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Scyllarus arctus (Crustacea: Decapoda: Scyllaridae) final stage phyllosoma identified by DNA analysis, with morphological description

FERRAN PALERO[1,3], GUILLERMO GUERAO[2], PAUL F. CLARK[4] AND PERE ABELLÓ[3]

[1]Evolutionary Genetics, Institute of Science and Technology Austria (ISTA), Am Campus 1, A–3400 Klosterneuburg, Austria, [2]IRTA, Unitat de Cultius Experimentals, Sant Carles de la Ràpita, Tarragona, Catalonia, Spain, [3]Institut de Ciències del Mar (CSIC), Passeig Marítim de la Barceloneta 37–49, 08003 Barcelona, Catalonia, Spain, [4]Department of Zoology, Natural History Museum, Cromwell Road, London SW7 5BD, UK

Advanced stages of Scyllarus *phyllosoma larvae were collected by demersal trawling during fishery research surveys in the western Mediterranean Sea in 2003–2005. Nucleotide sequence analysis of the mitochondrial 16S rDNA gene allowed the final-stage phyllosoma of* Scyllarus *arctus to be identified among these larvae. Its morphology is described and illustrated. This constitutes the second complete description of a Scyllaridae phyllosoma with its specific identity being validated by molecular techniques (the first was* S. pygmaeus*). These results also solved a long lasting taxonomic anomaly of several species assigned to the ancient genus* Phyllosoma *Leach, 1814. Detailed examination indicated that the final-stage phyllosoma of S. arctus shows closer affinities with the American scyllarid* Scyllarus *depressus or with the Australian* Scyllarus *sp. b (sensu Phillips et al., 1981) than to its sympatric species* S. pygmaeus.

Keywords: DNA barcoding, Achelata, Scyllaridae, slipper lobster, *Scyllarus*, *S. arctus*, *S. pygmaeus*

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INTRODUCTION

Identification of zooplankton is traditionally based on morphological characterization which is in some cases almost impossible (Evans *et al.*, 2007; Litaker *et al.*, 2007; Clark, 2009). A valuable resource to contribute to precise species identification, especially concerning meroplankton, has been provided over the past decades by the development of new tools based on molecular analysis (DNA barcoding: Hebert *et al.*, 2003; John *et al.*, 2005). One obvious advantage of DNA barcoding comes from the fact that genetic markers do not change during the development of the organism through its life stages. Therefore, molecular based identification is most useful when there are no obvious means to match adults with immature/juvenile specimens (Pegg *et al.*, 2006; Ahrens *et al.*, 2007) or larval stages. Furthermore, the analysis of COI (cytochrome oxidase-I) or 16S rRNA genes using universal primers allows the molecular characterization of an array of specimens that could belong to various phylogenetically distant taxa (Vences *et al.*, 2005). Nevertheless, despite its role in identifying samples to the species level and being an important aid for taxonomic workflow, it should be stressed that DNA barcoding is no replacement for comprehensive taxonomic analysis and complete morphological descriptions (Hajibabaei *et al.*, 2007; Wheeler, 2008).

Corresponding author:
F. Palero
Email: fpalero@ist.ac.at

The Scyllaridae Latreille, 1825, popularly known as slipper lobsters, is a group of decapod crustaceans widespread in tropical and temperate waters characterized by their unique plate-like antennae and the presence of a specialized larval phase called phyllosoma (Holthuis, 1991; Scholtz & Richter, 1995). Four subfamilies are recognized, containing ~80 species: Ibacinae, Arctidinae, Scyllarinae and Theninae (Holthuis, 1985, 1991, 2002; Webber & Booth, 2007). Scyllarinae are the most diverse group of slipper lobsters, with more than 40 species assigned to 14 genera, namely *Acantharctus, Antarctus, Antipodarctus, Bathyarctus, Biarctus, Chelarctus, Crenarctus, Eduarctus, Galearctus, Gibbularctus, Petrarctus, Remiarctus, Scammarctus* (all Holthuis, 2002) and *Scyllarus* Fabricius, 1775 (Holthuis, 2002). The phyllosoma larvae of the Scyllarinae are difficult to separate into species due to their similarity, especially the early stages (Lindley *et al.*, 2004; Booth *et al.*, 2005). Most scyllarinid larvae collected, even those recently described, remain unidentified below the generic level (McWilliam *et al.*, 1995; Coutures & Webber, 2005). Nevertheless, the correct identification of phyllosoma larvae in plankton samples is essential to recognize and understand the spatiotemporal distributions, behavioural ecology, population dynamics and reproductive strategies of the different species and DNA markers can facilitate this task (Chow *et al.*, 2006a, b; Shirai *et al.*, 2006; Suzuki *et al.*, 2006).

