereby, it can be inferred that the nutritional elements from which the algae inhabitants feed on may be limited in low tide periods or in warmer seasons. It is then interesting to analyze if fucoid peracarid crustacean nourish from different feed depending on the season, and to measure the importance of *F. spiralis* in their diet. We could also hypothesized that due to the low tide periods, peracarid crustacean would consume scarce detritus, which is suspended in the water column. Consequently, *Fucus spiralis* itself could be the best option as food for this peracarid to assure their nourishment; however, fucoids have manifested a high resistance to consumer species of peracarid crustacean as shown in Denton & Chapman (1991). For all these reasons, we considered interesting to determine the trophic relationships between alga and associated peracarids exploring the feeding habits of the most common peracarid crustaceans associated to *Fucus spiralis*.

## MATERIAL AND METHODS

### *Seasonal fluctuations of* Fucus spiralis *and associated peracarid crustaceans*

The study was conducted in “Punta Marroquí” (36º00′00.7″N, 5º36′37.5″W) the southern point of Tarifa Island. A single site was selected since a previous approach showed little variation in the peracarid fauna associated to algae along different sites of the whole Island. More details of the study area can be found in Guerra-García *et al.* (2011a,b)

The study was restricted to the upper site of the intertidal algae, where the *Fucus spiralis* belt was present. Three replicates (20x20 cm squares) were randomly sampled every two months (from December 2005 to December 2007). The surface was scrapped and the macroalga and associated fauna were collected. The samples were fixed in 80% ethanol, brought to laboratory and sieved using a mesh size of 0.5 mm. Peracarids were sorted and identified to species level. The dry weight of *Fucus spiralis* was measured (after 24h at 70°C). The abundance of crustaceans was expressed in number of individuals per $m^2$.

### *Feeding habitats*

The crustaceans obtained from the two years sampling explained above were prepared for observation following the methodology proposed by Bello and Cabrera (1999) with slight variations (Tierno de Figueroa *et al*., 2006; Guerra-García & Tierno de Figueroa, 2009). Each individual was introduced in a vial with Hertwig’s liquid (consisting of 270 g of chloral hydrate, 19 ml of chloridric acid 1N, 150 ml of distilled water and 60 ml of glycerin) and heated in an oven at 65°C, for 6 to 24h, depending on the cuticle thickness of the specimens. After this, they were mounted on slides for examination under the microscope. The percentage of the absolute gut content (100x), as the total area occupied by the content in the whole digestive tract, and the relative gut content (400 and 1,000x), as the area occupied for each component within the total gut content, were estimated using a microscope equipped with an ocular micrometer. Mean and standard error of the mean were calculated.

There was enough material of *Hyale perieri* to conduct a temporal study of the feeding contents. However, the material available of the remaining species was not abundant enough, so the data were treated globally.

## RESULTS AND DISCUSSION

### *Seasonal fluctuations of* Fucus spiralis *and associated peracarid crustaceans*

The study of *Fucus spiralis* biomass fluctuations along the two years in Tarifa Island, revealed that the algae population was present during the whole year, with higher biomass during summer months, decreasing towards the winter periods (Fig. 1). The seasonal fluctuations of *Fucus spiralis* are

