Journal of the Marine Biological Association of the United Kingdom, 2011, 91(2), 447–453.
doi:10.1017/S0025315410000810

Taxonomy and ecology of some gammaridean species (Crustacea: Amphipoda) from Tarifa Island, southern Spain

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On Tarifa Island (Strait of Gibraltar) several amphipod species were studied from intertidal algae: Ampithoe ferox, Apherusa mediterranea, Hyale spinidactyla, Hyale *cf.* youngi *and* Jassa cadetta. *The allometric growth of gnathopod 2 in male is demonstrated for* A. ferox. Jassa cadetta *had been recorded previously only from the northern Adriatic Sea, while* Hyale spinidactyla *and* Hyale *cf.* youngi *had been only known from the Atlantic Ocean. Along the intertidal area,* A. mediterranea *and* J. cadetta *were dominant in the low levels located near the infralittoral area, while* A. ferox, Hyale spinidactyla *and* Hyale *cf.* youngi *were distributed in intermediate and upper levels, closer to the supralittoral zone. All the species showed the maximum peaks of abundance from April to October, coinciding with the maximum seawater temperatures.*

Keywords: Strait of Gibraltar, ecology, amphipods, *Hyale*, *Ampithoe*, *Apherusa*, *Jassa*

Submitted 21 August 2009; accepted 15 February 2010; first published online 17 June 2010

INTRODUCTION

The Strait of Gibraltar is a biogeographical zone in which faunas of the Mediterranean and the Atlantic, along one axis, and of Europe and Africa along the other, overlap (Guerra-García *et al.*, 2009). It is a very important geographical–geological region formed in the final phases of the Pliocene period, being the boundary for the Mediterranean region (to the east), the Lusitanian region (to the north-west) and the Mauritanian region (to the south-west).

Europe and Africa are separated by 14.24 km at the Strait's narrowest point. The Strait depth ranges between 300 and 900 m. Around 5.9 million years ago, the connection between the Mediterranean Sea and the Atlantic Ocean was progressively restricted until its total closure (Messinian salinity crisis), which was one of the most dramatic events on Earth during the Cenozoic era (Hsü *et al.*, 1973). After a lengthy period of restricted intermittent or no water exchange between the Atlantic Ocean and Mediterranean basin, approximately 5.33 million years ago, the Atlantic–Mediterranean connection was completely re-established through the Strait of Gibraltar and again disconnected Africa from Europe. No evidence for a further closing of the Strait of Gibraltar exists (Blondel & Aronson, 1999). All these geological events have determined the terrestrial and marine fauna across the Strait of Gibraltar. And thus, the Strait has attracted the attention of marine taxonomists and several biogeographical studies have been published (e.g. bryozoans: López de la Cuadra & García-Gómez, 1994; sponges: Carballo *et al.*, 1997; ascidians: Naranjo *et al.*, 1998; molluscs: Gofás, 1998; crustaceans: Conradi & López González, 1999; Guerra-García & Takeuchi, 2002; Guerra-García *et al.*, 2009). Most of the invertebrates from the Strait of Gibraltar include species with Atlantic–Mediterranean distribution, but peracarideans also include an important Indo-Pacific element (Guerra-García *et al.*, 2009).

The Spanish side of the Strait is protected under the Straits Natural Park (Parque Natural del Estrecho) (Figure 1) which was declared a protected area in 2003. It is a maritime–terrestrial park along 54 km of coastline in southern Spain and includes highly diverse and structured marine communities

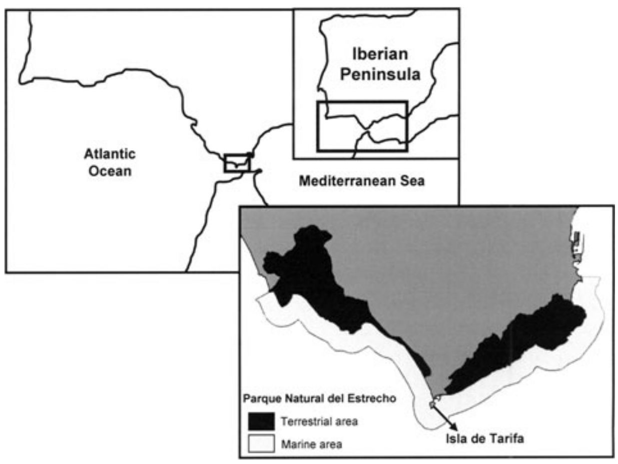

Fig. 1. Location of Tarifa Island in the Strait of Gibraltar.