Two congeneric species, *Scyllarus arctus* Linnaeus, 1758 and *S. pygmaeus* Bate, 1888, are commonly found in Mediterranean and north-eastern Atlantic waters (García-Raso, 1982; Holthuis, 1991). Adult specimens from these

two closely related species can be readily distinguished by precise morphological characters such as the shape of a tubercle on the last thoracic sternite, the pleura of pleonal somites or the shape of the thoracic sternum (Zariquiey Álvarez, 1968; Holthuis, 1987), as well as by size, with total body length being usually between 8–9 cm for *S. arctus* and about 4–5 cm for *S. pygmaeus* (Mura *et al.*, 1984). However, phyllosoma larvae cannot be generally assigned to a particular species using morphological traits, since the characters used to distinguish between *Scyllarus* species are only expressed during more advanced nisto and adult stages (Lindley *et al.*, 2004; Palero *et al.*, 2009a). It is not surprising to note that all wild-caught European *Scyllarus* phyllosoma larvae found in the literature have consistently been assigned to *S. arctus*, since this is apparently the most common species. However, *S. pygmaeus* is also a relatively common species in Mediterranean waters (Forest & Holthuis, 1960; Abelló *et al.*, 1988; Pessani & Mura, 2007), even though it is collected less often than *S. arctus*.

Accurate identification usually requires rearing (Robertson, 1971; Ito & Lucas, 1990), but the recent development of the molecular phylogeny of the Achelata (slipper and spiny lobsters) from Mediterranean and eastern Atlantic waters provides highly valuable species-specific markers for the correct identification of phyllosoma larvae (Palero *et al.*, 2009b). Final-stage and a sub-final stage phyllosoma belonging to *Scyllarus* were collected in the western Mediterranean Sea during fishery research surveys in 2003–2005. Their DNA was analysed and this material was subsequently identified as several final stage phyllosoma of *Scyllarus arctus* and *S. pygmaeus* and a sub-final phyllosoma of *S. pygmaeus*. This constitutes the second molecular identification of a phyllosoma stage for Scyllaridae species (see Palero *et al.*, 2008) and helped resolve the synonymy of several species referred to the ancient genus *Phyllosoma* Leach, 1814.

MATERIALS AND METHODS

Several final stage phyllosoma larvae identified as belonging to the genus *Scyllarus* were caught by demersal trawling in the western Mediterranean (Table 1). Each individual was preserved in 100% ethanol. DNA information was also obtained from various scyllarid species found in Mediterranean and Atlantic waters namely *Acantharctus posteli*, *Scyllarus arctus, S. caparti, S. pygmaeus, S. subarctus, Scyllarides latus*, *S. herklotsii* and *S. nodifer* (Palero *et al.*, 2009b). The Palinuridae species *Palinurus elephas*, *P. mauritanicus* and *P. charlestoni* were used as outgroup.

Total genomic DNA extraction was performed using the QIAamp DNA Mini Kit (QIAGEN Inc). A region of 440–450bp was amplified using universal primers for the mitochondrial 16S rRNA gene (16Sar 5′–CGC CTG TTT ATC AAA AAC AT–3′ and 16Sbr 5′–CCG GTC TGA ACT CAG ATC ACG T–3′; Palumbi, 1996). Amplification was carried out with 30 ng of genomic DNA in a reaction containing 1U of Taq polymerase (Amersham), 1X buffer (Amersham), 0.2 μM of each primer and 0.12 mM dNTPs. The PCR thermal profile used was 94°C for 4 minutes for initial denaturation, followed by 30 cycles of 94°C for 30 seconds, 54°C for 30 seconds, 72°C for 30 seconds, and a final extension at 72°C for 4 minutes. Amplified PCR products were purified with QIA-Quick PCR Purification Kit (QIAGEN Inc) prior to direct sequencing of the product. The sequences were obtained using the Big-Dye Ready-Reaction kit v3.1 (Applied Biosystems) on an ABI Prism 3770 automated sequencer from the Scientific and Technical Services of the University of Barcelona.

