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A new species of *Stephos* T.Scott, 1892 (Copepoda: Calanoida) from coastal waters of Sicily, Italy

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Abstract. *Stephos cryptospinosus* sp. nov., a new species of calanoid copepod, is described from Western Mediterranean coastal waters. It differs from other species of the genus in the structure of the fifth legs in both sexes, and in having a small spinous process on the posterolateral margins of the last prosomite in both sexes.

Introduction

The genus *Stephos* T.Scott, 1892 currently comprises 23 species, all generally of small body size. They live in shallow coastal waters close to the bottom, where they can be caught by dredges and sledges designed to sample the hyperbenthic community. Occasionally, they occur higher up in the water column and are caught in plankton nets (Fosshagen, 1970). Recently, species of *Stephos* have been found in anchihaline caves on Atlantic islands (Boxshall *et al.,* 1990) and Mediterranean islands (Riera *et al.,* 1991; Carola and Razouls, 1996). From a biogeographic point of view, the genus *Stephos* ranges widely throughout the North Atlantic and adjacent waters (where most species have been found), and the Northern Indo-West Pacific. It occurs in temperate, tropical and polar waters.

Method

The specimens were collected from coastal waters of western Sicily (Stagnone di Marsala—37°52'N 12°28'E) in April, May and December 1996, and January 1997 (during daytime). Furthermore, three day-night surveys were carried out in July and October 19% and March 1997; samples were collected every 3 h during 24 h cycles.

Samples were obtained using a subsurface plankton tow-net, towed horizontally near the coast, at a depth of about 2-3 m, above a sandy-muddy bottom covered with *Cymodocea nodosa* (Ucria) Ascherson, *Caulerpa prolifera* (Forskal) Lamouroux and *Posidonia oceanica* (Linneo) Delile. The net was conical, with a length of 150 cm and a mouth 40 cm in diameter. The mesh size was 125 (am.

For SEM, specimens were washed in clean distilled water, dehydrated through an alcohol series to 100% ethanol and subsequently, critical-point-dried. The specimens were mounted on a stub, coated with carbon, and observed with a SEM LEO S420.

A dissected adult female was designated as the holotype. The type series is deposited in the Natural History Museum of London. The registration numbers are: 1999. 1751-1754.

The morphological terminology used follows Huys and Boxshall (Huys and Boxshall, 1991).

***Stephos cryptospinosus* sp. nov.**

Adult female (holotype)

Body length (Figure 1 A) 0.86 mm. Cephalosome rounded in dorsal view; rostrum absent. Cephalosome and first pedigerous somite separate. Fourth and fifth pedigerous somites completely fused, slightly asymmetrical, with rounded postero-lateral margins each bearing a small spinous process dorsolateral^ (Figure IB); process more visible on left side. Prosome about 2.77 times longer than urosome; prosome length/width ratio 2.14:1.00. Urosome 4-segmented (Figure 1C). Genital double-somite symmetrical; genital aperture closed off by single unarmed operculum located medially on the postero-ventral surface of the double somite (Figure 5a). First abdominal somite naked dorsally and just longer than second; latter ornamented with dense row of spinules along free posterior margin both dorsally (Figure 1C) and ventrally (Figure 5b). Anal somite short. Caudal rami slightly longer than broad, with fine setules along outer distal margin, bearing 4 marginal long plumose setae around distal margin and short plumose seta on inner margin.

Antennule (Figure ID) 24-segmented, extending just beyond posterior margin of prosome. Segments 1 (I—II) and 2 (III-IV) separated by functional articulation; segments 8 (X-XI) and 24 (XXVII-XXVIII) double. Armature pattern as follows: segment 1 (I-II) - 5, 2 (III-IV) -4 + 1 aesthetasc, 3 (V) - 2, 4 (VI) - 2, 5 (VII) - 2 + 1 aesthetasc, 6 (VIII) - 2, 7 (IX) - 2, 8 (X-XI) -4 + 1 aesthetasc, 9 (XII) - 1, 10 (XIII) -1,11 (XIV) -2 + 1 aesthetasc, 12 (XV) -1,13 (XVI) -2 + 1 aesthetasc, 14 (XVII) - 1, 15 (XVIII) - 1, 16 (XIX) - 1, 17 (XX) - 1, 18 (XXI) -1 + 1 aesthetasc, 19 (XXII) -1,20 (XXIII) -1,21 (XXIV) -2,22 (XXV) -2,23 (XXVI) - 2,24 (XXVII-XXVIII) -4 + 1 aesthetasc. First segment bearing patch of minute spinules on ventral surface (Figure 6a); small comb of minute spinules present on ventral surface of each segment from 1 to 23 (Figure 6b), except for segment 11 (Figure 6c). Comb on segment 2 located mid segment; from 3 to 10, near distal margin; from 12 to 23, near proximal margin and smaller than those on segments 1 to 10. Combs of spinules very small, best observed using SEM.

