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On the morphological variation of two circum-mediterranean brakkish-water gammarids, *Rhipidogammarus rhipidophorus* (Catta) and *Echinogammarus foxi* (Schellemberg), from the spanish inland waters

(Crustacea, Amphipoda)

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The study of specimens of two circum-mediterranean brackish-water gammarids, collected in new localities from Spain, has shown the existence of a particular morphological variation in various segments and appendages. The specimens of *Rhipidogammarus rhipidophorus* (Catta, 1878) present little differentiation in some usually considered non discriminant characters for the species within the genus. In contrast, *Echinogammarus foxi* (Schellemberg, 1928), new to the Iberian Peninsula, presents populations with differentiation in some discriminant characters for the species of the *E. pungens*-group, to which it belongs.

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Introduction

Many species of gammarids having a large circum-mediterranean distribution present a conspicuous morphological variability (Stock 1967, 1968, 1971, 1978a). In very few cases, detailed studies have shown that some of these extended variable populations comprise distinct closely related (sub)species which are localy differentiated in certain areas of the Mediterranean coast (Stock 1971, 1978; Notemboom 1985).

Therefore, we consider interesting to determine, in a more detailed way, the morphological variability that these species may present in the newly discovered populations along their range.

Rhipidogammarus rhipidophorus (Catta, 1878) and *Echinogammarus foxi* (Schellemberg, 1928) are two such widely spread and variable species which deserve a careful analysis of the newly discovered populations. While their variability in other mediterranean populations has been previously studied (Stock 1968, 1971), the morphological characteristics of the Spanish populations have not yet been described. The latter show morphological characters which differ from those found in the populations from other parts of the Mediterranean sea, as it will be shown below.

Rhipidogammarus rhipidophorus belongs to a circum-mediterranean endemic genus, *Rhipidogammarus*, living in fresh and brackish waters near the sea coast (Ruffo 1982). The presence of *R. rhipidophorus* in Spain was firstly recorded by Stock (1971) from the hyporreic habitat of a dry river, near Puerto de la Selva (Gerona), and later, from the island of Mallorca (Balearic Islands), in the gravel of pools

in the dry bed of the Torrent de Pareis (Stock 1977). In a following paper Stock (1978) described *R. variicauda* from wells near Adraitx (west coast of Mallorca), and Notemboom (1985) described *R. triumvir* in two nearby wells between Mojonera and Las Norias (west Almería). Notemboom (1985) gave in his paper a map showing the distribution of the *Rhipidogammarus* species along the Spanish mediterranean coast. Among these, he included the localities of some unpublished material of *R. rhipidophorus,* from the Zoological Museum of Amsterdam, collected along the west coast of Mallorca. In this species, variability is known in the age-dependent setae and the presence or absence of fans of setae on the carpus of P3 in females (Stock 1971). Nevertheless, Notemboom (1985) did not described any morphological peculiarity of these Balearic populations.

Echinogammarus foxi is also very widely spread around the Mediterranean basin and belongs to the *Echinogammarus pungens*-group (Schellemberg 1928; Stock 1968; Karaman 1973, 1974). This species occurs in brackish coastal waters, lakes, and running waters with high ion-content along the Mediterranean sea as well as in the open Black Sea (Stock 1968; Karaman 1977). In Israel it is often found in small springs of the Sinai desert (Herbst & Dimentman 1983). After the redescription of this species, based on material collected from brackish lagoons and samples from European Museums (Stock 1968), it becomes clear that this species presents morphological variability in some particular features.

Although *E. foxi* is previously cited from Mallorca (Torrent de Pareis) by Stock (1978b), the presence of this species in the Iberian Peninsula is recorded for the first time in this paper.

In order to characterize the morphology of Spanish populations of these variable species, *E. foxi* and *R. rhipidophorus,* a detailed description of segments and appendages and the corresponding figures of specimens from the localities studied are given. Special emphasis will be made in those characters having the main differences with respect to the other mediterranean populations.

Results

Rhipidogammarus rhipidophorus (Catta, 1878)

Material examined. 11 males, 40 females and 22 juveniles. Spain, Soller (West Mallorca). A population from the spring of a little source from the beach La Costera. August 9, 1986. 6 males, 11 females and 24 juveniles. Spain, Soller (West Mallorca). A population from the spring of the source Font d'es Joncar. April, 4, 1985 and July 10, 1986.

