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Rhopalophthalmus tartessicus sp. nov. (Crustacea: Mysidacea), a new mysid species from the Guadalquivir estuary (SW Spain)

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Abstract

The first representative of the genus *Rhopalophthalmus* in European waters, *Rhopalophthalmus tartessicus* sp. nov., is described from specimens sampled in the Guadalquivir estuary (southwestern Spain). At first identified as the Algerian species *Rhopalophthalmus mediterraneus* Nouvel, 1960, the new mysid species can be distinguished from its closest relative by its higher number of articles on the carpopropodus of the third to seventh thoracic endopods, by the well hook-shaped eighth thoracic endopod of the male, by the slender eighth thoracic endopod of the female, and by the smaller antennal scale and telson. Its geographical distribution appears restricted to estuarine habitats in southwestern Spain. Its swimming behaviour, with the ventral side facing upwards, is unusual in mysids. An updated identification key for the 19 known species in the genus, including information on the respective geographical distribution and habitat, is presented.

Keywords: Mysidacea; *Rhopalophthalmus tartessicus* sp. nov.; Guadalquivir estuary; Swimming behaviour; Identification key

Introduction

Rhopalophthalmus, the only genus in the subfamily Rhopalophthalminae Hansen, 1910, was established by Illig (1906) for the type species, *Rhopalophthalmus flagellipes*. Later on, the subfamily was revised mainly by Tattersall (1957). So far, 18 species have been described, plus a probable new species (Grabe et al. 2004) from the Arabian Gulf (Kuwait, Bahrain), all listed in Table 1.

As shown in Fig. 1, the geographical distribution of the genus includes the Indo-Pacific coasts, the south, west and north Atlantic coasts of Africa, and the south Atlantic coast of Spain. *Rhopalophthalmus* has not been mentioned from the American continent. In the northern hemisphere, its northernmost limits are southern Spain in the Atlantic (the new species described herein) and northern Japan in the Pacific (*R. longipes*). In the southern hemisphere, its southernmost limits are southern Africa in the Atlantic (*R. terranatalis*) and southern Australia in the Pacific (*R. dakini*). Thus, the genus shows a predominantly tropical distribution between 36°N and 35°S.

Little ecological information is available for most *Rhopalophthalmus* species, usually only brief remarks included in the respective original description. All known species have been sampled in estuarine, brackish

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Table 1. List of known *Rhopalophthalmus* species, excluding the new species described herein, indicating description references and geographic locations

Species	Reference	Geographic location
R. africana	Tattersall (1957)	Sierra Leone, Ivory Coast
R. brisbanensis	Hodge (1963a)	West Australia
R. chilkensis	Tattersall (1957)	West India
R. constrictus	Panampunnayil (1992)	East Australia
R. dakini	Tattersall (1957)	South-western Australia
R. egregius	Hansen (1910)	Southern Japan
R. flagellipes	Illig (1906)	Cameroon, Congo
R. indicus	Pillai (1961)	South-eastern India
R. kempi	Tattersall (1957)	East India
R. longicauda	Tattersall (1957)	Sierra Leone
R. longipes	Ii (1964)	Japan
R. macropsis	Pillai (1964)	South-western India
R. mediterraneus	Nouvel (1960)	Algeria
R. orientalis	Tattersall (1957)	South Japan
R. phyllodus	Murano (1986)	Thailand
R. tattersallae	Pillai (1961)	South India
R. terranatalis	Tattersall (1957)	South-eastern South Africa
R. tropicalis	Wooldridge and Mees (2003)	Mozambique
R. sp. nov.	Grabe et al. (2004); misidentified as *R. tattersallae* by Grabe (1989)	Bahrain, Persian Gulf

or coastal waters and reported as gregarious and euryhaline mysids. Only five species are well-studied with respect to their biology and ecology: *R. terranatalis* from the Sunday estuary, South Africa (Wooldridge and Bailey 1982; Wooldridge and Webb 1986; Jerling and Wooldridge 1994); *R. brisbanensis* from the Brisbane River, Australia (Hodge 1963 a, b); *Rhopalophthalmus* n. sp. from Kuwait and Bahrain (Grabe 1989; Grabe et al. 2004); and a species at the time recorded as *R. mediterraneus* from the Guadalquivir estuary, south-western Spain (Baldó et al. 2001).

Rhopalophthalmus mediterraneus Nouvel, 1960 was primarily described from three damaged specimens sampled within the bay of Algiers: one mature male (holotype) and one mature female at the mouth of the Harrach River (3.3–6.6 m water depth; muddy sand bottom with plant detritus), and an immature female on muddy bottoms. These specimens (holotype and paratypes) were apparently not deposited in a museum collection and therefore are probably lost (J.P. Lagardère, pers. comm., 2006). No other material of this species is available for examination, neither in institutional collections nor in local collections of Algerian universities (M. Khelifi, pers. comm., 2006).

During recent ecological investigations in the tidal channels of the bay of Cádiz (Drake et al. 1997) and in the Guadalquivir estuary (Drake et al. 2002), *Rhopalophthalmus* specimens sampled in these estuarine habitats were first assigned to *R. mediterraneus* (see Cuesta et al. 1996; Baldó et al. 2001; Baldó and Drake 2000, 2002) due to their morphological resemblance to that Algerian species. However, a recent re-examination of specimens from the Guadalquivir estuary revealed some morphological differences, leading to the conclusion that they actually belong to a species new to science. The present paper deals with the detailed description of this new species, mainly focusing on the morphological characters described by Nouvel (1960) for *R. mediterraneus* (antennal scale, carpopropodus of thoracic endopods, telson), and gives additional information on its ecology and behaviour. An updated identification key to all the known *Rhopalophthalmus* species is also given.

Material and methods

Sampling

The mysids examined in this study were collected on the left bank of the Guadalquivir estuary (3–5 m water depth), at a sampling station located 8 km from its mouth. Collections were made with a plankton net with 250 μm mesh size. Specimens used for morphological descriptions were preserved in 10% formaldehyde before examination. Other specimens used for behavioural studies were kept alive in aquaria with in situ water (salinity range between 20‰ and 25‰), at 20 °C (the annual mean temperature at the Guadalquivir sampling site).

Laboratory procedures

After sorting, individuals were sexed and categorised into the following five demographic stages: juvenile = without secondary sexual characteristics; sub-adult female = with developing oostegites at the bases of the three posterior thoracopods, with poorly developed and uniramous pleopods; adult female = with a well-developed marsupium; sub-adult male = with developing biramous pleopods; adult male = with basal part of antennular outer flagellum swollen and hirsute.