A neighbour-joining phylogenetic tree (NJ) based on Kimura's 2-parameter model (K2P) and associated bootstrap support values were obtained using MEGA version 3.1 (Kumar *et al.*, 2004).

A binocular microscope equipped with an ocular micrometer was used for dissections and measurements of phyllosomata. The following measurements were taken: total length (TL) from the anterior margin of the cephalic shield between the eyes to the posterior margin of the telson; cephalic length (CL) from the anterior to the posterior margin of the cephalic shield; cephalic width (CW) measured at the widest part of the cephalic shield; thorax width (TW) measured at its widest point; eye length (EL) from the base of the eyestalk to the tip of the eyes; antennular length (A1L) from the insertion point to the tip of the inner ramus; total antennal length (A2L) from the insertion point to the tip of the inner ramus; pleon length (PL) from the anterior margin of the pleon to the posterior margin of the telson. The larvae are described using the basic malacostracan somite plan from anterior to posterior and appendage segments are described from proximal to distal, endopod then exopod (Clark *et al.*, 1998).

The two studied Mediterranean specimens of *S. arctus* final phyllosoma stage and the new *S. pygmaeus* samples have been deposited in the Biological Collections of Reference of the Institut de Ciències del Mar (CSIC) in Barcelona (Table 1).

RESULTS

DNA analysis

The length of the aligned dataset for the 16S rDNA gene was 435bp and the sequences have been deposited in GeneBank with Accession Numbers GQ922070–75. The 16S rDNA data from the studied larvae were analysed together with those obtained in recent phylogenetic work on Achelata lobsters (Palero *et al.*, 2009b). The phylogenetic tree showed the actual identity of the final-stage phyllosoma larvae (Figure 1), with the clade formed by the studied phyllosoma specimens collected at Stations M04L060 and M04L082 and the *S. arctus* adult specimen presenting a 100 bootstrap support. The identity of the *S. pygmaeus*-like final-stage phyllosoma larvae, was confirmed using molecular data, with the studied phyllosoma specimens collected at Stations M03L043, M03L093, M03L095 and M05L041 and the *S. pygmaeus* adult specimen presenting a 100 bootstrap support. The distance (K2P) among the phyllosoma specimens collected at Stations M04L060 and M04L082 and the adult *Scyllarus arctus* (0.000 ± 0.000) was much smaller than those between the larvae and either adult specimens from *Scyllarus pygmaeus* (0.110 ± 0.018) or *Acantharctus posteli* (0.095 ± 0.016). Therefore, the phyllosoma specimens collected at Stations M04L060 and M04L082 belong to *Scyllarus arctus*. Since the final-stage phyllosoma larva of *S. pygmaeus* has been recently described (Palero *et al.*, 2008), only the *S. arctus* phyllosoma specimens are described in the present study.

Table 1. Stations where final-stage phyllosoma larvae of *Scyllarus* were found (* ICM CODE assignation pending).

Species	Stage	ICM Code		Station	Date	Latitude	Longitude	Depth (m)
S. arctus	Final	ICMD-68/2007	1	M04L060	19/05/2004	38°59.03N	0°29.99E	701–750
S. arctus	Final	ICMD-69/2007	1	M04L082	23/05/2004	41°01.41N	1°22.58E	101–150
S. pygmaeus	Final	ICMD-63/2007	1	M03L043	05/05/2003	38°07.27N	0°03.76W	251–300
S. pygmaeus	Sub-final	*	1	M03L093	16/05/2003	41°54.35N	3°30.94E	401–450
S. pygmaeus	Final	ICMD-64/2007	1	M03L095	16/05/2003	42°06.55N	3°35.58E	401–450
S. pygmaeus	Final	*	2	M05L041	19/05/2005	38°04.82N	0°00.01E	601–650

Morphological description

DESCRIPTION

Individuals examined: ICMD68/2007 and ICMD69/2007 (Table 1).