Description of specimens studied

Male. First antenna (Fig. 1 D) with short setae on the ventral margin of peduncle segments 2 and 3, slightly shorter than diameter of the segment, although longer than in *R. karamani* Stock, 1971. The Spanish specimens lack aesthetascs on the flagellum. The accesory flagellum has up to 3 segments almost reaching the third flagellum segment. Peduncle segmentes 4 and 5 of the second antenna (Fig. 1 E) 3.8 and 4.2 as long as wide respectively. Both segments have ventrally 4 groups of setae longer than the diameter of the peduncle segments, and separated by short intervals (c. diameter of segment). Setae on 4th segment longer as in 5th. Flagellum bears setae that are much longer than the diameter of the flagellar articles.

1st uropod shorter than 2nd. Exopodite of the first uropod shorter than endopodite; ratio exo-endopdite about 0.6. The long terminal spine of the endopodite about 1/2 as long as the endopodite itself (Fig. 2 B). Second uropod armed with both endo- and exopodite equal in length. Outher ramus of third uropod has an elongated first exopodal segment armed with groups of short spines on lateral and medial margins. In each group, usually numerous setae are intermixed with the spines. A/B ratio 2.2 (see Stock 1971 and Fig. 2 E). Second exopodal segment tapering and distally armed with setae shorter than the segment.

Cephalic lobes rounded. Eye spot oval, ocelli pigmented (Fig. 2 F). The armature of urosome (Fig. 2 B) consists, on somite 1, both on dorsally and laterally, of a group with 1 spine and 1 setae, on somite 2 of two dorsal spines and on somite 3, both dorsally and laterally, of one group of 1 spine.