Antenna (Figure 2A) biramous: coxa and basis clearly separate, bearing 1 and 2 setae, respectively. Endopod 2-segmented, proximal segment with 2 setae; compound distal segment with 8 setae on lateral lobe and 8 setae apically. Exopod 6-segmented, segments 1 and 2 bearing 2 setae each, segment 3 with 1 seta, segment 4 with 2 setae, segment 5 with 1 seta, segment 6 with 1 proximal seta and 3 distal setae.

Mandible (Figure 2B) with cutting edge of gnathobase bearing 9 cuspidate teeth and 1 seta. Palp biramous; basis with 4 setae of unequal lengths along inner margin; endopod bearing 4 setae on proximal segment and 11 setae on distal segment; exopod 4-segmented, segments 1 to 3 each with 1 seta, segment 4 bearing 3 apical setae.

Maxillule (Figure 2C) well developed; praecoxa with endite bearing 9 strong spines and 4 sub-marginal slender setae. Coxa with 3 setae on endite; epipodite with 9 setae. Basis with 4 setae on proximal endite and 5 setae on distal endite.

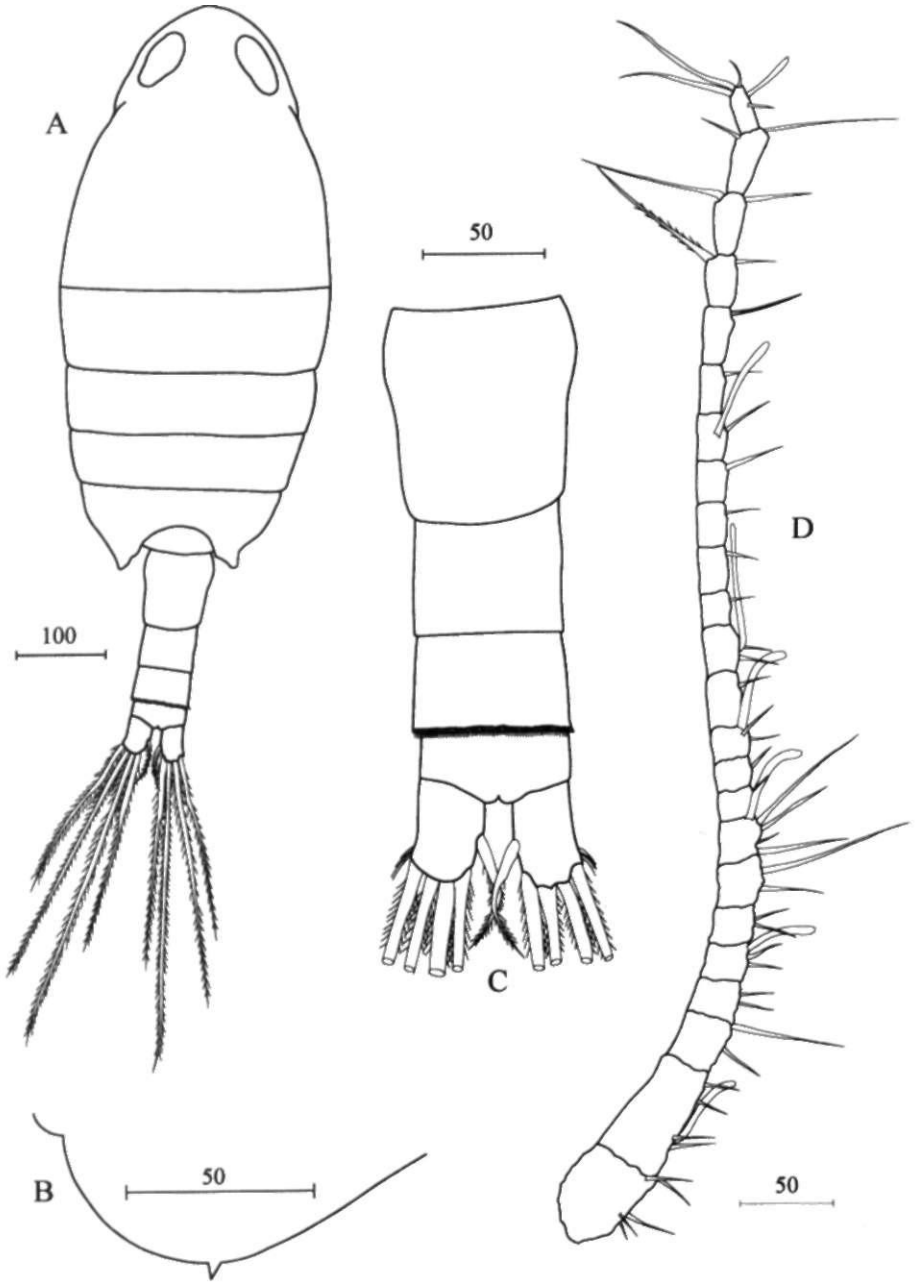

Fig. 1. *Stephos cryptospinosus* sp.nov., female: (**A**) dorsal view; (**B**) posterolateral margin of fifth pedigerous somite; (**C**) urosome, dorsal view; (**D**) Antennule. All scales in µm.