Morphological observations and drawings were made with a binocular microscope (Wild M5) and a dissecting

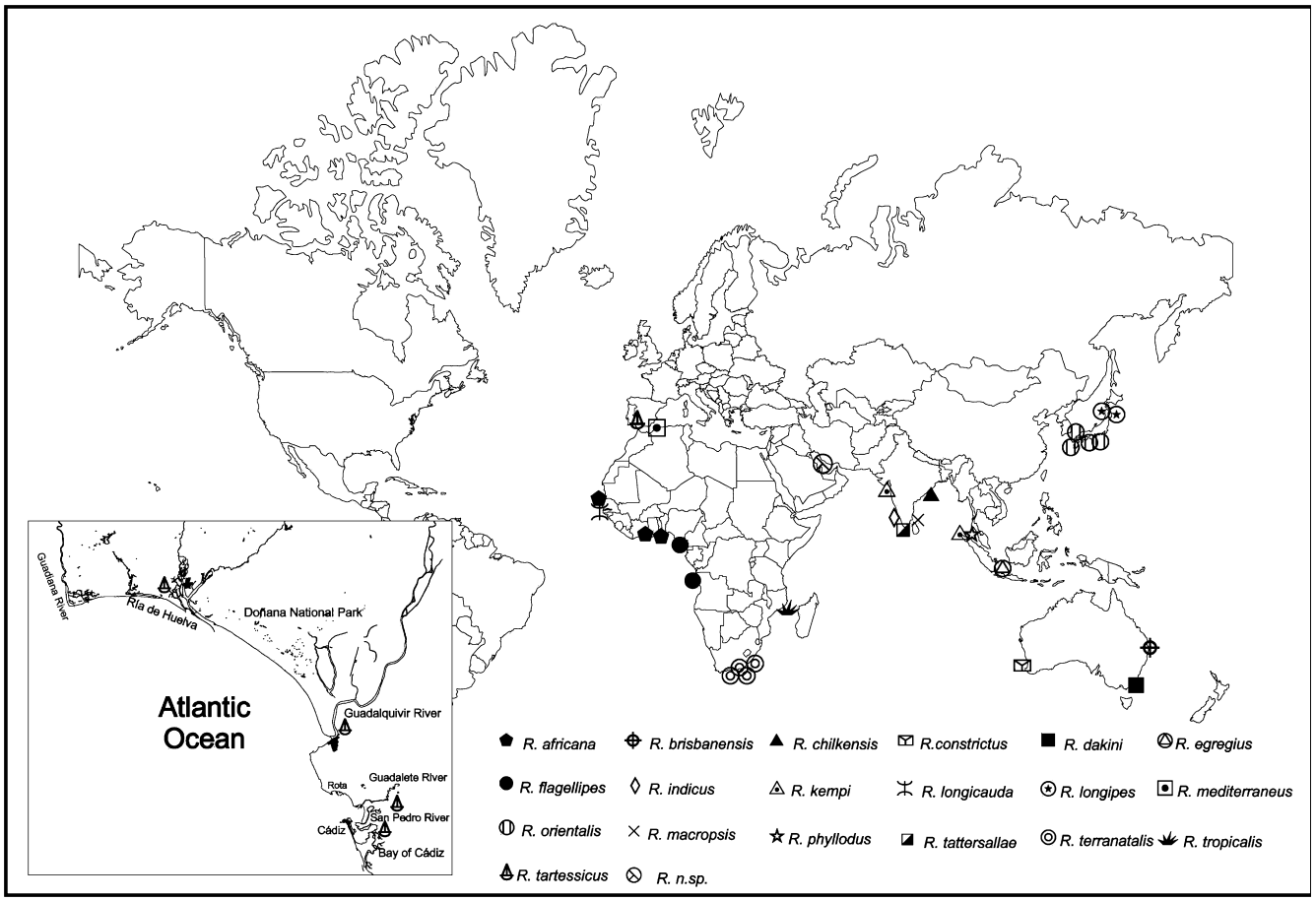

Fig. 1. Geographical distribution of the genus *Rhopalophthalmus* Illig, 1906, including the new species *R. tartessicus* from SW Spain (see also inset).

microscope (Nikon Eclipse E400). Biometrics were measured to the nearest 0.04 or 0.02 mm using a micrometer eyepiece. Carapace length (CL) was determined in lateral view from the tip of the rostrum to its posterior mediodorsal margin. Total body length (TL) was measured in lateral view from the tip of the rostrum to the posterior end of the telson excluding setae. Maximum lengths (*L*) and maximum widths (*W*) of antennal scale and telson were also measured. From the eighth thoracopods, the following measurements were taken: for males (see Fig. 5A), maximum length (*L*) of exopod basal article and length (*l*) of endopod distal part (between apex and elbow); for females (see Fig. 5C), maximum length (Li) of endopod and length (li) of inner margin of exopod basal article. Beside measurements, photos were also taken with a microscope fitted with a camera (software: Nikon ACT-1) to study the development of the eighth thoracic endopod across a wide range of individual body sizes. Morphological comparisons with other *Rhopalophthalmus* species were carried out from original data, when available, or from measurements realised on published figures with appropriate scale bars. Allometric relationships between body dimensions were computed using a geometric mean regression according to Ricker (1973). Significance of fitted models indicated with asterisks (*** = $p<0.001$).

In our opinion, there is some confusion in the literature with respect to segmentation and joint nomenclature of thoracic endopods (Th) in *Rhopalophthalmus* species. In the case of *R. mediterraneus*, besides the implicitly recognised absence of a dactylus in the third to seventh thoracic endopods, Nouvel (1960) mentioned the presence of a carpopropodus distal to the 'knee' (i.e. articulation between merus and carpopropodus) on which the number of articles varies with thoracic limb number (six articles in Th3–Th6, six or seven articles in Th7, adult male and female). We agree with such a morphological interpretation of thoracic endopods (Th3–Th7) in *Rhopalophthalmus* species, evidenced by the underlying musculature disposition that allows the whole carpopropodus to be moved with regard to the merus (see also Nouvel et al. 1999).

Furthermore, in *R. tartessicus* sp. nov. as well as probably in other species of this genus (see also Nouvel 1960), the separation between the carpopropodus articles of thoracic endopods is not well marked, and therefore it is difficult to count them accurately without limb treatment.

To resolve such a problem, individuals were first processed with a solution of sodium hypochlorite for 10–15 min before article-counting under the microscope.

Finally, in order to compare thoracopod morphology in the literature across all known *Rhopalophthalmus* species, it was considered that all articles distal to the knee actually belong to a carpopropodus (without dactylus), and therefore these were counted as well, regardless of what had been recorded in the respective original description.

Systematics

Order MYSIDA Haworth, 1825
Family MYSIDAE Haworth, 1825
Subfamily RHOPALOPHTHALMINAE Hansen, 1910
Genus *Rhopalophthalmus* Illig, 1906

Rhopalophthalmus tartessicus sp. nov.