Dimensions. TL = 2.00–2.20 cm; CL = 1.13–1.25 cm; CW = 1.30–1.50 cm; EL = 0.43–0.52 cm; A1L = 0.31–0.37 cm; A2L = 0.36–0.40 cm; TW = 0.66–0.78 cm; PL = 0.60–0.70 cm.

Cephalic shield (Figure 3A). Subrectangular, 1.15–1.20 times wider than long, and 1.70–1.80 times wider than thorax; eye slighly longer than antennule and antenna.

Antennule (Figure 3A). Biramous, peduncle 3-segmented; inner ramus unsegmented with 2–3 setae, slightly longer than outer; outer ramus unsegmented with 13–15 rows of sensory setae.

Antenna (Figure 3A). Unsegmented and unarmed, similar in length to antennules; lateral process directed anteriorly.

Mandibles (Figure 4A, B). Flattened, placed between labrum and paragnaths; incisor process and medial gnathal edge with several teeth, which differ in number and morphology (23–24 long and thin teeth on left mandible and 12–13 short and strong teeth on right mandible); molar process crowned by many denticules and papillae.

Maxillule (Figure 4C). Uniramous; coxal endite with 9 setae; basial endite with 3 strong cuspidate setae and 6 subterminal setae; palp (endopod) absent.

Maxilla (Figures 3A, 4D). Endites and endopod not differentiated, with 0–4 minute setae; scaphognathite without setae, flattened and considerably expanded anteriorly and posteriorly.

First maxilliped (Figure 4D). Unsegmented and unarmed; bilobed rudimentary bud.

Second maxilliped (Figures 3A, 4E). Protopod 2-segmented with one minute seta on distal segment (basis); endopod 4-segmented with 0, 0, 11 and 5 setae, ischio-merus fused to basis; unarmed exopod bud present.

Third maxilliped (Figure 3A). Protopod 2-segmented, with ventral coxal spine; endopod 4-segmented, ischio-merus fused to basis, distal part of propodus and dactylus densely setose; very minute exopod bud present.

Pereiopods (Figures 3, 4F, G). Pereiopods 1–4 biramous, with coxal and subexopodal spines, endopod four-segmented, ischio-merus fused to basis and with 2 distal spines, one distal spine on carpus; exopods with flagellae distally with 23–24, 24, 19–20 and 17–18 annulations, respectively, each annulation bears a pair of setae; pereiopod 5 uniramous, 5-segmented, not reaching posterior margin of telson, with ventral coxal spine, 2 distal minute spines on ischio-merus and one or no distal spine on carpus.

Thorax (Figure 3A, C). Dorsal thoracic spines present above pereiopods 1–4.

Gills (Figure 3C). Full complement of gill buds present: third maxilliped and pereiopod 1 with one pleurobranch, one arthrobranch and two podobranchs; pereiopods 2–4

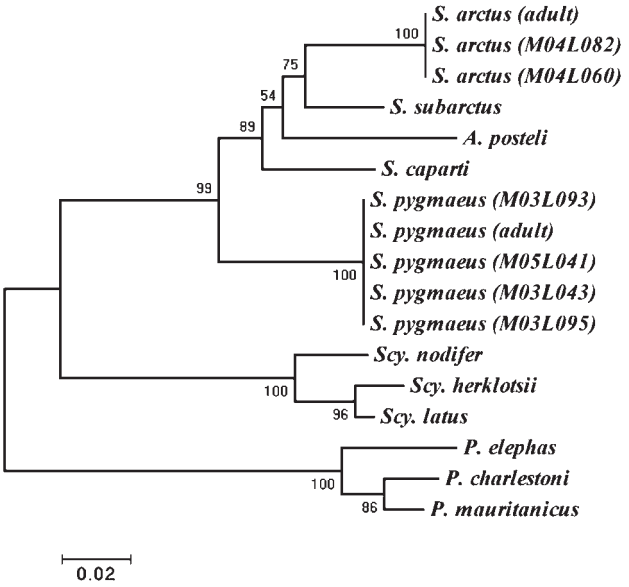

Fig. 1. Neighbour-joining phylogenetic tree estimated from the partial mitochondrial 16S rDNA sequence data, showing the position of the phyllosoma specimens genetically analysed in the present study.