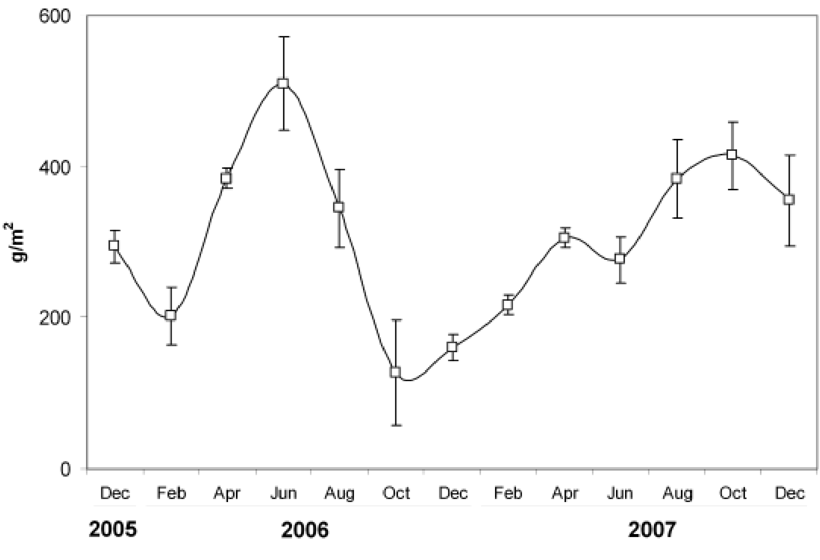


Fig. 1.—Seasonal fluctuations in biomass of the alga *Fucus spiralis* along the two years study. Values are mean ± standard error of the mean.
Fig. 1.—Fluctuaciones estacionales de la biomasa del alga *Fucus spiralis* durante los dos años de estudio. Los valores representan la media ± error estándar de la media.

similar to those of the most common associated peracarids such as *Hyale perieri* (Lucas, 1849), and also, the isopod *Dynamene bidentata* (Adams, 1800) (Fig. 2). But the pattern was not so clear for the other two main peracarid crustacean found in the belt, *Ischyromene lacazei* Racovitza, 1908 and *Tanais dulongii* (Audouin, 1826). These two species dominated in winter, and seem to disappear in summer from *F. spiralis* belts (Fig. 2). However, as Guerra-García *et al.* (2011b) showed, they can be found in lower intertidal algae belts. Probably, these species move down into lower intertidal belts in summer, where they find higher humidity conditions, to cope with the dehydration that may occur in *F. spiralis* belt during the hottest months. Occasionally, other species can be found associated to *Fucus*

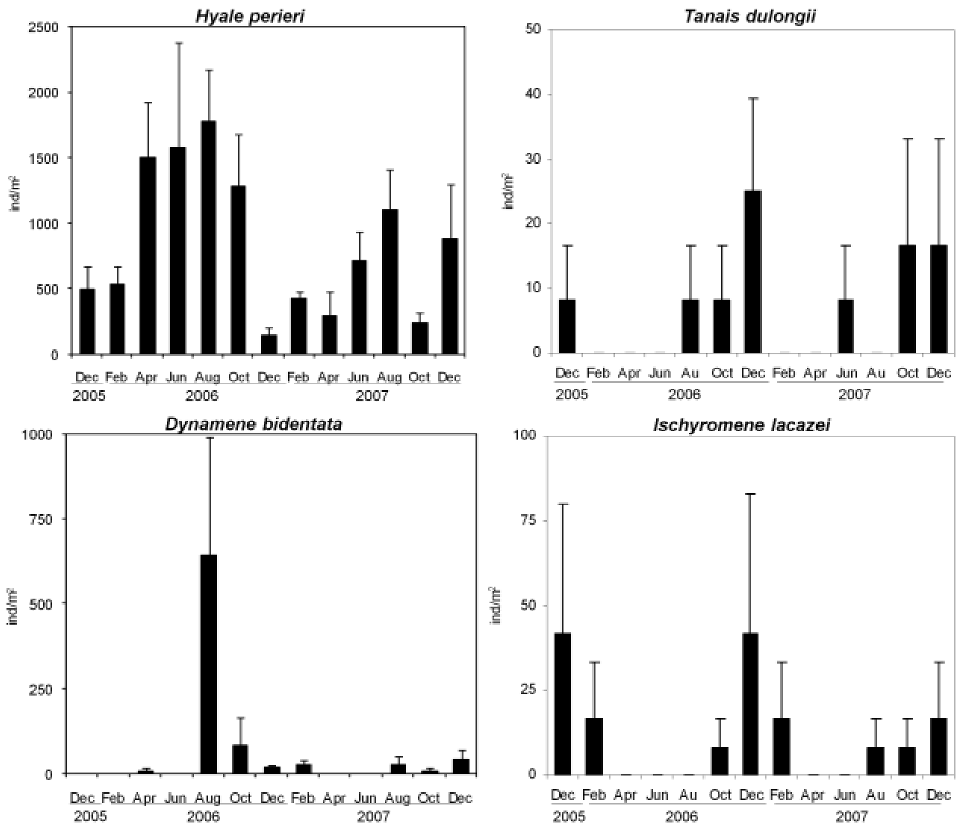


Fig. 2.—Seasonal fluctuations of abundance (ind/m$^2$) of the crustacean species associated to *Fucus spiralis*. Values are mean ± standard error of the mean.