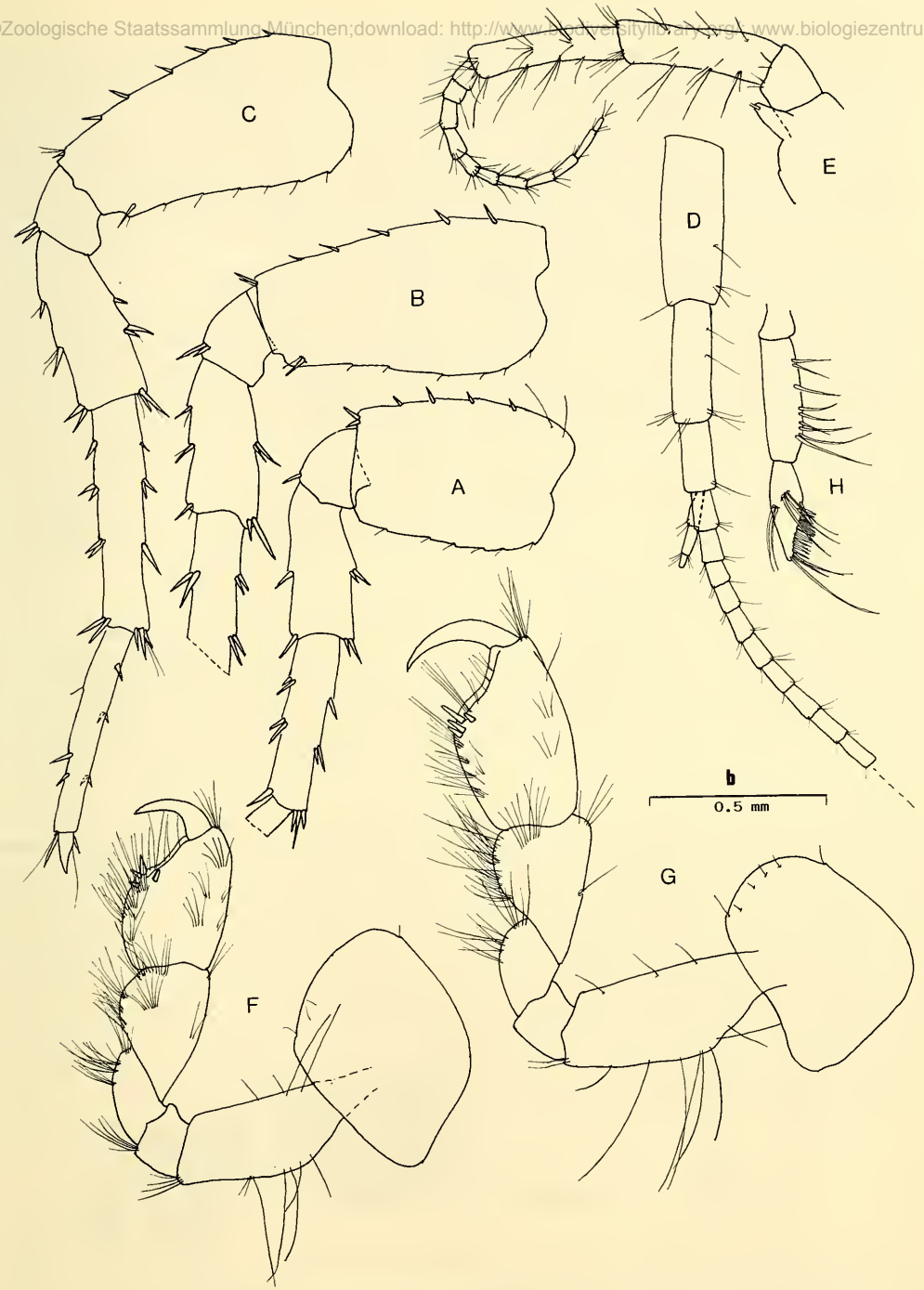

Fig. 1. *Rhipidogammarus rhipidophorus* (Catta, 1878) from Font des Joncar, Mallorca. Male. A. Pereiopod 5 (scale b); B. Pereiopod 6 (b); C. Pereiopod 7 (b); D. Antenna 1 (b); E. Antenna 2 (b); F. Gnathopod 1 (b); G. Gnathopod 2 (b); H. Mandible palp (a).