(Figs. 2–7)

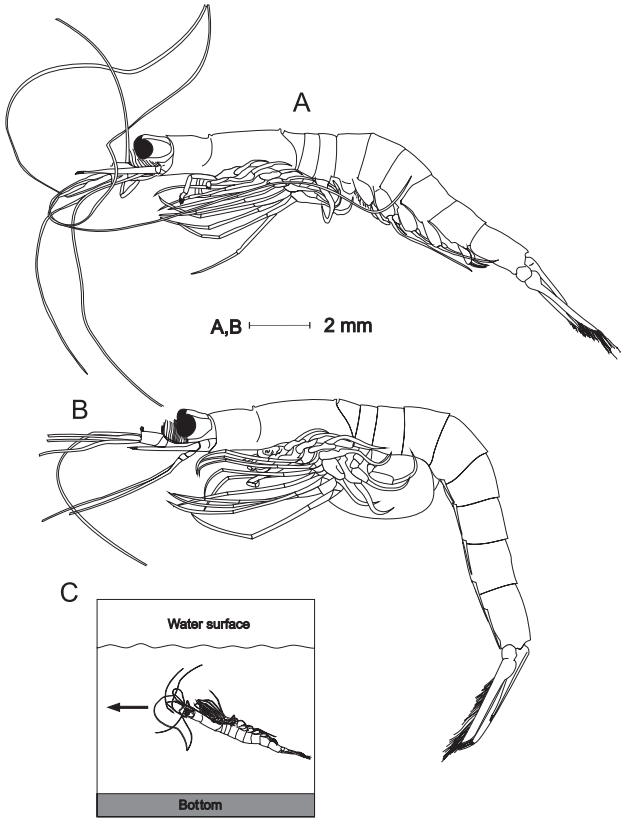

Fig. 2. *Rhopalophthalmus tartessicus* sp. nov.: (A) holotype (MNCN 20.04/5917), adult male in lateral view; (B) paratype (MNCN 20.04/5920), adult female in lateral view; and (C) swimming behaviour.

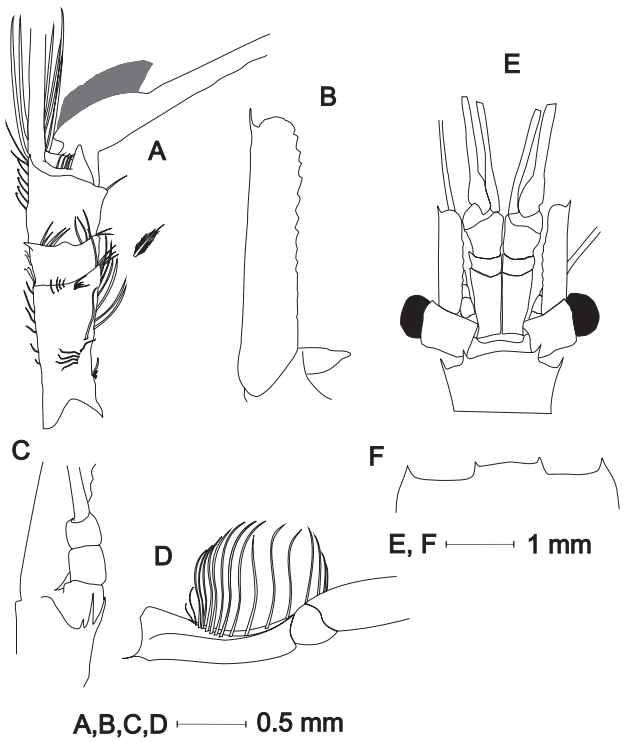

Fig. 3. *Rhopalophthalmus tartessicus* sp. nov.: (A, B, C, F) adult male paratype (MNCN 20.04/5918); (D) adult female paratype (MNCN 20.04/5919); (E) adult male holotype (MNCN 20.04/5917). (A) Antennule of adult male, (B) antennal scale of adult male, (C) distal margin of antennal sympod of adult male, (D) lateral view of antennule of adult female, (E) head of adult male in dorsal view and detail of carapace anterior margin, and (F) flattened carapace in dorsal view.

Etymology

The new species is dedicated to Tartessos, a great civilisation which lived in areas around the Guadalquivir River (Andalucia, Spain), between the 12th and the 5th century BC. The species epithet is to be treated as adjectival.

Material examined

Holotype: adult male, 3.7 mm CL [MNCN 20.04/5917]; Guadalquivir estuary, Bonanza station, 36°51′12″N, 06°21′03″W, 3–5 m water depth, muddy bottom, subsurface sampling (1 m depth) with plankton net; collected by C. Vilas-Fernández, October 9, 2002.

Paratypes: adult male, 4.1 mm CL, specimen completely dissected [MNCN 20.04/5918]; other data as for holotype. Adult female, 4.1 mm CL [MNCN 20.04/5919]; other data as for holotype. Adult female, 4.2 mm CL [MNCN 20.04/5920]; other data as for holotype, except coll. May 15, 2003.

Additional material: six adult males, nine adult females [MNCN 20.04/5921]; other data as for holotype. Three immature males, one immature female and four

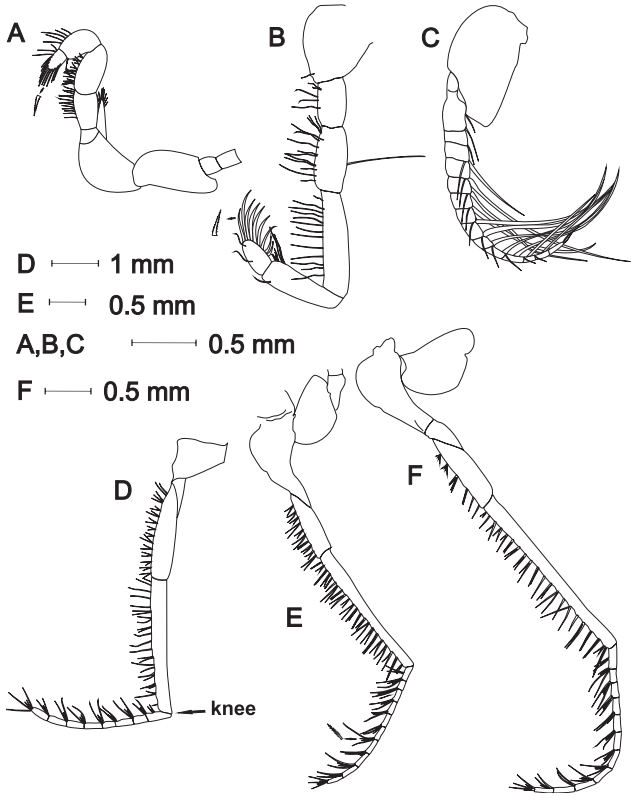

Fig. 4. *Rhopalophthalmus tartessicus* sp. nov.: adult male paratype (MNCN 20.04/5919), endopods and an exopod of thoracic limbs. (A) Endopod (Th 1), (B) endopod (Th 2), (C) exopod (Th 7), (D) endopod (Th 3), (E) endopod (Th5), and (F) endopod (Th7).