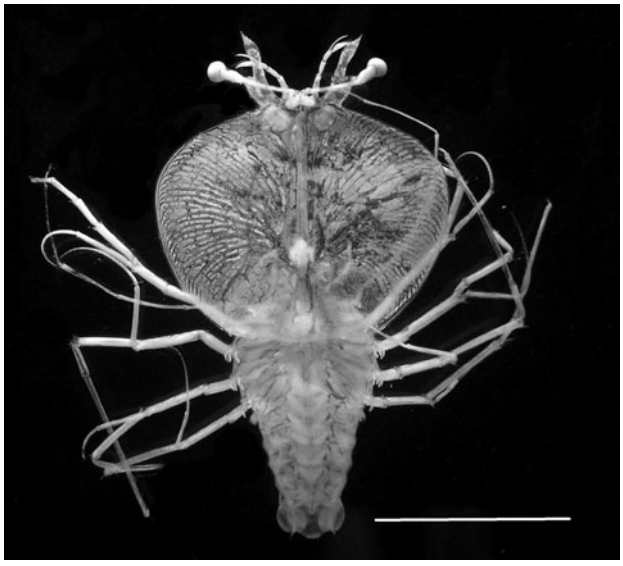

Fig. 2. *Scyllarus arctus*. Final-stage phyllosoma, dorsal view. Scale bar = 1 cm.

with two pleurobranchs, one arthrobranch, two podobranchs; pereiopod 5 with one pleurobranch.

Pleon (Figures 3A, D, 4H). Segmented, with 6 somites; somites 2–5 with a pair of pleopods; pleopods biramous, unsegmented and unarmed (Figure 4H); biramous uropods not outreaching posterior margin of telson; telson rounded posteriorly with strong postero-lateral processes that reach beyond the posterior margin (Figure 3D).

SYSTEMATICS

Order DECAPODA Latreille, 1802
Suborder PLEOCYEMATA Burkenroad, 1963
Infraorder ACHELATA Scholtz & Richter, 1995
Family SCYLLARIDAE Latreille, 1825
Genus *Scyllarus* Fabricius, 1775
Scyllarus arctus (Linnaeus, 1758)
(Figures 2–4)

Astacus arctus Pennant, 1777: 14.
Cancer (*Astacus*) *ursus minor* Herbst, 1793: 83–84, table XXX, figure 3.
Scyllarus ursus minor Bosc, 1802: 20.
Scyllarus tridentatus Leach, 1814: 397.
Scyllarus cicada Risso, 1816: 61–62; Hope 1851: 14; Holthuis, 1978: 56.
Scyllarus cicada var. A Risso, 1816: 62; Holthuis, 1978: 56.
Scyllarus cicada Risso, 1827: 43; Roux, 1828: unnumbered; Holthuis, 1978: 56.
Scyllarus cicada var. I Risso, 1827: 43; Holthuis, 1978: 56.
Scyllarus Arctus var. *cicada* Risso Ms. in Holthuis, 1978: 56.
Scyllarus ursus minor Bosc, 1830: 54; Roux, 1828: unnumbered.
Phyllosoma Lukis, 1835a: 459–462.
Phyllosòma sarniénse Lukis, 1835b: 685; Lukis, 1836: 48–49.
Arctus arctus de Haan, 1849: 238.
Arctus ursus minor Hope, 1851: 14.
Arctus urus Dana, 1852a: 14, 1852b: 124, 1853: 516; Bate, 1888: 66.
Nisto asper Sarato, 1885: 3; Bouvier, 1913: 1647; 1915a: 289–290; 1915b: 50; 1917: 108–114, pl. 10, figures 1–2; Stephensen, 1923: 69, 74, figure 24; Demirhindi, 1959: 52; Holthuis, 1991: 218.
Arctus arctus Bouvier, 1905: 479.
Arctus crenulatus Bouvier, 1905: 480; *Scyllarus* (*Arctus*) *crenulatus* Bouvier, 1915a: 290.
Scyllarus Arctus var. *lutea* Risso Ms. in Holthuis, 1978: 56.
Yalomus depressus Rafinesque MS in Holthuis, 1985: 141–142, 144–145.
Non-*Chrysoma mediterraneum* Risso, 1827: 88–89, pl. 3, figure 9, 1844: 96; Risso Ms. in Holthuis, 1978: 56 = *Scyllarus pygmaeus* Bate, 1888.
Non-*Chrysoma Mediterraneum* Roux, 1830: unnumbered, pl. 25 = *Scyllarus pygmaeus* Bate, 1888.
Non-*Phyllosoma Mediterraneum* Costa & Costa, 1840: 5; Hope, 1851: 20 = *Scyllarus pygmaeus* Bate, 1888.
Non-*Phyllosoma parthenopaeum* Costa & Costa, 1840: 5–8, table XI, figure 5a–c, d = *Scyllarus pygmaeus* Bate, 1888.
Non-*Phyllosoma Parthenopaeum* Hope, 1851: 20 = *Scyllarus pygmaeus* Bate, 1888.
Non-*Nisto laevis* Sarato, 1885: 3; Bouvier, 1913: 1647; 1915a: 289–290; 1915b: 50; 1917: 108–114, pl. 11, figures 1–2; Stephensen, 1923: 69, 74; Demirhindi, 1959: 52; García-Raso, 1982: 74–76; Holthuis, 1991: 218 = *Scyllarus pygmaeus* Bate, 1888.