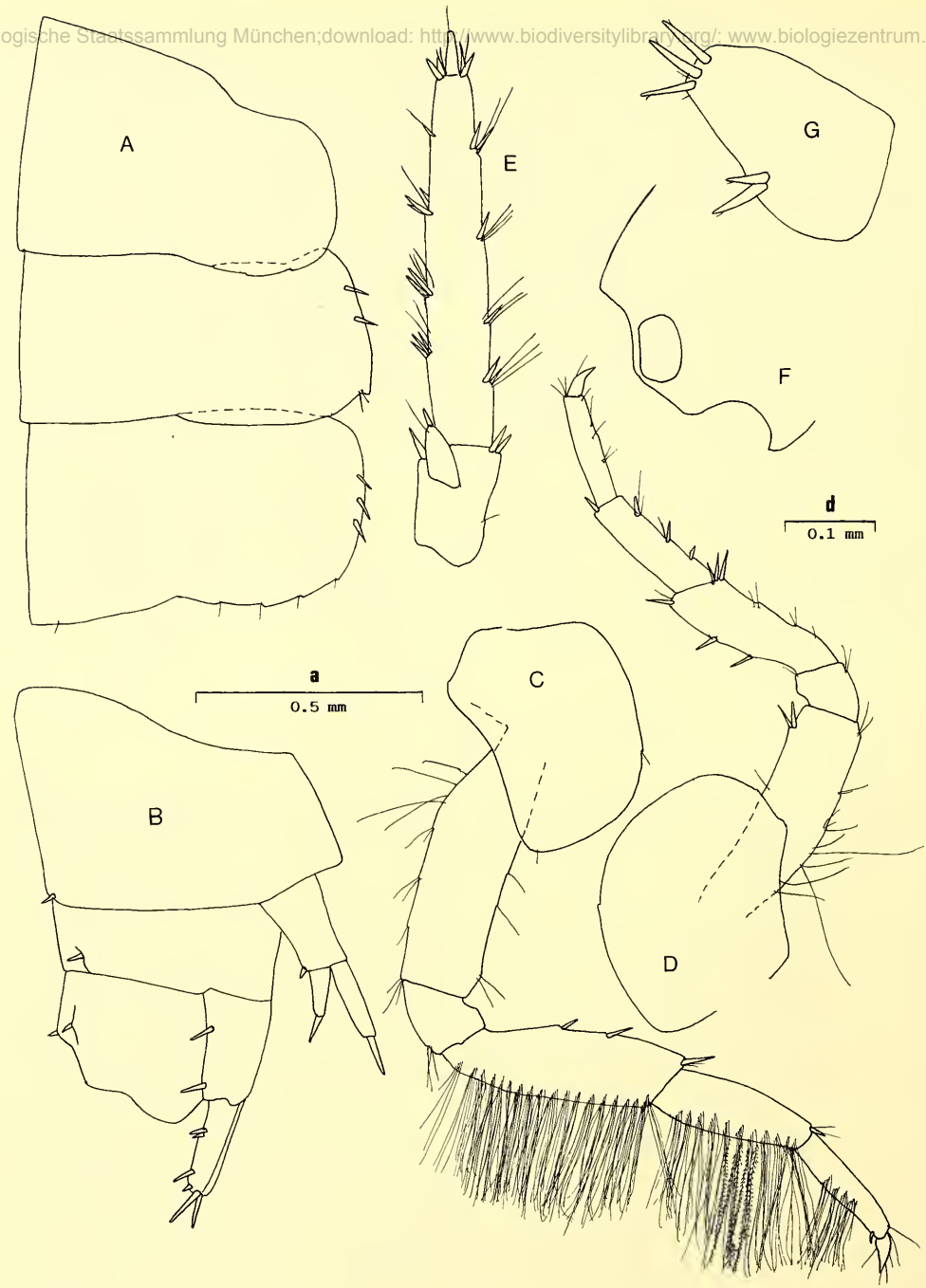

Fig. 2. *Rhipidogammarus rhipidophorus* (Catta, 1878) from Font des Joncar, Mallorca. Male. A. Metasome (scale b); B. Urosome (b); C. Pereiopod 3 with the plumosities only partially represented (b); D. Pereiopod 4 (b); E. Uropod 3 (b); F. Head (b); G. Telson lobe (d).

First gnathopod (Fig. 1F) 6.0 times as long as wide. It has a moderate number of setae on posterior margin of propodus, the palme is concave with a markedly notch in middle and lacks a medial palmar spine. The palmar angle group has 4 spines. Second gnathopod (Fig. 1G) a little stronger than first, propodus more rectangular. This segment bears 4 rows of setae on its posterior margin. The palme is concave and has a palmar group with 4 spines. It lacks a medial palmar spine.

Third pereiopod (Fig. 2C) with very long plumose setae. The posterior margin of merus and propodus armed with 14–15 and 9 rows of long plumose setae respectively. Fourth pereiopod with the margins of basis bearing setae, some of them longer (Fig. 2D). Coxal plates 1 to 4 very poorly setose (Figs 1F, G and 2C, D).

5th pereiopod with an elongated basis (length/wide = 1.4); anterior margin convex, armed with 5 small spines. Posterior margin straight with very short setules. Ventroposterior corner produced in a rounded unarmed lobe (Fig 1A). The 6th pereiopod also slender; anterior margin concave with 7 short spines. Non protrunding posterior corner with a spine placed at some distance from the corner. Posterior margin with very short setae (Fig. 1B). The 7th pereiopod with a convex anterior margin of basis armed with 6. small spines; posterior margin with 7 very short setae; ventroposterior corner with 1 spine and 2 setae (Fig. 1C).

Epimeral plates with angular posterior corners. Second epimeral plate with a somewhat acute corner (in difference with the usually rounded feature found in this species). Ventral margin of plates 2 and 3 armed with 2 and 4 spines respectively (Fig. 2A).

Telson lobes armed with 2 lateral and 3 terminal spines accompanyed by two extremelly short setae (Fig. 2G).

Female. It shows little secondary sexual differentiation. It is slightly smaller than the male. Propudus of the first and second gnathopods with a straight palm. Second gnathopod slightly more elongate and more rectangular than first gnathopod. The "fan" of setae on the propodus of the male third pereiopod is lacking. The females of the populations studied present variability in the presence or absence of numerous fans of setae along the ventral margin of the carpus.