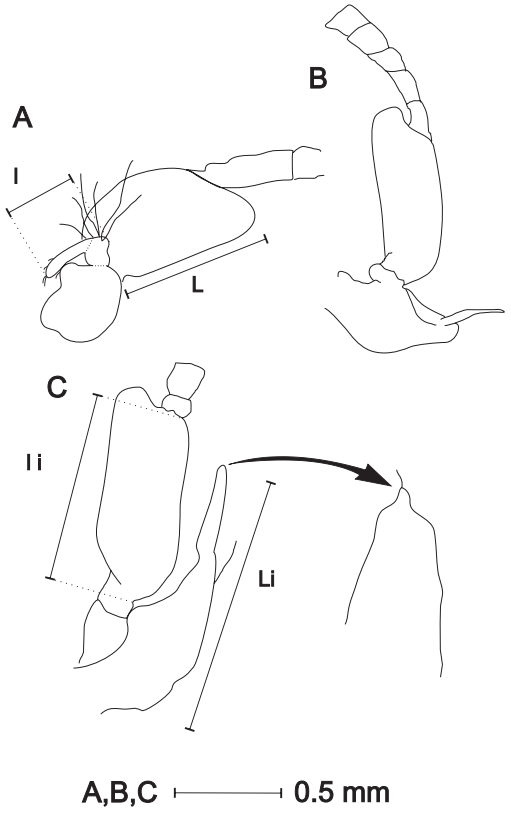

Fig. 5. *Rhopalophthalmus tartessicus* sp. nov., endopod and exopod (proximal part) of eighth thoracic limb. (A) Adult male paratype (MNCN 20.04/5918), (B) adult female paratype (MNCN 20.04/5919), (C) adult female paratype (MNCN 20.04/5920). L = maximum length of exopod basal article, l = maximum length of endopod distal part; Li = maximum length of endopod, li = length of inner margin of exopod basal article.

juveniles [MNCN 20.04/5922]; other data as for holotype, except coll. August 22, 2001.

Diagnosis

Carapace with two dorsal median nodules. Eyes not extending beyond distal margin of second article of antennular peduncle. Antennal scale 4.4–5.0 times as long as broad and slightly longer than antennular peduncle. Antennal sympod armed with two long and equal inner teeth and a shorter ventral one. Carpopropodus of seventh thoracic endopod with 9–11 articles. Apical spines of telson armed with non-flattened spinules.

Description

Adult male

Carapace short posteriorly, exposing the last three thoracic somites. Two small median dorsal nodules: first one immediately posterior to cervical sulcus, second one in middle of posterior margin of carapace (Fig. 2). Carapace tegument rough, due to presence of minuscule scattered scales. Anterior margin slightly convex between the two post-orbital teeth, without trace of rostral projection. Post-orbital teeth very well marked. Antero-lateral angles pointed, sharper than post-orbital teeth, but not extending beyond them. 'Cheeks' straight (Fig. 3E and F).

First article of antennular peduncle slightly longer than or equal to combined length of following two articles; more robust in males than in females. Outer margin bearing seven (one bigger than others) short plumose setae about one-fourth along distal length, distal angle armed with three short plumose setae. Dorsal surface with large depression (Fig. 3D) directly beneath eye, fringed with 13 long curved setae along outer rim and with six shorter setae along inner edge. Second article short, with plumose setae at both distal angles. Inner distal margin armed with one robust tooth. Inner margin bearing two coiled, non-plumose setae midway along margin and one longer plumose seta. Distal margin bearing seven plumose setae, slightly projecting forward in middle. Third article about as long as broad, with seven long plumose setae on inner distal angle and seven shorter setae along distal half of inner margin. One seta on outer distal angle. Basal part of outer flagellum hirsute (Fig. 3A).

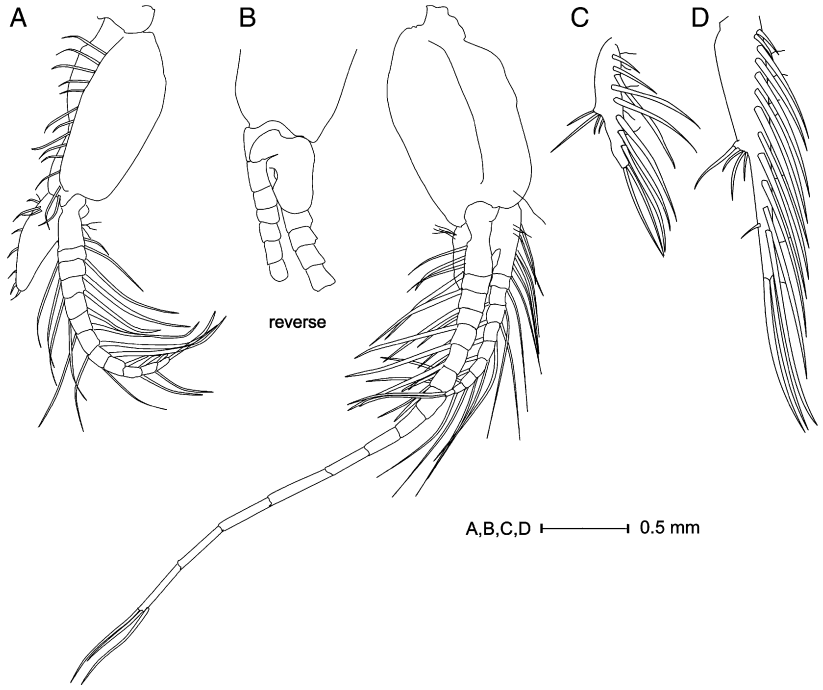

Fig. 6. *Rhopalophthalmus tartessicus* sp. nov.: (A, B) adult male paratype (MNCN 20.04/5918); (C, D) adult female paratype (MNCN 20.04/5919). (A) Male first pleopod, (B) male second pleopod (anterior and posterior side), (C) female second pleopod, (D) female fifth pleopod.