Fig. 2.—Fluctuaciones estacionales de abundancia (ind/m$^2$) de las especies de crustáceos asociados a *Fucus spiralis*. Los valores representan la media ± error estándar de la media.

*spiralis* (Guerra-García *et al.,* 2011b), but were not representative (just one or few specimens in one sampling) and have not been included in this study.

*Feeding habitats*

*Hyale perieri* was the dominant species and therefore the best suited to be used in a seasonal fluctuation feeding habits analysis. The other three species were only used for global data. A total of 286 specimens of *H. perieri* were examined, 23 of *D. bidentata*, 10 of *I. lacazei* and 6 of *T. dulongii*. The gut contents studied showed that these peracarids are clearly herbivorous (Table 1) being the same fucoid algae the greatest part of their diet (>60% in all cases). Therefore we can consider that *Fucus spiralis* supports a mainly herbivorous community, in spite of the presence of tannins. Further research is necessary to explore how the high amounts of anti-herbivore tannins is compatible with the existence of an abundant community of herbivorous species. As we expected, the amount of detritus ingested by the peracarid crustacean living in *F. spiralis*, is scarce compared to the alga contribution. This contrasts with the feeding habits of other crustacean inhabiting different seaweed assemblages, which feed mainly on detritus (Vázquez-Luis *et al*., 2011; Alarcón-Ortega *et al*., 2012; Guerra-García & Tierno de Figueroa, 2009). The low content in detritus found in the crustaceans associated to *F. spiralis* is expected to occurr in the upper parts of the intertidal algae belt,

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. *Fs*: *Fucus spiralis*, Din: dinoflagellates, Diat: diatoms, Vort: vorticellids, Cru: crustaceans, Det: detritus. Data are mean values ± standard errors.

Tabla 1.—Contenidos digestivos de las especies de caprélidos estudiadas. N: número de ejemplares examinados de cada especie, n: número de ejemplares con presencia de contenido digestivo. %Abs: área total ocupada por el contenido en el tracto digestivo completo. *Fs*: *Fucus spiralis*, Din: dinoflagelados, Diat: diatomeas, Vort: vorticélidos, Cru: crustáceos, Det: detritus. Los datos son valores medios ± errores estándar.

| | | | *Components (100%)* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *N/n* | *%Abs* | *%Fs* | *%Din* | *%Diat* | *%Vort* | *%Cru* | *%Det* |
| *Hyale perieri* | 286/233 | 50.9 (4.3) | 62.1 (5.6) | 10.6 (1.4) | 4.0 (0.7) | 1.0 (0.8) | 14.7 (5.4) | 7.6 (2.9) |
| *Dynamene bidentata* | 23/13 | 53.8 (14.5) | 92.7 (13.4) | 7.3 (1.9) | — | — | — | — |
| *Tanais dulongii* | 6/6 | 72.5 (17.0) | 72.2 (10.3) | 13.1 (5.0) | 3.4 (0.8) | — | 11.3 (3.5) | — |
| *Ischyromene lacazei* | 10/4 | 43.3 (19.2) | 62.7 (8.5) | 13.3 (3.1) | 7.3 (1.5) | — | — | 16.7 (3.8) |

where the access to detritus suspended in the water is difficult. The detritus found in *H. perieri* (7.6%) and *I. lacazei* (16.7%) was probably collected scraping the surface of the algae or even the surrounding rocks. Both *H. perieri* and *I. lacazei* also captured other crustaceans. The contribution of dinoflagellates was higher than the diatoms in the four species. The presence of vorticellids was registered only in *H. perieri*, probably due to the large number of specimens examined for this species

*Hyale perieri* feeding habits did not vary greatly within each year of the study period (Table 2). *Hyale perieri* fed mainly on *Fucus spiralis*, but also on crustaceans, dinoflagellates, vorticellids and detritus. During summer, there is a decreasing tendency in the amount of alga consumed and a slight increase in crustaceans. Although it was impossible to identify the crustacean rests (mostly gammarids and copepods) to species level, there