Remarks

The specimens studied show clear differences respect to the most commonly "form" found in the Mediterranean sea coast (Stock 1971). The cephalic lobes are more rectangular, whereas they are rounded in most of populations. The third uropod is a little more slender and thin; the ratio between length/wide being 6.2 in the studied populations whereas it is near 6 in the other populations. The P5 presents two long setae on the proximal part of the anterior margin of the basis, which are lacking in other populations. Peduncle segments 2 and 3 of A1 with setae shorter than in other mediterranean populations. The flagellum lacks the characteristic aesthetascs. The accesory flagellum of this antenna has usually 3 segments. The A2 has a little longer setae on the posterior margin of the fourth segment. Second epimeral plate with a clearly pointed posterior corner, whereas it is rounded in other populations. The variability is also found in females in the setation of the P3. Like the observed by Stock (1971), one can find side by side females from the same population having setae on merus only and females having setae on merus and carpus.

Echinogammarus foxi Schellemberg, 1928

Material examined. Many hundred of specimens. Spain, Alicante, Elche, Vinalopó River, just downstream of the Elche reservoir. July 18, 1987.

Description of specimens studied

Male. In this population the specimens are large, and may attain 10 mm. Eye enlarged, slightly reniform. Cephalic lobes slightly acute (Fig. 4F). First urosome segment dorsally slightly excavated (the

Fig. 3. *Echinogammarus foxi* (Schellemberg, 1928) from Vinalopó River, Alicante. Male. A. Antenna 1 (scale c); B. Antenna 2 (c); C. Pereiopod 5 (c); D. Pereiopod 6 (c); E. Pereiopod 7 (c); F. Pereiopod 3 (c); G. Pereiopod 4 (c); H. Gnathopod 1 (a); I. Gnathopod 2 (a); J. Mandible palp (a); K. Uropod 3 with the plumosities only partially represented (c).

shaddle is indistinct). Other urosome segments with inconspicuous non compressed dorsal elevations. Very few setae accompany the dorsal urosome spines. First segment with one dorsal and one lateral spines. Second segment with two dorsal and 2–3 lateral spines. Third segment with one dorsal and 2–3 lateral spines (Fig. 4 C).

Peduncle segments of the first antenna (Fig. 3 A) carry several tufts of setae (2–3 in each segment). Second antenna with a slender peduncle (more densely hairy than in *E. pungens* [H. Milne-Edwards, 1840]) with densely implanted setae along both anterior and posterior margins of peduncle segments and on the former flagellar segments. Calceoli present in segments 2 to 6 of the flagellum. Anterior setae almost as long as the posterior ones. Setae implanted on A 2 are not feathered (Fig. 3 B).

The distal segment of mandible palp bears a regular "comb" of setae (Fig. 3 J).

First gnathopod (Fig. 3 H) with a group of two small lateral spines and two palmar angle spines, one of them longer and pointed. Medial palmar spine trunked. Second gnathopod (Fig. 3 I) a little more strongly developed, with 3 lateral spines and 3 palmar angle spines. Medial palmar spine trunked.