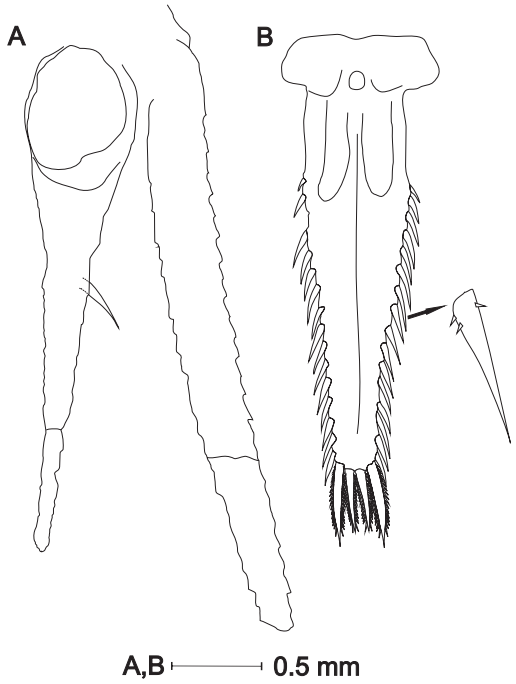

Fig. 7. *Rhopalophthalmus tartessicus* sp. nov., adult male paratype (MNCN 20.04/5918). (A) Uropod and (B) telson and ornamentation of lateral spines.

Antennal scale extending beyond antennular peduncle (Fig. 3E), five times as long as broad. Outer margin straight, naked and terminating in a sharp tooth extending beyond apex of scale. Internal margin parallel to outer margin almost along entire length, armed with 18–20 long plumose setae and five smaller distal setae (Fig. 3B). Apex rounded, with six setae. Inner distal angle of antennal sympod armed with two long, strong, equal, smooth teeth and a shorter more ventral tooth (Fig. 3C).

First thoracic endopod short, with a well-developed inner lobe, articles robust and densely setose (Fig. 4A). Endopod of second thoracic limb long and robust, the distal two articles armed with barbed spines; one long seta on lateral margin of third article (Fig. 4B). Endopods from third to seventh thoracic limbs increasing in length, carpopropodus with eight articles in third limb, nine articles in fourth limb, 10 articles in fifth and sixth limbs, and 11 in seventh limb. Segmentation not well-marked in preserved specimens. Four grouped distal setae on each article except the basal one, two inner setae smaller than outer ones, V-shaped; inner small setae with serration (Fig. 4D–F).

Eighth thoracic endopod reduced, hook-shaped and composed of three parts but considered as non-segmented (articulations not visible). First proximal part robust and bigger than the two others. Second part short, distally bearing six long setae. Third distal part half maximal length of exopod basal article ($L/l = 2.1$), apex conical and bearing four small setae (Fig. 5A).

Pleopods biramous (Fig. 6B). Endopod of first pair less than half length of exopod and reduced to a single

article, armed with seven setae along inner margin. Exopod with 12 articles armed with plumose setae. Sympod bearing row of 13 long and plumose setae along inner margin (Fig. 6A). Exopod of second pair with 15 articles, three times as long as endopod. Distal eight articles without marginal setae. Article length progressively increasing towards apex. Distal article bearing one strong barbed seta on inner margin, one smooth seta and one barbed seta at apex. Endopod with 10 articles and large pseudobranchial lobe. Third to fifth pleopods with 11 articles on exopod and endopod, both similar in length.

Uropod setose all around, both rami divided by transverse articulation, at about three-quarters and two-quarters length from base in endopod and exopod, respectively. Endopod distinctly tapered, armed with strong spine near midlength on inner margin, outer margin with short setae interspersed with longer setae in distal half. Exopod slightly longer than endopod, apex blunt (Fig. 7A).

Telson 2.7 times as long as basal width. Distal margins tapering towards blunt apex, armed with 16 lateral spines (one lateral spine broken on the left side). Distal pair of lateral spines more or less equal to preceding spines, except for the two shorter proximal ones. Distal 12 lateral spines with serrations. Apex armed with four long stout spines, the outer pair slightly longer than the inner pair. Apical spines barbed, bearing 16–18 teeth on each side, lateral teeth slightly increasing in length towards apex. Longer pair of spines one-fifth length of telson (Fig. 7B).

Adult female

Endopod of eighth thoracic limb tapered, 1.3 times as long as basal article of exopod, constricted at two-thirds length from its base (but without clear articulation), a single long seta at about midlength of inner margin, apex constricted, pointed and bearing a small seta (Fig. 5C). Distal part bent and crumpled in another specimen (Fig. 5B).

Pleopods small, in the form of single plates, increasing in size posteriorly. Sympod of first pleopod armed with seven long plumose setae along inner margin, three setae on outer margin, and two apical plumose setae. Second pleopod bearing eight long plumose setae on inner margin, four setae on outer margin, and two long setae at apex (Fig. 6C). Remaining pleopods similar in form to second pair, with 10 long plumose setae along inner margin in third and fourth pleopod, 12 long plumose setae and two proximal shorter ones along inner margin in fifth pleopod, four setae on outer margin in all of them (Fig. 6D).

Morphological variation

Total length/carapace length

The total body length TL (in mm) of individuals is significantly correlated with their carapace length CL (in mm) by the following equation (GM regression):

$$TL = 3.6781\ CL^{1.0837}\ (n = 101;\ r = 0.99^{***})$$

where the exponent is significantly higher than 1 ($t_{obs} = -11.0205$; df = 99; $p < 0.001$), thus indicating a slight positive allometric relationship between the two morphological dimensions during the growth of individuals.

Antennal scale

The ratio between scale length (L) and width (W) decreases during ontogenetic development of individuals: L/W is 5.4–6.3 for juveniles, 5.0–5.7 for sub-adults, 4.4–5.0 for adults (Table 2).

The scale length L (in mm) is significantly correlated with the total body length TL (in mm) of individuals by the following equation (GM regression):

$$L = 0.1753\ TL^{0.8636}\ (n = 33;\ r = 0.99^{***}),$$

where the exponent is significantly lower than 1 ($t_{obs} = 10.6636$; df = 31; $p < 0.001$).

Carpopropodus of thoracic endopods

In each specimen, the number of carpopropodus articles increases from the third to the seventh thoracopod. Furthermore, for each thoracic endopod, the number of carpopropodus articles increases during the ontogenic development of individuals (see Table 2), from one article in juveniles (Th3–Th7) to 11 articles in adults (Th6 and Th7).

Telson

As shown in Table 2, the number of lateral spines increases during the ontogenetic development of

Table 2. Change in morphological features of antennal scale, thoracic endopods (Th) and telson during post-marsupial development of the mysid *Rhopalophthalmus tartessicus* sp. nov. from the Guadalquivir estuary

Demographic stage	n	Antennal scale L/W	Carpopropodus, number of joints					Telson	
			Th3	Th4	Th5	Th6	Th7	Lat. spines	L/W
Juveniles (CL = 0.7–1.7)	8	5.4–6.3	1	1–2	1–2	1–3	1–3	6–10	2.6–3.0
Sub-adults (CL = 1.6–3)	8	5.0–5.7	3–5	3–6	4–6	4–6	4–7	11–16	2.6–3.0
Adults (CL = 2.6–4.6)	17	4.4–5.0	6–8	7–10	8–10	8–11	9–11	15–20	2.6–3.1

n = number of individuals examined; L/W = maximum length/maximum width; CL = range of carapace length in mm.