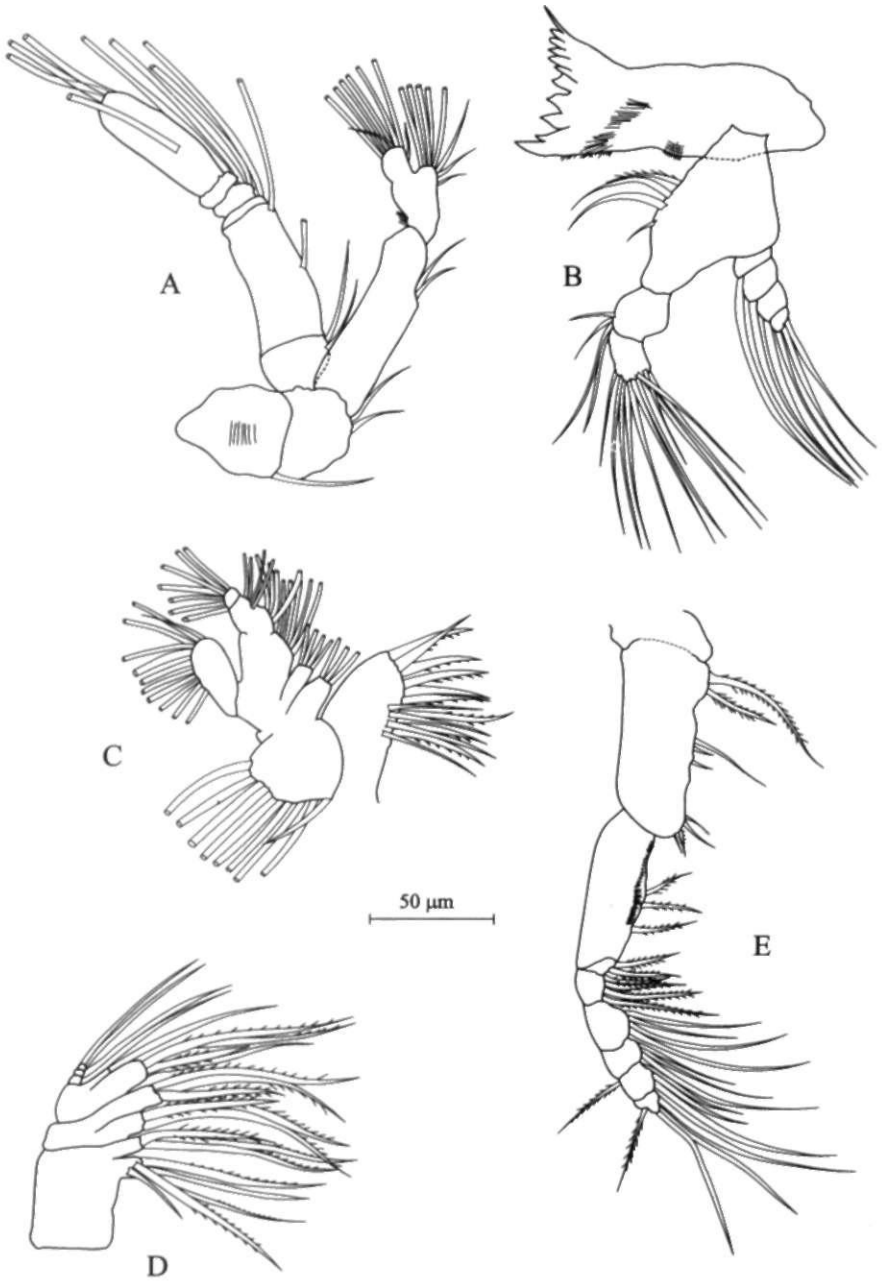

Fig. 2. *Stephos cryptospinosus* sp. nov., female: (**A**) antenna; (**B**) mandible; (**C**) maxillule; (**D**) maxilla; (**E**) maxilliped.

Proximal endopod segment double, bearing proximal and distal groups of 4 setae each on inner margin; apical segment with 7 setae. Exopod bearing 11 plumose setae along lateral and distal margins.

Maxilla (Figure 2D) with proximal praecoxal endite bearing 1 short and 4 long setae, distal endite with 3 setae; both coxal endites with 1 stout and 2 slender setae. Basis and first endopodal segment fused to form allobasis; proximal (basal) endite with 1 stout and 3 slender setae; distal endite (derived from first endopodal segment) with 1 seta. Free endopod 3-segmented, segments 1 and 2 each bearing 1 seta, segment 3 with 2 setae.

Maxilliped (Figure 2E) indistinctly 9-segmented; praecoxa and coxa apparently separate. Coxa bearing groups of 2, 3 and 4 setae along inner margin representing endites. Basis bearing 3 setae on inner margin and 2 setae distally, derived from incorporated first endopodal segment. Basis ornamented with row of short spinules along inner margin. Free endopod 5-segmented; first and second segments each bearing 4 inner marginal setae; third segment with 3 inner setae, fourth segment with 3 inner and 1 outer seta; fifth segment with 4 setae.