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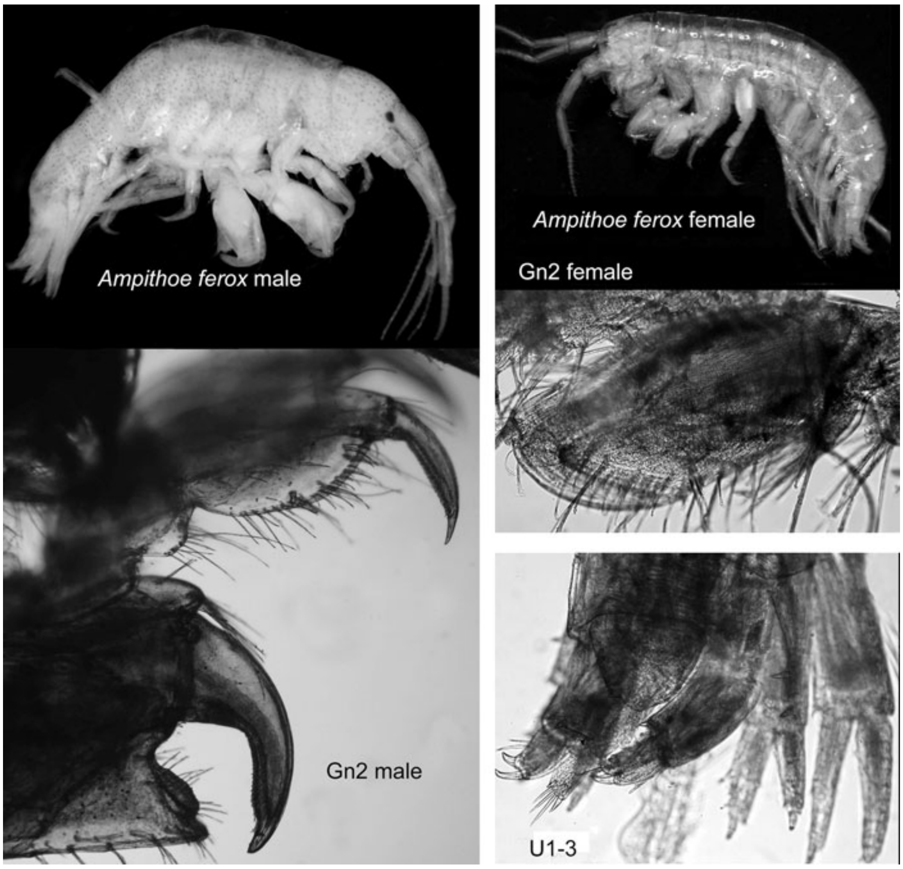

Fig. 2. *Ampithoe ferox* Chevreux; habitus male, female; gnathopods male, female; urosome.

(García-Gómez *et al.*, 2003). Inside the Park, Tarifa Island is considered a marine reserve, and constitutes the most interesting enclave of the park regarding the marine habitats. Tarifa Island is the southernmost point of Europe, just between the Mediterranean and Atlantic, with 21 hectares and 2 km of coastline. Its unique biogeographical position together with the substrate heterogeneity and the long-term military access restrictions, have contributed to maintain the richest rocky shore intertidal ecosystems of southern Spain (Guerra-García & García-Gómez, 2000).

During a general monitoring study of the peracaridean community associated with intertidal algae in Tarifa Island, several interesting gammaridean species were registered, some of them previously collected only from the Atlantic. In the present paper these gammarids are illustrated, and ecological data and seasonal fluctuation patterns are also included for each species.

MATERIALS AND METHODS

All the samples were collected from the most southern point of Tarifa Island (Punta Marroquí, 36°00′00.7″N 5°36′37.5″W). The width of the intertidal range in this location is 2.5 m approximately and we considered 5 levels to establish the zonation of the intertidal algae (level 1: from zero tidal level to 0.5 m; level 2: 0.5–1 m; level 3: 1–1.5 m; level 4: 1.5–2 m and level 5: 2–2.5 m). A ruler, set square and rope were used to establish the different heights. The first height was the zero tidal level and the process was

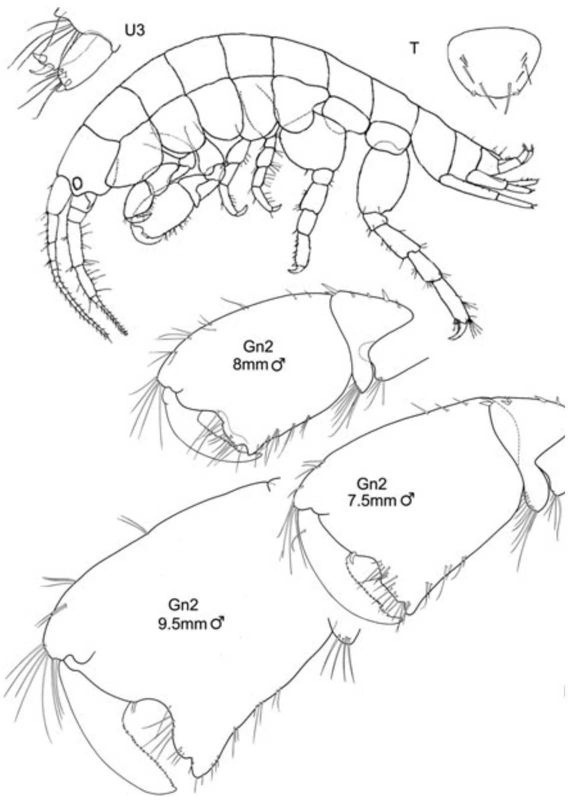

Fig. 3. *Ampithoe ferox* Chevreux; habitus male, U3, T and Gn2 of three different males.

continued until the vertical height of 2.5 m had been achieved, coinciding with the upper limit of the intertidal community (see also Fa *et al.*, 2002; Guerra-García *et al.*, 2006). At each height, three replicates (quadrats 20 × 20 cm) were sampled. The surface was scraped and all specimens of algae and associated fauna were collected. Samples were taken every two months from the different intertidal levels (December 2005 to December 2007). The samples were fixed in ethanol 70–80% and brought to the laboratory for further identification and quantification after sieving using a mesh size of 0.5 mm. Biomass of algae was expressed in grams of dry weight per m^2 and abundance of gammaridean species was expressed in number of individuals per m^2. In each sampling, water temperature and salinity were measured using a conductivimeter WTW LF-323.