Table 3. Comparative morphological features of the mysid species *Rhopalopthalmus mediterraneus* from the Algerian coasts and *R. tartessicus* sp. nov. from the Guadalquivir estuary (adult specimens)

Character	*R. mediterraneus*	*R. tartessicus*
Antennal scale	5.25–5.5 times as long as broad	4.4–5.0 times as long as broad
Thoracic endopods: number of carpopropodus articles	(TL = 14 mm) Th3–Th6: 6, Th7: 7	(TL = 11–17 mm) Th3: 6–8, Th4: 7–10, Th5: 8–10, Th6: 9–10, Th7: 9–11
8th thoracic endopod	Male (TL = 14 mm): rudimentary, hook-shaped, much smaller than basal article of exopod, distal part inconspicuous; $L/l = 7$ Female (TL = 14 mm): rudimentary, conical stump shorter than basal article of exopod Li/li = 1.5	Male (TL = 9–17 mm): rudimentary, hook-shaped, smaller than basal article of exopod, distal part well developed; $L/l = 1.5$–3.1 Female (TL = 11–18 mm): rudimentary, more slender than in *R. mediterraneus*, more or less equal to inner margin of basal article of exopod Li/li = 0.8–1.3
Telson	3.5 times as long as broad	2.6–3.1 times as long as broad

L, l = maximum lengths of exopod basal article and endopod distal part (between apex and elbow), respectively, in male eighth thoracopod (see Fig. 5A); Li, li = maximum lengths of endopod and of inner margin of exopod basal article, respectively, in female eighth thoracopod (see Fig. 5C), TL = total body length, Th = thoracic endopod.

individuals, from a minimum of six spines in juveniles to a maximum of 20 spines in some adult specimens. The two longest apical spines are about 3.7–4.5 times shorter than telson length in juveniles and immature individuals, and 5.0–5.5 times shorter in adults. The ratio between telson length and width (maximum dimensions) is fairly constant during the growth of individuals (L/W range: 2.6–3.1). The telson length L (in mm) is significantly correlated with total body length TL (in mm) of individuals by the following equation (GM regression):

$$L = 0.1786\ \mathrm{TL}^{0.9217}\ (n = 33;\ r = 0.99^{***}),$$

where the exponent is significantly lower than 1 ($t_{obs} = 3.9119$; df = 31; $p < 0.001$).

Remarks

As mentioned above, *R. tartessicus* sp. nov. shows a close resemblance to *R. mediterraneus* from the Algerian coast. Unfortunately, the holotype and paratypes of the latter species are no longer available and attempts to get new specimens were unsuccessful. Therefore, morphological comparisons of the two species are limited to adult specimens and exclusively based on Nouvel's (1960) description.

As shown in Table 3, adult specimens from the Guadalquivir estuary can be distinguished from adult stages of *R mediterraneus* by several morphological features: distinctly lower length/width ratio of antennal scale, higher number of articles on the carpopropodus of thoracic endopods (mainly on the posterior ones), well hook-shaped eighth thoracic endopod in the male, more slender eighth thoracic endopod in the female (more or less equal to inner margin of exopod basal article), and distinctly lower length/width ratio of telson.

Ecological and biological comments

Rhopalophthalmus tartessicus sp. nov. is the sole representative of this genus in European waters and one of its northernmost representatives (see Fig. 1). Based on recent sampling carried out in suitable habitats on both the Atlantic and Mediterranean side of the Gibraltar Strait, the geographical distribution of *R. tartessicus* sp. nov. appears restricted to estuarine waters of southwestern Spain (Fig. 1): Guadalquivir estuary (Cuesta et al. 1996; Baldó et al. 2001), tidal channels and small estuaries of the Bay of Cádiz (Drake et al. 1997), and Ría de Huelva (unpublished observations). Up to now, it has not been recorded from similar estuarine habitats in southern Portugal (see Cruz et al. 2003).

In the Guadalquivir river, *R. tartessicus* sp. nov. is mainly concentrated downstream, in the lower 20 km of the estuary. This population shows considerable abundance fluctuations during its annual life cycle, with a minimum observed in winter and maxima in spring and summer. The highest abundances were generally observed at salinities between 10‰ and 30‰ and temperatures higher than 15 °C. This population also shows a sexual segregation of individuals along the salinity gradient: females were clearly dominant at the most upstream station (32 km from the estuary mouth), while males were significantly more abundant in the lower estuary, as were juveniles and sub-adults. Brooding females were present in all the monthly samples carried out in the estuary during several annual cycles, indicating that *R. tartessicus* is reproductively active during the entire year (Baldó et al. 2001; Vilas 2005).

During laboratory experiments on the ecophysiology of *R. tartessicus* sp. nov. (see Vilas 2005), specimens from the Guadalquivir estuary were kept in aquaria for a few weeks. These experiments allowed observing the peculiar swimming behaviour of this mysid. Contrary to most mysids, it swims with its ventral side upturned towards the water surface, as shown in Fig. 2C. Wooldridge and Bailey (1982) first reported such a swimming behaviour in the case of *R. terranatalis* from South African estuaries. We suspect it is a common behavioural characteristic of species in this genus.

Key to the species of the genus *Rhopalophthalmus* Illig

The following key has been drawn up for adults, except for *R. constrictus* the original description of which treats sub-adults. The potentially new *Rhopalophthalmus* species from the Arabian Gulf has not been included in the key because it is only partially described (see Grabe et al. 2004). It is morphologically very close to *R. tattersallae* from southwestern India, although it can be distinguished from the latter by the relative length and armature of telson apical spines, the armature of the antennal sympod, and by the number of articles on the carpopropodus of thoracic endopods (Fig. 8).