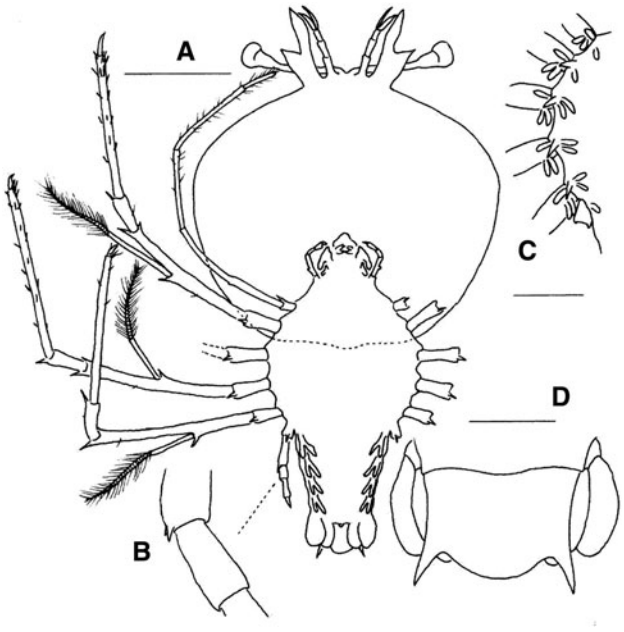

Fig. 3. *Scyllarus arctus*. Final-stage phyllosoma. (A) Ventral surface; (B) detail of the pereiopod 5; (C) left side of thorax, dorsal view; (D) telson, dorsal view. Scale bar A = 5 mm; C = 2 mm; D = 1 mm.