Selected specimens were dissected under a Reichert dissecting microscope. All dissected appendages were mounted in Faure's medium. The figures were drawn using a Wild compound microscope equipped with a camera lucida (drawing-tube).

All the examined material for the present study is deposited at the Museo Civico di Storia Naturale di Verona.

The symbols used in plates are: A1, 2 = antenna 1, 2; Gn1, 2 = gnathopods 1 & 2; P3-7 = pereopods 3–7; U1-3 = uropods 1–3; T = telson.

SYSTEMATICS

Ampithoe ferox (Chevreux)
Figures 2 & 3

Pleonexes ferox Chevreux, 1902: 697 figure 21-2i; Chevreux & Fage 1925: 336, figure 345

Ampithoe ferox (Chevreux) Krapp-Schickel, 1982b: 95, figure 64; Marchini *et al.*, 2007: 27–31

material examined (all intertidal)

4 spec.; 4 December 2005: *Corallina elongata, Jania rubens*. 3 spec.; 1 May 2006: *Corallina elongata, Jania rubens*. 18 spec.;

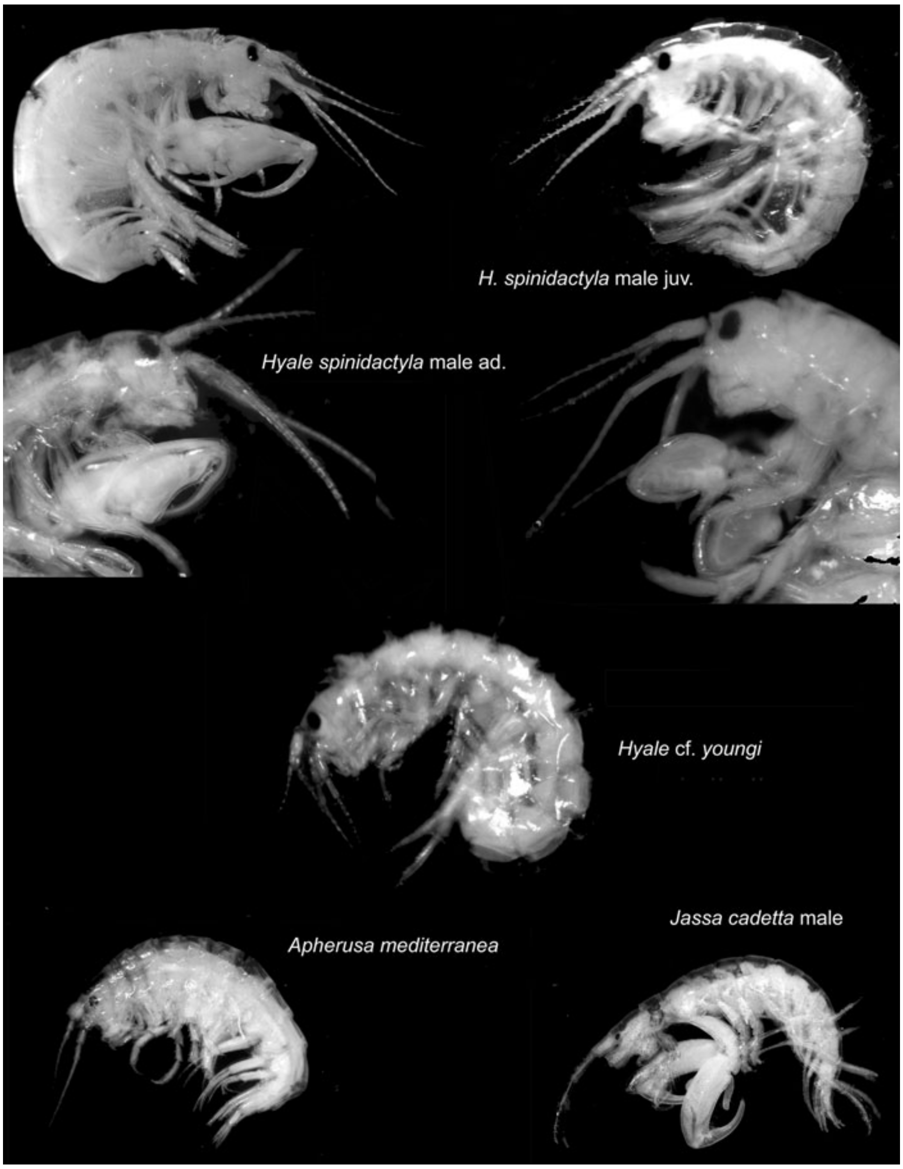

Fig. 4. Habitus of *Hyale spinidactylus* adult and juvenile male, *Hyale* cf. *youngi*, *Apherusa mediterranea* and *Jassa cadetta*.