1. Eyes slender and longer than antennular peduncle (Fig. 8A) . . . . . *R. flagellipes* Illig [Distribution: Congo estuary; Cameroon; ?offshore south Moroccan coast (see remark below). Ecology: estuaries.]
– Eyes not extending beyond distal margin of second article of antennular peduncle 2
2. No dorsal median nodules on carapace 3
– Two dorsal median nodules on carapace (Fig. 8B) 6
3. Antennal scale more than seven times as long as broad; inner distal angle of antennal sympod with three long spines (Fig. 8C) . . . . . *R. chilkensis* O.S. Tattersall [Distribution: Chilka Lake (India). Ecology: brackish waters; gregarious.]
– Antennal scale five times as long as broad 4
4. Telson with six to eight lateral spines. Carpopropodus of third to seventh thoracic endopod with four joints; inner distal angle of antennal sympod with one long tooth flanked on its dorsal side by a very small tooth (Fig. 8D) . . . . . *R. africana* O.S. Tattersall [Distribution: Sierra Leone estuary (Sierra Leone); Ebrié Lake (Ivory Coast). Ecology: estuaries; gregarious and euryhaline (salinity range: 13–>25‰).]
– Telson with more than eight lateral spines. Carpopropodus of third to seventh thoracic endopod with four to seven joints 5
5. Inner distal angle of antennal sympod armed with 13 small graduated spines (Fig. 8E) . . . . . *R. dakini* O.S. Tattersall [Distribution: New South Wales (Australia). Ecology: brackish waters; gregarious.]
– Inner distal angle of antennal sympod armed with four teeth, the smaller ones being ventral to the larger ones (Fig. 8F) . . . . . *R. brisbanensis* Hodge [Distribution: Brisbane River (West Australia). Ecology: estuaries; gregarious.]
6. Antennal scale shorter than or equal to antennular peduncle (Fig. 8G) 7
– Antennal scale longer than antennular peduncle 11
7. Spinules on telson apical spines flattened (Fig. 8H) 8
– Spinules on telson apical spines not flattened 9

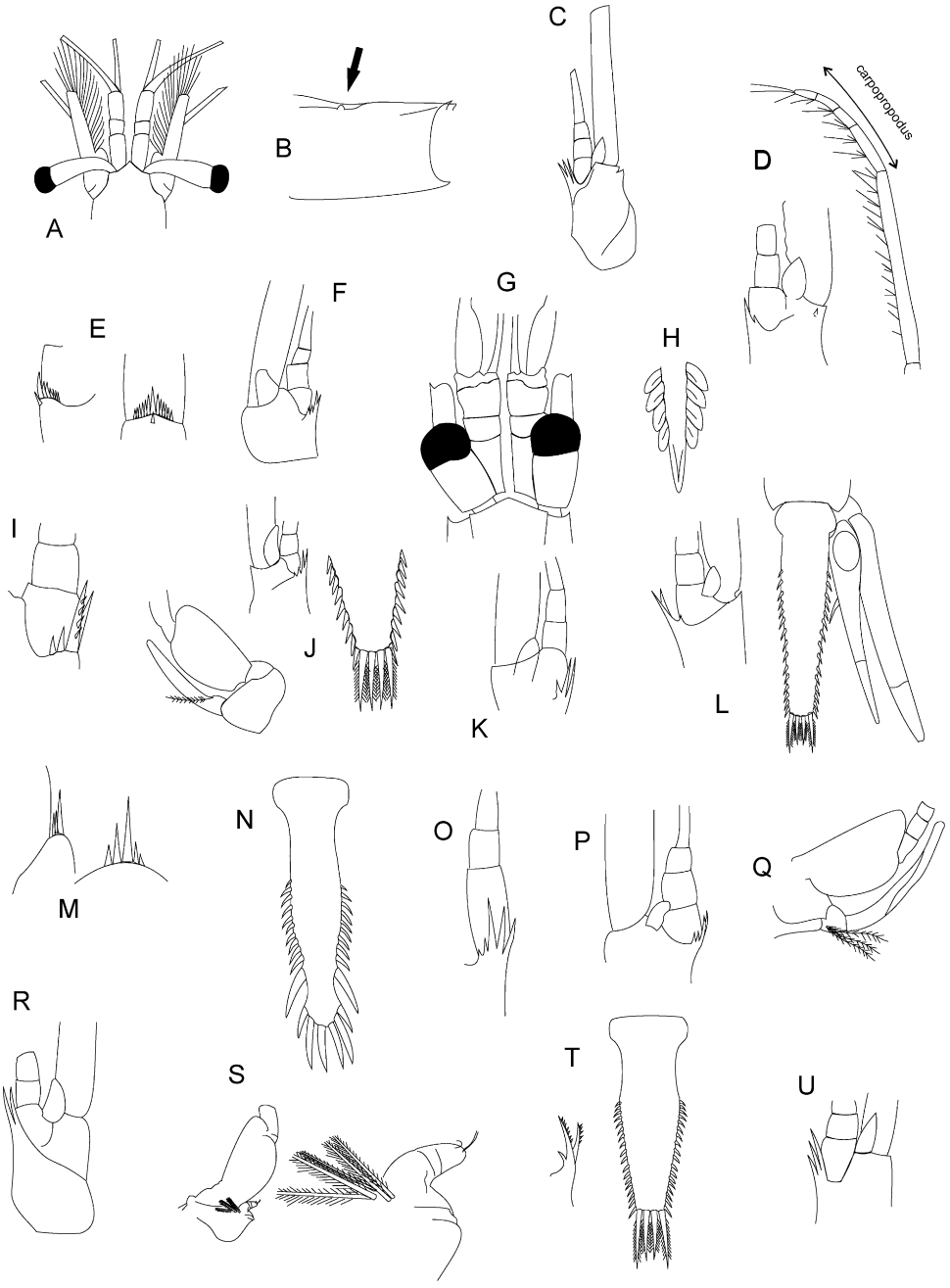

Fig. 8. (A) Head of *Rhopalophthalmus flagellipes* Illig, 1906; (B) lateral view of carapace of *R. mediterraneus* Nouvel, 1960, showing the dorsal median nodules; (C) antennal sympod of *R. chilkensis* Tattersall, 1957; (D) antennal sympod and carpopropodus of third thoracic endopod of *R. africana* Tattersall, 1957; (E) lateral and dorsal views of inner distal angle of antennal sympod of *R. dakini* Tattersall, 1957; (F) antennal sympod of *R. brisbanensis* Hodge, 1963b; (G) head of *R. kempi* O.S. Tattersall, 1957; (H) distal part of one flattened apical spine on telson of *R. phyllodus* Murano, 1986; (I) antennal sympod of *R. tattersallae* Pillai, 1961; (J) eighth thoracic appendage of male, antennal sympod and telson of *R. kempi* Tattersall, 1957; (K) antennal sympod of *R. orientalis* Tattersall, 1957; (L) antennal sympod, telson and right uropod of *R. longicauda* Tattersall, 1957; (M) lateral and dorsal views of inner distal angle of antennal sympod of *R. indicus* Pillai, 1961; (N) telson of *R. constrictus* Panampunnayil, 1992; (O) antennal sympod of *R. phyllodus* Murano, 1986; (P) antennal sympod of *R. longipes* Ii, 1964; (Q) eighth thoracic appendage of male of *R. macropsis* Pillai, 1964. (R) Antennal sympod of *R. terranatalis* O.S. Tattersall, 1957.; (S) eighth thoracic appendage of male of *R. mediterraneus* Nouvel, 1960; (T) antennal sympod and telson of *R. tropicalis* Wooldridge & Mees, 2003; (U) antennal sympod of *R. egregius* Hansen, 1910.