Swimming legs with 3-segmented exopods; endopod 1-segmented in leg 1, 2-segmented in leg 2, and 3-segmented in legs 3 and 4 (Figure 3A, B, C and D). Spine and seta formula of swimming legs shown in Table I. Leg 1 with long curved inner seta on basis, and endopod with lobe on outer margin, bearing minute spinous process. Leg 3 with patch of minute spinules on outer coxal margin.

Fifth legs (Figure 3E) uniramous, 2-segmented, nearly symmetrical. Proximal transverse plate representing fused coxae and intercoxal sclerite. First free segment (basis) of leg naked. Second segment armed with spine in mid part; distal part of both legs with finely serrated fringe on outer margin; inner margin with 6 spinules on left side and from 1 to 4, but usually 3 spinules, on right side.

Adult male

Body (Figure 4A) 0.78 mm, slightly smaller and more slender than female. Cephalosome and first pedigerous somite separate; fourth and fifth pedigerous somite fused; posterolateral margins of prosome symmetrical, bearing minute spine dorsolateral^ on both sides. Rostrum absent. Prosome about 2.38 times longer than urosome. Prosome length/width ratio 2.12:1. Urosome 5-segmented (Figure 4B); genital somite symmetrical; first urosomal segment produced posteroventrally into short process; third abdominal somite ornamented with row of spinules both dorsally and ventrally along posterior margin. Caudal rami as in female.

Table I. Spine and seta formulae of legs 1-4 of *Stephos cryptospinosus* sp. nov.

	Coxa	Basis	Exopod	Endopod
Legl	0-0	0-1	0-0; 1-1; 1,1,3	0,2,3
Leg 2	0-1	0-0	1-1; 1-1; 111,1,4	0-1; 1,2,2
Leg 3	0-1	0-0	1-1; 1-1; 111,1,4	0-1; 0-1; 1,2,2
Leg 4	0-1	0-0	1-1; 1-1; 111,1,4	0-1; 0-1; 1,2,2