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29 July 2006: *Corallina elongata, Jania rubens, Gelidium* sp., *Caulacanthus ustulatus, Laurencia pinnatifida*. 4 spec.; 8 October 2006: *Gelidium* spp., *Caulacanthus ustulatus, Laurencia pinnatifida*. 6 spec.; 9 November 2006. *Ulva rigida, Chaetomorpha* sp. 4 spec.; 22 April 2007: *Corallina elongata, Jania rubens*. 1 spec.; 17 July 2007: *Corallina elongata, Jania rubens*.

REMARKS

This species has been only rarely collected in France, Sicily, Malta and the northern Adriatic Sea (Krapp-Schickel, 1982b). It is the first time the allometric growth of Gn2 in male has been demonstrated.

Apherusa mediterranea Chevreux
Figures 4 & 5

Chevreux, 1911: 208 figure 9, pl. 14 figures 1–14
Krapp-Schickel, 1982a: 170–172 figure 115

MATERIAL EXAMINED (INTERTIDAL)

12 spec.; 1 May 2006: *Gelidium sesquipedale*.

REMARKS

This species is very sparsely cited from the Atlantic coast of Morocco, from Sicily and Algeria in the Mediterranean (Krapp-Schickel, 1982a).

Hyale spinidactyla Chevreux
Figures 4 & 6

Chevreux, 1925: 366, figures 13 & 14 partim
Reid, 1951: 245 figure 39
Arresti, 1996: 81, figures 2–8
Serejo, 2001: 480–84, figures 1 & 2

MATERIAL EXAMINED (ALL INTERTIDAL)

11 males, 23 females + juvenile; 17 July 2007: *Corallina elongate, Jania rubens, Ulva rigida*. 1 spec.; 1 October 2007: *Corallina elongata, Jania rubens*. 1 spec.; 15 December 2007: *Ulva rigida, Chaetomorpha* sp.

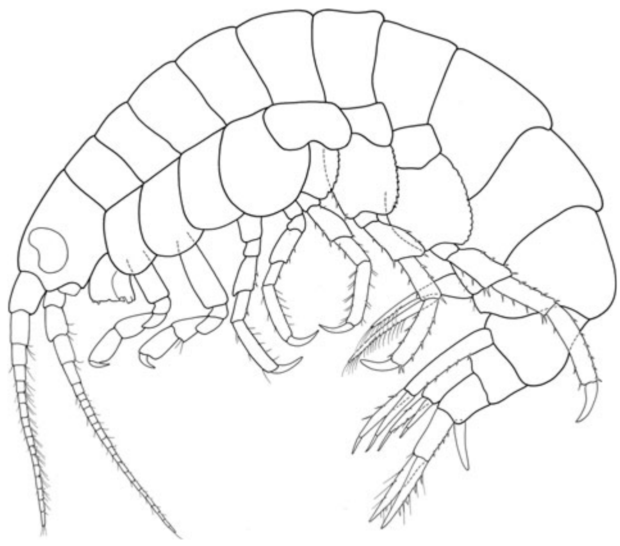

Fig. 5. *Apherusa mediterranea* Chevreux; habitus.

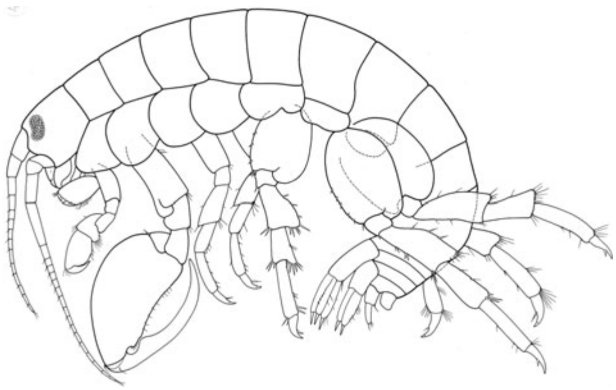

Fig. 6. *Hyale spinidactyla* Chevreux; habitus.

REMARKS

This species has been cited until now exclusively from the Atlantic. The type locality is Canary Islands (Chevreux, 1925) but the species has been also reported from São Tomé Island, Cape Verde, Azores and coast of the Basque Country, northern Spain (Serejo, 2001).

Hyale cf. *youngi* Serejo
Figures 4, 7 & 8
Serejo, 2001: 484–491, figures 3–7

MATERIAL EXAMINED (ALL INTERTIDAL)

1 juvenile male, 14 females + juvenile; 29 July 2006: *Corallina elongata, Jania rubens*. 1 juvenile male; 15 December 2007: *Ulva rigida, Chaetomorpha* sp.