Table 2.—Gut contents of *Hyale perieri* along the two year. 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. *Fs*: *Fucus spiralis*, Din: dinoflagellates, Diat: diatoms, Vort: vorticellids, Cru: crustaceans, Det: detritus. Data are mean values ± standard errors

Tabla 2.—Contenidos digestivos de *Hyale perieri* a lo largo de los dos años. N: número de ejemplares examinados de cada especie, n: número de ejemplares con presencia de contenido digestivo. %Abs: área total ocupada por el contenido en el tracto digestivo completo. *Fs*: *Fucus spiralis*, Din: dinoflagelados, Diat: diatomeas, Vort: vorticélidos, Cru: crustáceos, Det: detritus. Los datos son valores medios ± errores estándar

| | | | | | *Components* | | | |
|---|---|---|---|---|---|---|---|---|
| | *N/n* | *%Abs* | *%Fs* | *%Din* | *%Diat* | *%Vort* | *%Cru* | *%Det* |
| Dec. 2005 | 28/25 | 74.4 (4.2) | 94.7 (2.0) | 3.0 (1.2) | 1.1 (0.8) | 0.4 (0.3) | — | 0.8 (0.6) |
| Feb. 2006 | 21/21 | 38.8 (5.7) | 79.1 (5.4) | 0.1 (0.1) | 5.0 (1.7) | — | 1.9 (1.1) | 13.9 (4.5) |
| Abr. 2006 | 22/18 | 54.4 (6.4) | 95.6 (2.4) | 3.8 (2.4) | 0.2 (0.1) | — | 0.4 (0.3) | — |
| Jun. 2006 | 29/25 | 32.3 (4.7) | 59.9 (8.7) | 3.0 (1.5) | 5.3 (2.8) | 0.4 (0.4) | 19.2 (7.3) | 12.2 (6.4) |
| Aug. 2006 | 23/17 | 37.6 (5.4) | 38.8 (9.0) | 13.9 (6.1) | 2.2 (1.2) | — | 29.8 (10.2) | 15.3 (6.6) |
| Oct. 2006 | 27/20 | 40.8 (7.1) | 91.5 (5.2) | 5.7 (5.0) | 0.3 (0.1) | — | 2.5 (2.0) | — |
| Dec. 2006 | 12/11 | 85.4 (3.9) | 92.0 (1.7) | 7.3 (1.8) | 0.3 (0.2) | — | 0.4 (0.5) | — |
| Feb. 2007 | 25/20 | 54.0 (5.7) | 86.0 (3.4) | 4.9 (2.3) | 7.0 (2.5) | — | — | 2.1 (1.4) |
| Apr. 2007 | 15/11 | 46.4 (12.5) | 89.4 (4.8) | 6.5 (4.5) | 2.3 (1.2) | — | — | 1.8 (1.8) |
| Jun. 2007 | 22/16 | 39.1 (8.2) | 95.2 (1.8) | 3.7 (1.7) | 0.5 (0.2) | — | 0.6 (0.6) | — |
| Aug. 2007 | 23/16 | 50.6 (8.1) | 71.4 (8.5) | 7.0 (3.1) | 1.9 (0.9) | 0.6 (0.6) | 12.5 (8.5) | 6.6 (2.7) |
| Oct. 2007 | 19/15 | 63.0 (7.1) | 91.1 (3.4) | 6.0 (2.7) | 2.1 (1.3) | 0.1 (0.1) | — | 0.7 (0.7) |
| Dec. 2007 | 20/20 | 45.0 (6.5) | 66.4 (7.6) | 5.8 (2.7) | 2.6 (1.5) | — | 24.7 (7.8) | 0.5 (0.3) |

were clear morphological evidences that a great proportion of the rests were belonging to the species *H. perieri* itself, confirming that they are able to eat specimens of their own species (cannibalism). Probably, during summer periods, the alga is less abundant and also less palatable for the crustaceans, due to strong dissecation. Consequently, the intraspecific competition for resources could trigger a higher cannibalism in this gammarid species. Further studies under laboratory conditions are still needed in order to understand the performance of the peracarid crustacean in the trophic networks and their influence on dynamics and growth of their substrate *F. spiralis*.

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