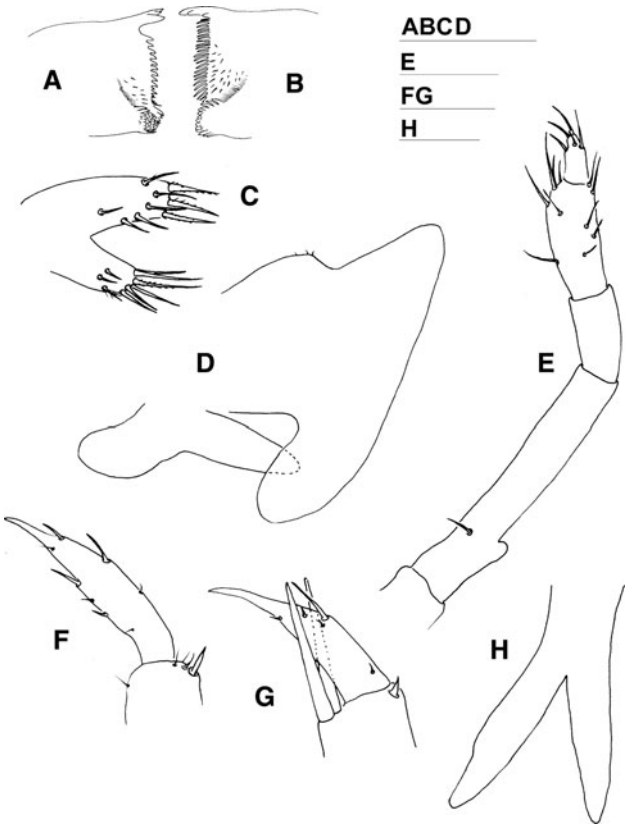

Fig. 4. *Scyllarus arctus*. Final-stage phyllosoma. (A) Right mandible; (B) left mandible; (C) maxillule; (D) maxilla and first maxilliped; (E) second maxilliped; (F) dactylus of first pereiopod; (G) dactylus of fourth pereiopod; (H) pleopod. Scale bar of A–D and H = 500 μm; E = 1 mm; F and G = 200 μm.

REMARKS

Lukis' corrections to the description of *Phyllosòma sarniénse*, despite being dated 22 October 1835, were actually published late in 1836 in Volume IX of the *Magazine of Natural History*.

DISCUSSION

The identification of the phyllosoma specimens collected as belonging to both *Scyllarus pygmaeus* and *S. arctus* has been determined using DNA barcoding techniques by comparing larval DNA sequences with sequences from every species of Scyllaridae present in Mediterranean or adjacent eastern Atlantic waters i.e. *Scyllarides latus*, *Acantharctus posteli*, *Scyllarus arctus*, *S. caparti* and *S. pygmaeus* (García-Raso, 1982; Pessani & Mura, 2007; Palero *et al.*, 2009b) and using several *Palinurus* species as outgroup. The *S. arctus* phyllosoma larvae studied in the present work are stage X larvae, with the presence of a complete set of gills (Webber & Booth, 2001). The key characteristics, useful for diagnosis, of the final stage phyllosoma larva of *S. arctus* concern the shape of the cephalic shield, antennulae about the same length as the antennae, the presence of a small exopod bud on the third maxilliped, the presence of strong dorsal thoracic spines and the presence of telson spines. Despite many specimens having been previously described as belonging to *S. arctus*, this is the first time the identity of the phyllosoma larva of *S. arctus* has been confirmed using molecular techniques and therefore the larva has been described following present day standards. Moreover, thanks to the identification of the phyllosoma larva of both *S. pygmaeus* and *S. arctus*, together with a thorough literature review, the authors have been able to identify the species previously assigned to the genus *Phyllosoma* currently synonymized with *S. arctus* (Holthuis, 1991).

Antoine Risso claimed to have discovered *Chrysoma mediterraneum* in 1815, although he did not publish a description until his *Histoire Naturelle de l'Europe Méridionale* in 1827 (Risso, 1827, 1844). Most of Risso's descriptions are good enough for proper specific identification. Thus, the *Chrysoma mediterraneum* figured by him could recently be assigned to *S. pygmaeus*, given the shape of the cephalic shield (Risso, 1827; Palero *et al.*, 2008). Interestingly, two more *Phyllosoma* species were described from Mediterranean and nearby Atlantic waters: *Phyllosòma sarniénse* captured in 1835 by Lukis, near the coast of Guernsey, Channel Islands (Lukis, 1835b 1836), and *Phyllosoma parthenopaeum* Costa & Costa, 1840 captured near Naples, Italy. According to the results obtained in the present study, *Phyllosòma sarniénse* can now be identified as the final-stage phyllosoma of *S. arctus*, while *Phyllosoma parthenopaeum* Costa & Costa, 1840, which was previously thought to be a phyllosoma stage of *S. arctus*, actually represents a sub-final stage of *S. pygmaeus*. Together with the results obtained in a previous study (Palero *et al.*, 2009a), the authors intend to submit an application to the International Commission for Zoological Nomenclature to suppress the names *Nisto laevis* Sarato, 1885, *Chrysoma mediterraneum* Risso, 1827 and *Phyllosoma parthenopaeum* Costa & Costa, 1840 whenever they are considered a synonym of *S. arctus*, under Article 23.9.3 of the International Code of Zoological Nomenclature (ICZN).