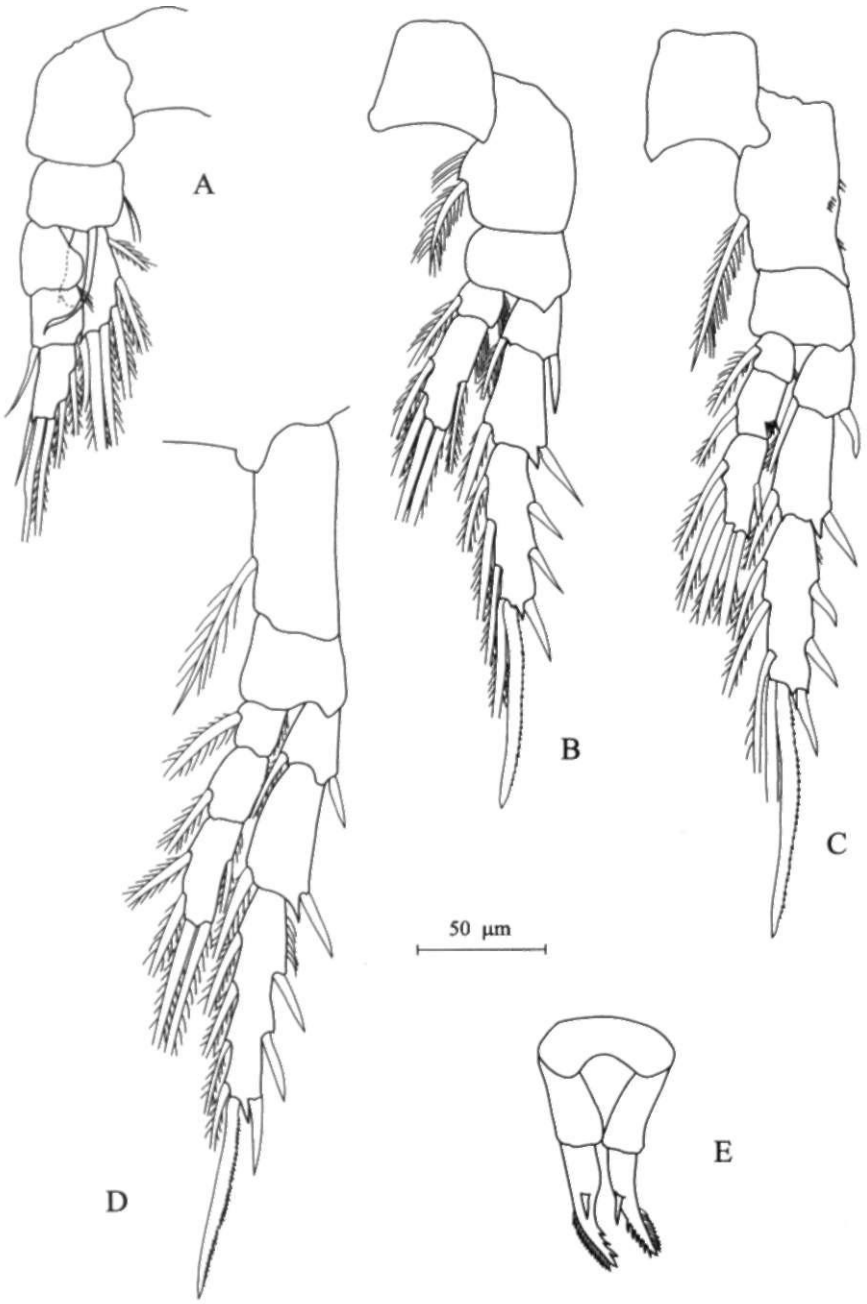

Fig. 3. *Stephos cryptospinosus* sp. nov., female: (**A**) first swimming leg; (**B**) second swimming leg; (**C**) third swimming leg; (**D**) fourth swimming leg; (**E**) fifth legs.

Antennule (Figure 4C) 24-segmented; extending approximately to posterior margin of genital somite.

Segmentation and setation patterns as follows: segment 1 (I—II) -5 + 2 aesthetascs, 2 (III-IV) -4 + 3 aesthetascs, 3 (V) - 2 + 1 aesthetasc, 4 (VI) - 2, 5 (VII) -1 + 1 aesthetasc, 6 (VIII) - 2, 7 (IX) -2 + 1 aesthetasc, 8 (X-XI) -4 + 1 aesthetasc, 9 (XII) - 1,10 (XIII) -1,11 (XIV) -2 + 1 aesthetasc, 12 (XV) -1,13 (XVI) -2 + 1 aesthetasc, 14 (XVII) - 1,15 (XVIII) - 1,16 (XIX) - 1,17 (XX) - 1 + 1 aesthetasc, 18 (XXI) -1 + 1 aesthetasc, 19 (XXII) - 1, 20 (XXIII) -1 + 1 aesthetasc, 21 (XXIV) -2 + 1 aesthetasc, 22 (XXV) - 2, 23 (XXVI) - 2, 24 (XXVII-XXVIII) -4 + 1 aesthetasc. Antennular aesthetascs thicker than in female. Small combs of spinules on segments as in female.