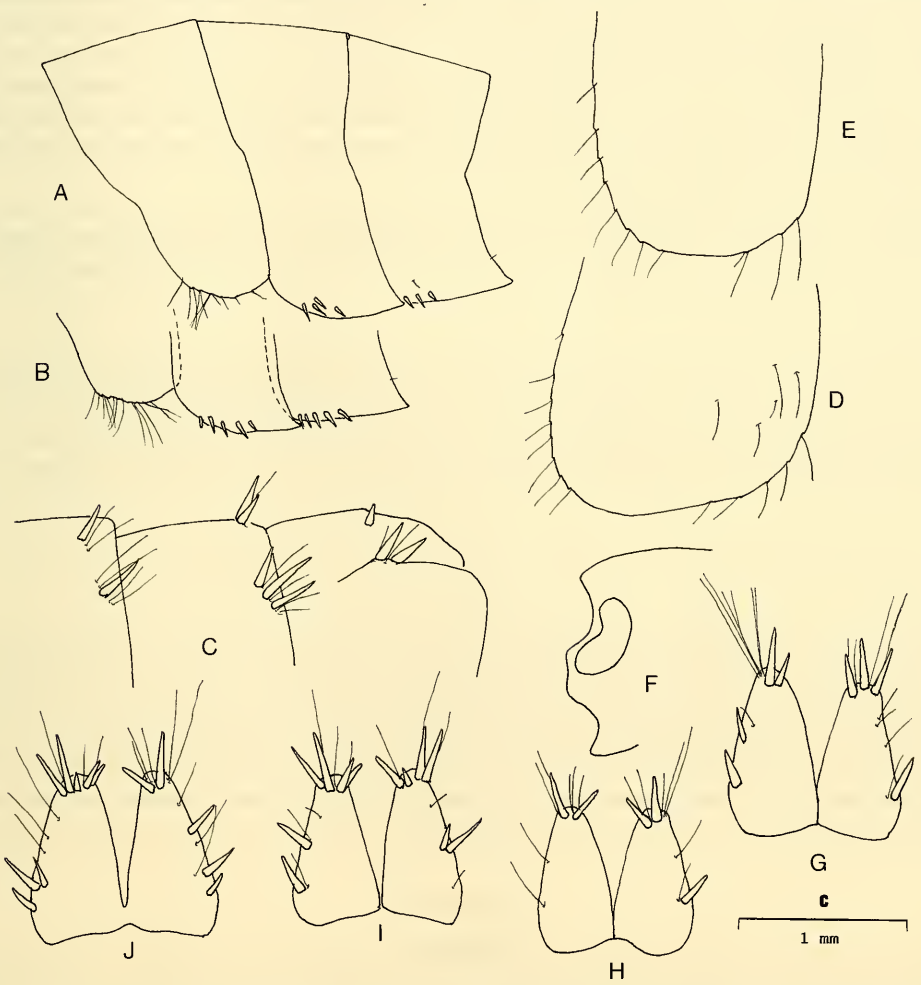

Fig. 4. *Echinogammarus foxi* (Schellemberg, 1928) from Vinalopó River, Alicante. Male. A Metasome (scale c); B. Epimeral plates from other specimen (c); C. Dorsal urosome (b); D. Coxal plate of first gnathopod (b); E. Coxal plate of second gnathopod (b); F. Head (b); G.-J. Telson lobes from different specimens (b).

Coxal plates 1 and 2 (Figs 4 D, E) with some long setae implanted on the anterior and posterior corners. Ventral margin relatively smooth. Coxal plate 2 with several long setae on the lateral surface. Coxal plate 3 and 4 with shorter setae (Figs 3 F, G).

Basis of P3 and P4 with individual long setae on both margins (Fig. 3 G). Posterior margin of merus and carpus of P3 with long setae longer than the segments on which they are implanted (Fig. 3 F). P4 with scarce and short setae.

Pereiopods P5 to P7 with groups of 3–4 setae on the propodus twice longer than the accompanying spines, the terminal group being denser. Some long setae implanted along the proximal part of the anterior margin of basis of these legs. Pereiopod 5 (Fig 3 C) is characteristic in so far that has a peculiar broadly rounded infero-posterior corner which pojects backward. Its anterior margin with spines and very short setules. The proximal setae are however longer than in other populations. Merus is short and wide with a projecting infero-posterior lobe. This leg bears very few and short setae. 6th and 7th legs (Figs 3 D, E) less hairy than *E. veneris* and *E. pungens*. Only some setae occur on the anterior margin of merus and carpus. Basal segment with short, rather widely spaced setules on the posterior margin. Anterior margin with some long proximal setae. P7 with a group of 5–6 long proximal setae implanted on the lateral surface of the basis.

Epimeral plates (Figs 4 A, B) with slightly pointed posterior corners, mainly in the third plate. First plate with long setae on the inferior margin. Second and third plates armed with four or five spines.

Third uropod with long plumose setae. Inner ramus shorter than the one described by Stock (1971). Outer ramus more slender and elongated (Fig. 3 K).

Telson lobes elongated. Apical armature more or less constant with 2–4 spines and some setae overreaching the spines. The armature of the lateral surface is variable, however, in number and position of spines. These spines may be medial, sub-basal and basal. The figures 4 G–J show differents armatures found in the population studied.