The main characters that can be used to distinguish between the final-stage phyllosoma larvae of *S. pygmaeus* and *S. arctus* are:

(1) the overall smaller size of *S. arctus* larvae. Despite the larger size of *S. arctus* adults, *S. pygmaeus* final-stage larvae were consistently larger than final-stage larvae of *S. arctus* (average of TL = 2.52, CL = 1.44 and CW= 1.91 in *S. pygmaeus*; TL= 2.14, CL= 1.19 and CW= 1.42 in *S. arctus*);
(2) the shape of the cephalic shield, being much narrower in *S. arctus* than in *S. pygmaeus*. The TL/CW ratio is larger in *S. arctus* (> 1.4) than in *S. pygmaeus* (< 1.4);
(3) the lateral process of the antenna of *S. arctus* is directed anteriorly, while in *S. pygmaeus* is directed laterally;
(4) coxal endites of the maxillule with 9 setae in *S. arctus* and 10 setae in *S. pygmaeus*;
(5) second maxilliped five-segmented, with 0, 1, 2, 10 and 6 setae in *S. pygmaeus* and with 0, 1, 0, 11 and 5 setae in *S. arctus*; and
(6) *S. arctus* final-stage phyllosoma shows a very minute exopod bud on the third maxilliped, while no exopod bud was observed in *S. pygmaeus* larvae.

Comparison with scyllarinid larvae found in previous literature

The specific identity of the scyllarinid phyllosoma larvae has been confirmed only for a few species in the world (Webber & Booth, 2001; Holthuis, 2002), which makes any attempt to carry out a systematic comparative study almost impracticable. Nevertheless, the final-stage phyllosomata of both *S. arctus* and *S. pygmaeus* are larger than most Scyllarinae species described to date (*Eduarctus martensii*: Phillips & McWilliam, 1986; *Crenarctus bicuspidatus*: Inoue & Sekiguchi, 2006). The phyllosomata of both *S. arctus* and *S. pygmaeus* can be easily distinguished from other species of scyllarinid lobster that have distinctly different morphologies and never develop elongate telson spines (*Scyllarus americanus*: Robertson, 1968; *Petrarctus demani*: Ito & Lucas, 1990). Only a minority of scyllarinid phyllosomata, including the *Scyllarus* phyllosomata described in this study, have a pair of spines outreaching the posterior margin of the telson (and uropods) in the final stage (Webber & Booth, 2001; Palero *et al.*, 2008). Within this group of larvae, *S. arctus* phyllosomata can be distinguished from other *S. pygmaeus*-like larvae found in the Juan Fernandez Islands (*Acantharctus delfini* Johnson, 1971), Western and South-Eastern Australia (*Crenarctus bicuspidatus sensu* Phillips *et al.*, 1981) and Japan (*Chelarctus cultrifer* sensu Higa & Shokita, 2004) using differences in the shape of the cephalic shield. However, the authors could not find any morphological trait that would distinguish the phyllosoma larva of *S. arctus* from those larvae attributed to *S. depressus* (Robertson, 1971) and *Scyllarus* sp. b (*sensu* Phillips *et al.*, 1981) from the South-Eastern Indian Ocean.

The present study, together with Palero *et al.* (2008) showed the real identity of the phyllosoma larvae of *S. arctus* and *S. pygmaeus* and allowed a comparison of scyllarinid phyllosomata. From these results, the present generic classification of scyllarinid lobsters based on adult characters does not match with those characters found in the larval stages (Holthuis, 2002). Strikingly similar larvae have been

described as belonging to different genera (e.g. *Acantharctus delfini*, *Crenarctus bicuspidatus* and *Chelarctus cultrifer*), while species within a particular genus may show clearly distinct larvae (e.g. *Scyllarus arctus* and *S. americanus*). Work is in progress to develop a molecular phylogenetic study including every known Scyllaridae genus, which will provide a new set of molecular markers to infer larval identity through DNA barcoding (Palero *et al.*, 2009c). Finally, the definitive identification of the scyllarinid larvae will stimulate new research on the life history of the members of the Scyllaridae family and provide a great chance to infer the evolution of the larval form in a well-defined group of marine crustaceans.

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Correspondence should be addressed to:
F. Palero
Evolutionary Genetics
Institute of Science and Technology Austria (ISTA)
Am Campus 1, A–3400 Klosterneuburg, Austria
email: fpalero@ist.ac.at