Mouthparts and swimming legs 1 to 4 as in female in segmentation and setation.

Fifth legs (Figure 4D) complex, elongate and markedly asymmetrical. Both legs uniramous. Right slender, 4-segmented; first and second segments short, unarmed; third segment elongate, bearing acute outer process near base, slightly curving inwards; fourth segment comprising 2 processes of unequal length, each bearing minute spine. Left leg 5-segmented, first to third segments short, unarmed; fourth segment strongly developed, bearing proximal tuft of setules on inner surface and two rounded inner margin processes, one midway of margin, other disposed distally. Fifth segment complex, with 4 long, wide lamellar spines, 2 long, narrow lamellar spines and 9 short, broad-based, lamellar spines.

Taxonomic remarks

The new species is readily distinguished from the rest of *Stephos* species by the structure of the fifth legs in both sexes and also by the presence of the minute spinous process on the posterolateral margins of the last pedigerous somite. This process is present on both sides but is more visible on the left side in both sexes.

Significant differences between the new species and the other three taxa present in the Mediterranean region are the presence on the second female abdominal somite of a dense row of spinules along the free posterior margin both dorsally and ventrally; the absence, on the genital female double somite, of spines that are present in *Stephos gyrans* Giesbrecht, 1892, and the shorter length of the female antennules compared with that of the Balearic species, *Stephos margalefi* Riera *et al.*, 1991, and *Stephos balearensis* Carola and Razouls, 1996. The new species can also be distinguished from the foregoing species by the structure of the female and male fifth legs.

The fifth legs of the female of the new species are similar to those of *S.pacificus* Ohtsuka and Hiromi, 1987, but differ in having the terminal segment armed with a spine on the middle part, and also in displaying a different spinulation on the apical inner margin. The left fifth leg of the male of the new species is similar to that of *S.robustus* Ohtsuka and Hiromi, 1987, but differs in lacking the large bifurcate spine on the inner margin, and in the presence of a complex cristate formation on the distal margin on the subapical segment. The two species also differ in the number of lamellar spines on the apical segment of the left leg. In