8. Inner distal angle of antennal sympod armed with two long, equal teeth and one small tooth at base of the more dorsal long one (Fig. 8K) . . . . . *R. orientalis* O.S. Tattersall [Distribution: Japanese coasts. Ecology: coastal waters; gregarious.]

– Inner distal angle of antennal sympod armed with four strong spines, the first two comparatively short and subequal, third slightly longer than fourth and with four to five strong barbs (Fig. 8I). . . . . *R. tattersallae* Pillai [Distribution: Kerala (India).Ecology: estuarine waters.]

9. Inner pair of apical telson spines shorter than outer pair 10

– Inner pair of apical telson spines longer than or equal to outer pair. Antennal scale six times as long as broad. Eighth thoracic endopod unsegmented, straight and longer than basal article of exopod in both sexes. Inner distal angle of antennal sympod armed with two long, equal teeth and one or two smaller graduated teeth dorsal to them (Fig. 8J). . . . . *R. kempi* O.S. Tattersall [Distribution: Mormugoa Bay (India), Andaman Islands (India). Ecology: coastal waters, muddy bottom.]

10. Inner distal angle of antennal sympod armed with two long, equal teeth and one small tooth dorsal to them. Unusually long telson and long, slender uropods (Fig. 8L). . . . . *R. longicauda* O.S. Tattersall [Distribution: Sierra Leone estuary. Ecology: estuaries; gregarious and euryhaline (salinity >15‰).]

– Inner distal angle of antennal sympod armed with five spines arranged in the form of a cone, the two ventral ones very small (Fig. 8M) . . . . . *R. indicus* Pillai [Distribution: Kayamkulam Lake, Kerala (India). Ecology: brackish waters.]

11. Spinules on telson apical spines flattened (Fig. 8H) 12

– Spinules on telson apical spines not flattened 14

12. Telson with prominent constriction at distal end; last pair of lateral spines long and as stout as apical spines. Anterior five abdominal somites with rounded epimeral plates. Antennal scale eight times as long as broad (Fig. 8N) . . . . . *R. constrictus* Panampunnayil [Distribution: southwest Australia. Ecology: coastal waters; young males caught in oblique hauls (0–40 m water depth).]

– Telson not constricted at distal end 13

13. Inner distal angle of antennal sympod armed with three long, graded teeth and two short teeth. Telson 2.5 times as long as maximum basal width (Fig. 8O) . . . . . *R. phyllodus* Murano [Distribution: Thailand. Ecology: coastal and brackish waters.]

– Inner distal angle of antennal sympod armed with two long, equal teeth and two small teeth at base of the more dorsal long one. Carpopropodus with two articles in third thoracic endopod, three articles in fourth and fifth, four in sixth and seventh endopod (Fig. 8P). . . . . *R. longipes* Ii [Distribution: Japan. Ecology: coastal waters.]

– Inner distal angle of antennal sympod armed with four teeth, the first and second small, third long, fourth slightly shorter than third. Eighth thoracic endopod three-articulated in male, third article very long, extending beyond basal segment of exopod (Fig. 8Q). . . . . *R. macropsis* Pillai [Distribution: West India. Ecology: coastal waters.]

14. Inner distal angle of antennal sympod armed with two long, strong, equal teeth and a shorter more ventral tooth. Carpopropodus of seventh thoracic endopod with more than six articles 15
– Inner distal angle of antennal sympod not as above. Carpopropodus of seventh thoracic endopod with no more than six articles 17
15. Antennal scale six to seven times as long as broad. The two long teeth of antennal sympod barbed with six to eight stout barbs (Fig. 8R) . . . . . *R. terranatalis* O.S. Tattersall [Distribution: southwest Africa. Ecology: estuaries; gregarious and euryhaline.]
– Antennal scale less than six times as long as broad 16
16. Antennal scale 5.25–5.5 times as long as broad. Carpopropodus of seventh thoracic endopod with seven articles. Male eighth thoracic endopod unsegmented, bipartite, rudimentary and much smaller than basal segment of exopod, distal part inconspicuous (Fig. 8S). . . . . *R. mediterraneus* Nouvel [Distribution: Algeria. Ecology: adults caught at mouth of Harrach River (muddy sand bottom), sub-adult female caught in bay of Algiers (muddy bottom).]
– Antennal scale 4.4–5.0 times as long as broad. Carpopropodus of seventh thoracic endopod with 9–11 articles. Distal part of male eighth thoracic endopod long and hooked, apex conical . . . . . *R. tartessicus* sp. nov. [Distribution: Guadalquivir estuary and Bay of Cádiz (Spain). Ecology: estuaries, tidal channels; gregarious and euryhaline.]
17. Inner distal angle of antennal sympod armed with two long, strong, equal, smooth teeth, a shorter more ventral tooth and three small spines at base of ventral one. Telson distinctly constricted in proximal half (Fig. 8T) . . . . *R. tropicalis* Wooldridge and Mees [Distribution: Mozambique. Ecology: estuaries; gregarious.]
– Inner distal angle of antennal sympod armed with three long graduated teeth. Antennal scale five times as long as broad (Fig. 8U). . . . . *R. egregius* Hansen [Distribution: Bawean Islands, Java Sea; southern Japan. Ecology: estuaries.]

Remark

Furnestin (1959) identified as *R. flagellipes* Illig one young male sampled in surface waters between Cap Juby and Fuerteventura Island (the exact location – neritic or oceanic waters? – of this offshore sampling station is not mentioned). We agree with Nouvel (1960) that this was a misidentification as clearly demonstrated by Furnestin's figure: the eyes of the Moroccan specimen are not longer than the antennular peduncle. Although incompletely described, the few morphological features given by Furnestin (1959) show that this specimen cannot be referred to any of the species known from the western African coast (*R. africana* and *R. longicauda*), the Mediterranean coast of Algeria (*R. mediterraneus*) or from the southern Atlantic coast of Spain (*R. tartessicus* sp. nov.). Unfortunately, this unique specimen is probably lost (M.L. Furnestin, pers. comm., 2005). Due to its offshore habitat (taken above at least 25 m of water), unusual within the genus *Rhopalophthalmus*, this Moroccan species is probably new to science and could be related to another offshore *Rhopalophthalmus* mentioned by Casanova (1977) from the northern Mauritanian coast (material probably lost; J.P. Casanova, pers. comm., 2005).

Note added in proof

While this manuscript was in press, Panampunnayil and Biju (2006) described four additional species in the genus *Rhopalophthalmus*.

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