Remarks

Some of the "typical" characters of *E. foxi* remain constant in this population (viz. dorsal elevations of urososme not compressed, basis of P5 with large postero-distal lobes, paucity of setation on legs P5 to P7 and on the urosome). Nevertheless, the population of *E. foxi* from the river Vinalopó present variability in some characters previously known as variable, in general, for the species of the *pungens*-group (Stock 1968). This is observed in the shape of the epimeral plate corners and the armature of the telson. Furthermore, the specimens present morphological differentiation in other characters previously considered constant for this species. They are hence clearly different from the specimens redescribed by Stock (1968) in the following aspects: the presence of trunked medial palmar spines on both gnathopods; the armature of the epimeral plates 2 and 3, bearing spines wilst there are only found setae in the other populations; the presence of long setae on both corners as well as on the lateral side of the coxal plates 1 and 2 (these are very smooth in other populations); presence of plumose setae on Ur3; the setation on P5 to P7 (basis with some long setae in its anterior proximal part, propodus with 2–4 groups of few longer setae, lateral surface of P7 with a group of long setae implanted in its proximal part); the peduncle segments of the first antenna has less groups of setae, 2–3 in each segment, whereas there are 4–5 in other populations; the anterior setae of antenna 2 are almost as long as the posterior ones; the setae implanted on this antenna are not feathered. The setae on P3 are longer.

Discussion

Although a clear morphological differentiation has been found in the present population of *R. rhipidophorus*, it must be admitted that the variation found in some of the discriminant characters within the genus (viz. setation of the antennae, gnathopods, shape and setation of P5 to P7 and uropod 3) is

scarce. Therefore, we consider the specimens studied as mere morphological varieties or ecophenotypes spread over a very limited area.

The specimens of the river Vinalopó present clear differences from the redescription of *E. foxi* given by Stock (1968). He characterized this species by the following aspects: Basis of P5 with a large postero-distal lobe, merus of P5 broad and short, poor setation on the legs and urosome, absence of compressed elevations on the urosome and the smooth lower margin of the coxal plates. Stock (1968) also pointed that this is a very variable species and considered that the differences among the populations of this species are correlated in a rather loose way with their distribution. He distinguished, on one hand, a "normal form" living in inland waters and, on the other, the "form" of the open Black Sea. The latter is characterized by larger size specimens without calceoli, with a setose third uropod and presence of plumose setae on the appendages. But, as "normal" specimens occur as well on the Black Sea populations, and every possible combination of characters can be found as well in at least some individuals, he considered all these forms to belong to the same species.

The populations of the river Vinalopó resembles in more than one aspect to the Black Sea specimens. Nevertheless, the presence of calceoli and the scarcity of plumose setae on A2 make these specimens appear to be an intermediate "form". Some of the "typical" characters of *E. foxi* remain constant in the Spanish population. Nevertheless, the specimens present differentiation in some of the characters usually considered to be the most characteristic features of the *pungens*-group species. Thus, the specimens from the Vinalopó result difficult to identify, not only because of the previously mentioned variability found in *E. foxi,* but because this variability is also boserved in some of the characters, such as the setation on the coxal plates 1 and 2, the presence of setae on the epimeral plates and on the basis of P5 to P7, usually employed for its identification in the keys for the *pungens*-group, (Stock 1968 in part); Karaman 1973, 1974).

The wide variability found in this species lead Stock (1968) to think that it migth be advisable in the future to delimit subspecies. Consistentely, as a substantial amount of differentiation is found in this population, the possibility that these specimens belongs to a new taxon would be considered as well.

Nevertheless, the analysis of characters within the *pungens*-group is, at this moment, very difficult since recent studies (Pinkster in press) have shown that some diagnostic characters may present also a seasonal variability. Thereby, the taxonomical importance of the differences observed in the Iberian populations of *E. foxi* is uncertain for the moment until more populations of this form will be discovered.

Resumen

El estudio en nuevas localidades españolas de dos especies circunmediterráneas de gamáridos de aguas salobres ha mostrado que los ejemplares presentan unas características morfológicas particulares en determinados segmentos y apéndices. Los ejemplares de la población de *Rhipidogammarus rhipidophorus* (Catta) presentan diferenciación en algunos caracteres considerados no discriminantes para las especies dentro del género. En cambio, *Echinogammarus foxi* (Schellemberg), citada por primera vez para la Península Ibérica, presenta diferenciación en algunos caracteres discriminantes empleados en las claves de determinacion de las especies del grupo de *E. pungens,* al cual pertenece. Aunque la diferenciación es clara, ésta debe ser confirmada en un futuro mediante el análisis de mas poblaciones.

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