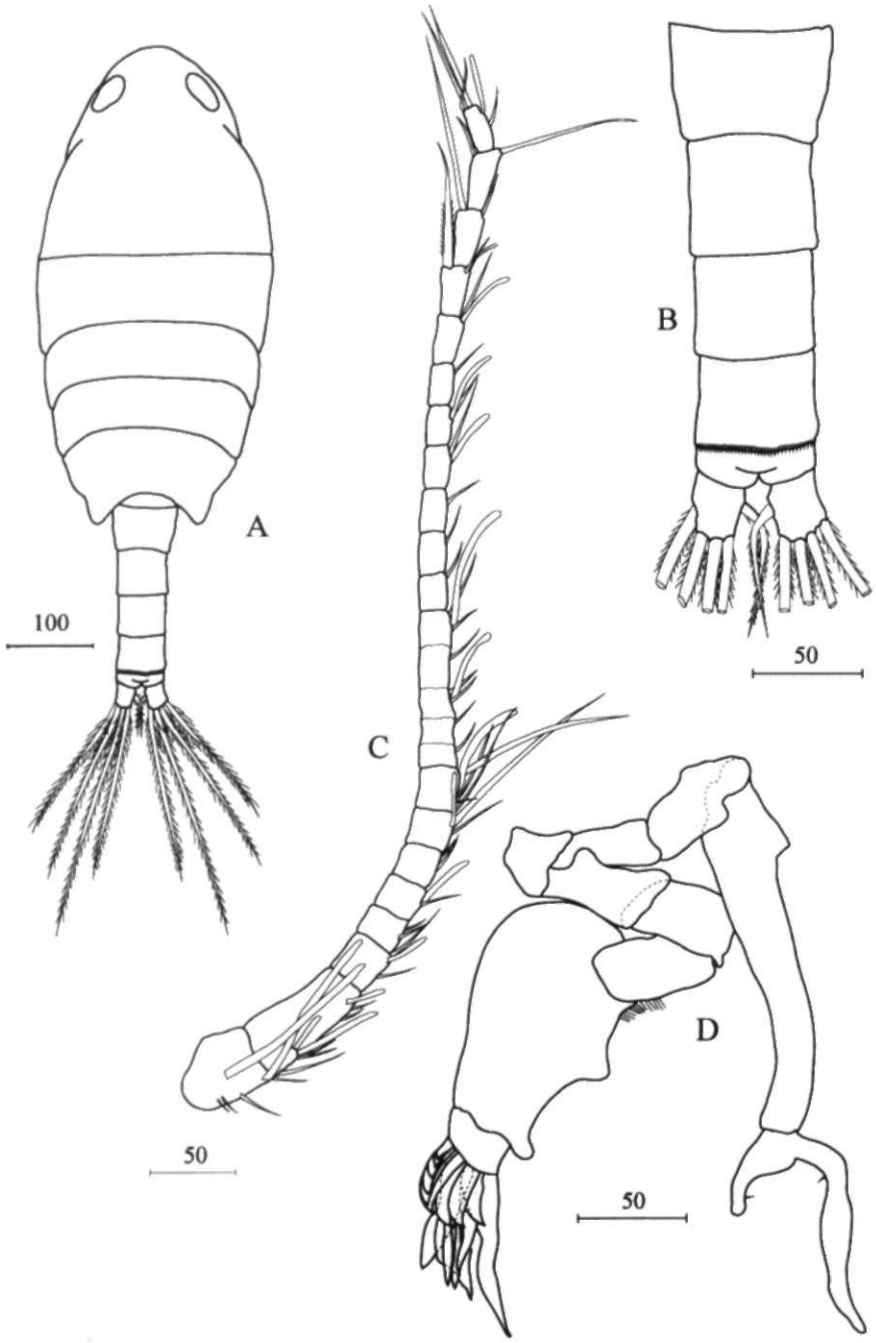

Fig. 4. *Stephos cryptospinosus* sp. nov., male: (**A**) dorsal view; (**B**) urosome dorsal view; (**C**) antennule; (**D**) fifth legs. All scales in μm.