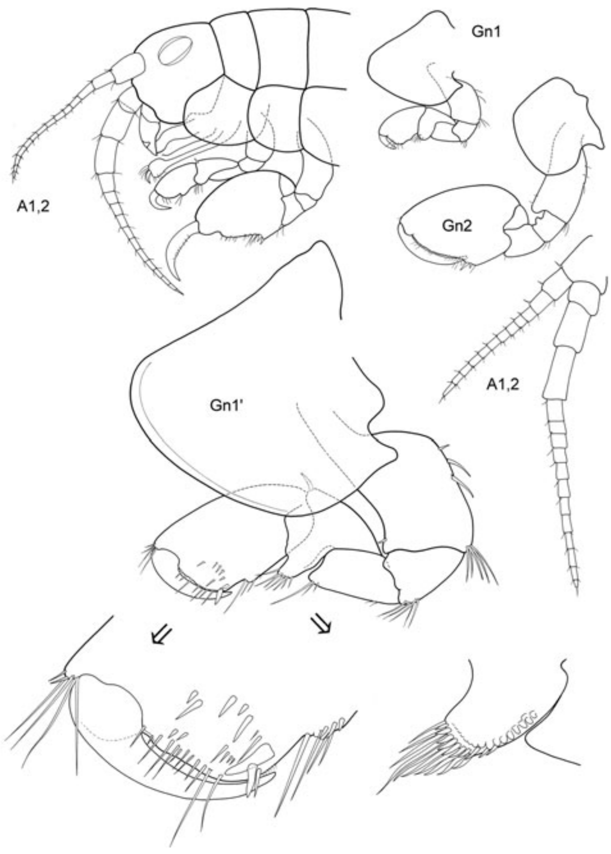

Fig. 7. *Hyale* cf. *youngi* Serejo; morphological details.

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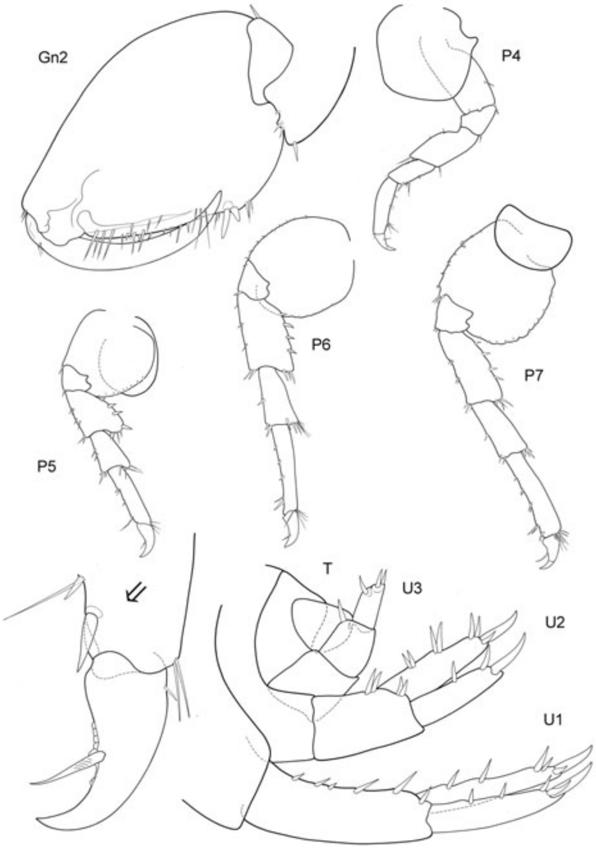

Fig. 8. *Hyale* cf. *youngi* Serejo; morphological details.

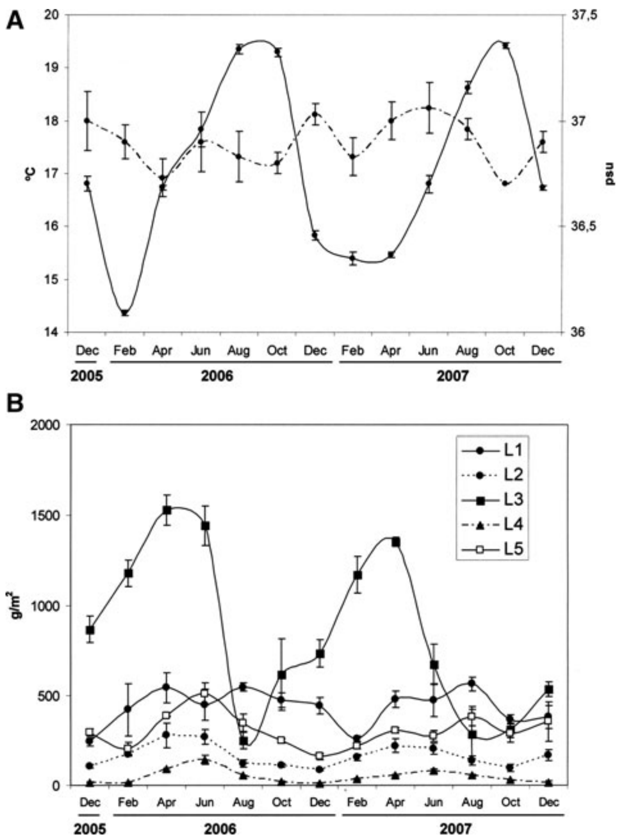

Fig. 10. (A) Seawater temperature (°C) and salinity (psu) in the study area; (B) seaweed biomass in each intertidal level considered. Mean values ± standard deviation are included.

REMARKS

As there are seemingly no adults collected, the identification cannot be certain; as above, also this species is only known from Brazil (States of Bahia, Rio de Janeiro and São Paulo).

Jassa cadetta Krapp, Rampin & Libertini
Figures 4 & 9

Krapp, Rampin & Libertini, 2008: 341–43 figures 4–7

MATERIAL EXAMINED

4 males, 3 females; 29 July 2006 intertidal: on *Gelidium sesquipedale*.

REMARKS

Only known from the northern Adriatic Sea until now. This study represents the first record of the species after its original description based on specimens collected from the Lagoon of Venice (Krapp *et al*., 2008).

SPATIO-TEMPORAL DISTRIBUTION

Salinity values remained similar throughout the year. Water temperature showed maximum values by the end of summer (August–October) and minimum values in February (Figure 10A). Biomass of seaweed was higher in level 3 than in the other levels (Figure 10B). Maximum values of biomass were reached by the end of spring and

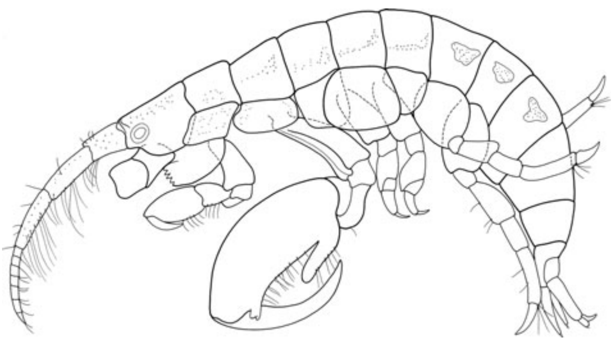

Fig. 9. *Jassa cadetta* Krapp, Rampin & Libertini; habitus.

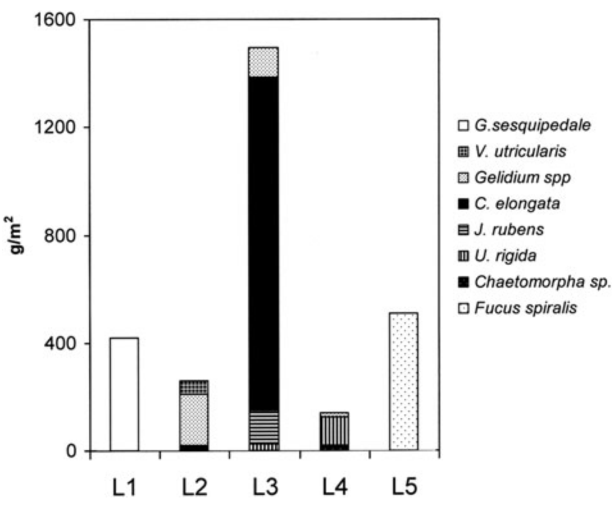

Fig. 11. Main seaweed species in each intertidal level and their abundance.

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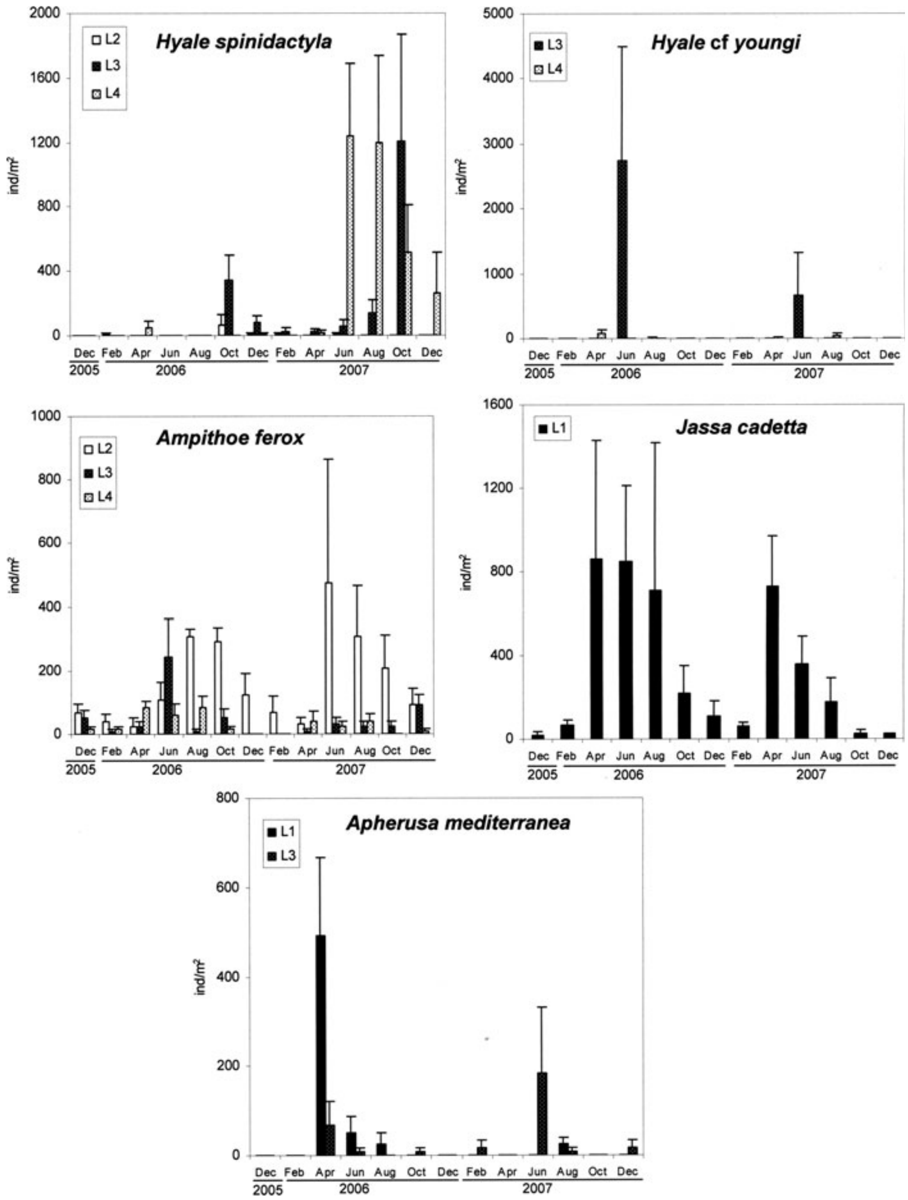

Fig. 12. Abundance (ind/m^2) of the gammaridean species studied in the different levels in which each species were found. Mean values $\pm$ standard error of the mean are included.

beginning of summer (April–June) and an important decrease was registered coinciding with the highest temperature of August, except for level 1 (0–0.5 m, closer to the subtidal) in which seaweed biomass did not decrease in August. Level 1 was dominated by *Gelidium sesquipedale*, level 2 (0.5–1 m) by *Gelidium* spp. (mainly *G. latifolium* and *G. spinulosum*) and *Valonia utricularis* (Figure 11). Level 3 (1–1.5 m) was composed mainly of *Corallina elongata*, but also *Jania rubens* and *Gelidium* spp. Level 4 (1.5–2 m) was dominated by green algae, such as *Ulva rigida* and *Chaetomorpha* sp., and level 5 (2–2.5 m) was exclusively represented by *Fucus spiralis*. In connection with the gammaridean species included in this study, *Jassa cadetta* and *Apherusa mediterranea* were dominant in level 1, *Ampithoe ferox* in levels 2 and 3, *Hyale* cf. *youngi* in level 3 and *Hyale spinidactyla* in levels 3 and 4 (Figure 12), demonstrating a spatial segregation of these species in the intertidal zone. All the species showed maximum peaks of abundance from April to October (late spring and summer) coinciding with the maximum seawater temperatures. The stability of the peracaridean composition assemblages through the year had been shown previously for soft bottom communities (Moreira *et al.*, 2008) but little had been explored for rocky shores. Collecting data of abundance over the year is rare in ecological literature because it is time-consuming, costly and often not possible (Simkanin *et al.*, 2005). However, knowledge of seasonal fluctuations of seaweeds and associated macrofauna is essential for future monitoring, conservation and for making reliable management decisions, especially in protected areas such as Tarifa Island in the Strait of Gibraltar.

ACKNOWLEDGEMENTS

Financial support of this work was provided by the Ministerio de Educación y Ciencia (Project CGL2007-60044/BOS)

https://doi.org/10.1017/S0025315410000810 Published online by Cambridge University Press

co-financed by FEDER funds, and by the Consejería de Innovación, Ciencia y Empresa, Junta de Andalucía (Project P07-RNM-02524). Special thanks to the directors of the Parque Natural del Estrecho (Jesús Cabello and Esther Gordo) and to the Comandancia General de la Guardia Civil for providing authorizations and facilitating access to the marine reserve Isla de Tarifa.

REFERENCES

Arresti A. (1996) Descripcion del anfípodo marino *Hyale spinidactyla* Chevreux, 1926 (Crustacea, Amphipoda, Gammaridea) en el País Vasco. *Miscellània Zoologica* 19, 79–91.

Blondel J. and Aronson J. (1999) *Biology and wildlife of the Mediterranean region*. New York: Oxford University Press.

Carballo J.L., Naranjo S. and García-Gómez J.C. (1997) Where does the Mediterranean Sea begin? Zoogeographical affinities of the littoral sponges of the Strait of Gibraltar. *Journal of Biogeography* 24, 223–232.

Chevreux E. (1902) Amphipodes recueillis par la Melita sur les côtes occidentale et meridionale de Corse. *Association Française pour l'Avancement des Sciences, Congrès d'Aiaccio* 30, 692–699.

Chevreux E. (1911) Campagnes de la Melita. Les Amphipodes d'Algerie et de Tunisie. I. Gammarina. *Mémoires de la Société Zoologique de France* 23, 143–285, 1–17, taf VI–XX, Text Abb 1–17.

Chevreux E. (1925) Voyage de la goelette Melita aux Canaries et au Sénégal 1889–1890. Amphipodes. I. Gammariens (suite). *Bulletin de la Société Zoologique de France* 50, 365–393.

Chevreux E. and Fage L. (1925) *Amphipodes. Faune de France 9*. Paris: P. Lechevalier, 488 pp, 438 figs.

Conradi M. and López-González P.J. (1999) The benthic Gammaridea (Crustacea, Amphipoda) fauna of Algeciras Bay (Strait of Gibraltar): distributional ecology and some biogeographical considerations. *Helgoland Marine Research* 53, 2–8.

Fa D.A., Finlayson C., García-Adiego E., Sánchez-Moyano J.E. and García-Gómez J.C. (2002) Influence of some environmental factors on the structure and distribution of the rocky shore macrobenthic communities in the Bay of Gibraltar: preliminary results. *Almoraima* 28, 73–88.

Gofás S. (1998) Marine molluscs with a very restricted range in the Strait of Gibraltar. *Biodiversity and Distributions* 4, 255–266.

Guerra-García J.M. and García-Gómez J.C. (2000) La fauna submarina de la Isla de las Palomas (Tarifa, Cádiz). In *Temas de Flora, Fauna y Ecología del Campo de Gibraltar*. Cuadernos del Instituto II, Campo de Gibraltar, pp 7–17.

García-Gómez J.C., Corzo J.R., López-Fe C.M., Sánchez-Moyano J.E., Corzo M., Rey J., Guerra-García J.M. and García-Asencio I.M. (2003) Metodología cartográfica submarina orientada a la gestión y conservación del medio litoral: mapa de las comunidades bentónicas del frente litoral norte del Estrecho de Gibraltar. *Boletín del Instituto Español de Oceanografía* 19, 149–163.

Guerra-García J.M., Maestre M.J., González A.R. and García-Gómez J.C. (2006) Assessing a quick monitoring method using rocky intertidal communities as a bioindicator: a multivariate approach in Algeciras Bay. *Environmental Monitoring and Assessment* 116, 345–361.

Guerra-García J.M., Cabezas M.P., Baeza-Rojano E., Espinosa F. and García-Gómez J.C. (2009) Is the north side of the Strait of Gibraltar more diverse than the south side? A case study using the intertidal peracarids (Crustacea: Malacostraca) associated to the seaweed *Corallina elongata*. *Journal of the Marine Biological Association of the United Kingdom* 89, 387–397.

Guerra-García J.M. and Takeuchi I. (2002) The Caprellidea (Crustacea: Amphipoda) from Ceuta, North Africa, with the description of three species of *Caprella*: a key to the species of *Caprella*, and biogeographical discussion. *Journal of Natural History* 36, 675–713.

Hsü K.J., Ryan W.B.F. and Cita M. (1973) Late Miocene desiccation of the Mediterranean. *Nature* 242, 240–244.

Krapp T., Rampin M. and Libertini A. (2008) A cytogenetical study of Ischyroceridae (Amphipoda) allows the identification of a new species, *Jassa cadetta* sp. n., in the Lagoon of Venice. *Organisms, Diversity and Evolution* 8, 337–345.

Krapp-Schickel G. (1982a) Family Calliopiidae. In Ruffo (ed.) The Amphipoda of the Mediterranean, Part 1, Gammaridea. *Mémoires de l'Institut Océanographique* 13, 164–178.

Krapp-Schickel G. (1982b) Family Ampithoidae. In Ruffo (ed.) The Amphipoda of the Mediterranean, Part 1, Gammaridea. *Mémoires de l'Institut Océanographique* 13: 94–110.

López de la Cuadra C.M. and García-Gómez J.C. (1994) *Zoogeographical study of the Cheilostomatida from the Strait of Gibraltar. Biology and paleobiology of bryozoans*. Denmark: Olsen and Olsen.

Marchini A., Sconfietti R. and Krapp-Schickel T. (2007) Role of the artificial structures on biodiversity: the case of arthropod fauna in the North Adriatic lagoons. *Studi Trentini di Scienze Naturali, Acta Biologica* 83, 27–31.

Moreira J., Gestoso L. and Troncoso J.S. (2008) Diversity and temporal variation of peracarid fauna (Crustacea: Peracarida) in the shallow subtidal of a sandy beach: Playa America (Galicia, NW Spain). *Marine Ecology* 81, 1069–1089.

Naranjo S., Carballo J.L. and García-Gómez J.C. (1998) Towards a knowledge of marine boundaries using ascidians as indicators: characterising transition zones for species distribution along Atlantic–Mediterranean shores. *Biological Journal of the Linnean Society* 64, 151–177.

Reid D.M. (1951) Report on the Amphipoda (Gammaridea and Caprellidea) of the coast of tropical West Africa. *Atlantide Report* 2, 189–291.

Serejo C.S. (2001) A new species of amphipod from the Brazilian coast, with redescription of *Hyale spinidactyla* Chevreux 1925 (Crustacea, Amphipoda, Hyalidae). *Zoosystema* 23, 479–492.

and

Simkanin C., Power A.M., Myers A., McGrath A., Southward N., Mieskowska N., Lepaer R. and O'Riordan R. (2005) Using historical data to detect temporal changes in the abundance of intertidal species on Irish shores. *Journal of the Marine Biological Association of the United Kingdom* 85, 1329–1340.

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