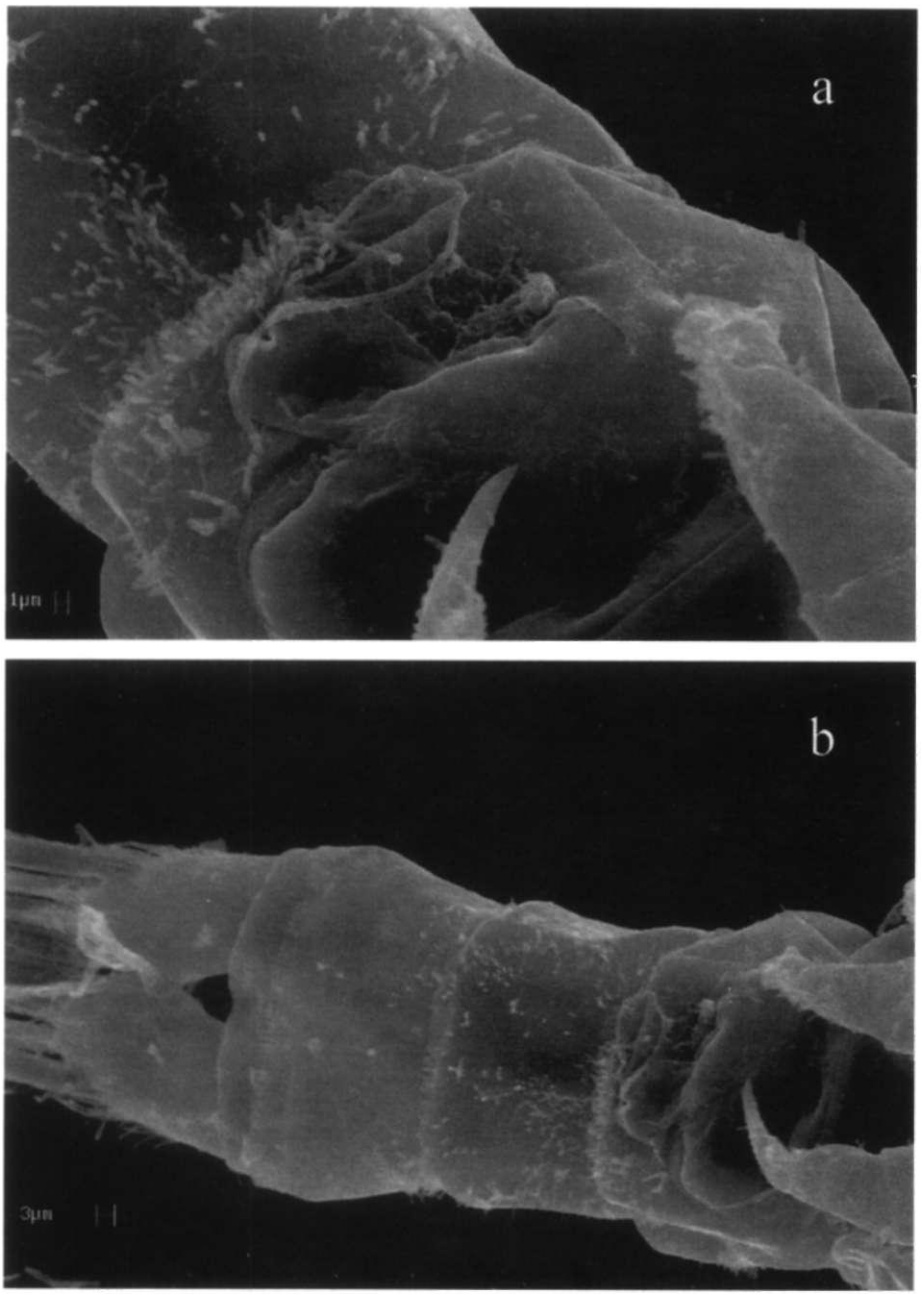

Fig. 5. ***Stephos cryptospinosus*** **sp. nov., female, scanning electron micrographs, (a) Genital aperture; (b) urosome, ventral view.**

addition, the new species can be distinguished from *S.robustus* by the armature of the male antennule. Thus, the antennule segments 1 and 2 of *S.robustus* carry only one aesthetasc on the second segment. In *S.cryptospinosus* sp. nov., the antennule segments 1 and 2 bear, respectively, two and three aesthetascs. The new species is further distinguished from the foregoing species by its symmetrical female genital double-somite and by the different urosome ornamentation in both sexes.

In the new species, SEM observations have allowed us to identify the presence of combs of spinules from antennule segments 1 to 23, with the exception of segment 11. This pattern of antennule ornamentation is very similar to that of *S.pacificus* and *S.robustus* (Ohtsuka and Hiromi, 1987), but with some minute differences. In *S.pacificus,* combs of spinules are lacking on antennule segments 4 (VI) and 11 (XIV) while in *S.robustus,* segments 3 (V), 4 (VI), 10 (XIII) and 11 (XIV), as well as the ornamental elements of antennule segments 12 (XV) to 23 (XXVI), are described as lamellar plates. However, it is possible that (i) the putative lamellar plates of the antennule in the foregoing species could really be smaller combs of spinules glued together by organic detritus (as in Figure 6d), and (ii) the reported lack of combs of spinules on segment 4 (VI) of *S.pacificus* and on segments 3 (V), 4 (VI) and 10 (XIII) of *S.robustus,* could be due to mistaken observations on account of their very small size. If this were true, two different lines could be hypothesized in *Stephos* based on the data on the ornamentation of the antennule segments available in the literature. The first line would display combs of spinules from antennule segments 1 (I—II) to 23 (XXVI) with the exception of 11 (XIV), while the second line would present combs of spinules from antennule segments 12 (XV) to 21 (XXIV), as described for *S.canariensis* [see (Boxshall *et al.,* 1990)]. These models could indicate phylogenetic affinities and would have interesting implications for the interpretation of the geographic distribution of the species of *Stephos.*

Etymology. The specific name *cryptospinosus* has been chosen because the last prosomite has a small spinous process hardly visible on both sides.

Discussion

Most *S.cryptospinosus* were collected during night sampling, suggesting that this hyperbenthic copepod could effect daily vertical migrations. *Stephos kurilensis* (Kos, 1972) and *S.robustus* (Ohtsuka and Hiromi, 1987) were recorded from coastal waters in plankton samples taken at night.

The upward migratory behaviour is a complex phenomenon related to factors such as feeding, reproduction, moulting, dispersal and niche diversification (Alldredge and King, 1980).

The recovery, in addition to *S.cryptospinosus,* of two other new hyperbenthic species (not yet published) belonging to the genera *Stephos* and *Paramisophria,* T.Scott, 1897, together with *Metacalanus acutioperculum* (Ohtsuka, 1984) and *Ridgewayia marki minorcaensis* (Razouls and Carola, 1996), is particularly interesting with regard both to their biogeography and evolutionary history

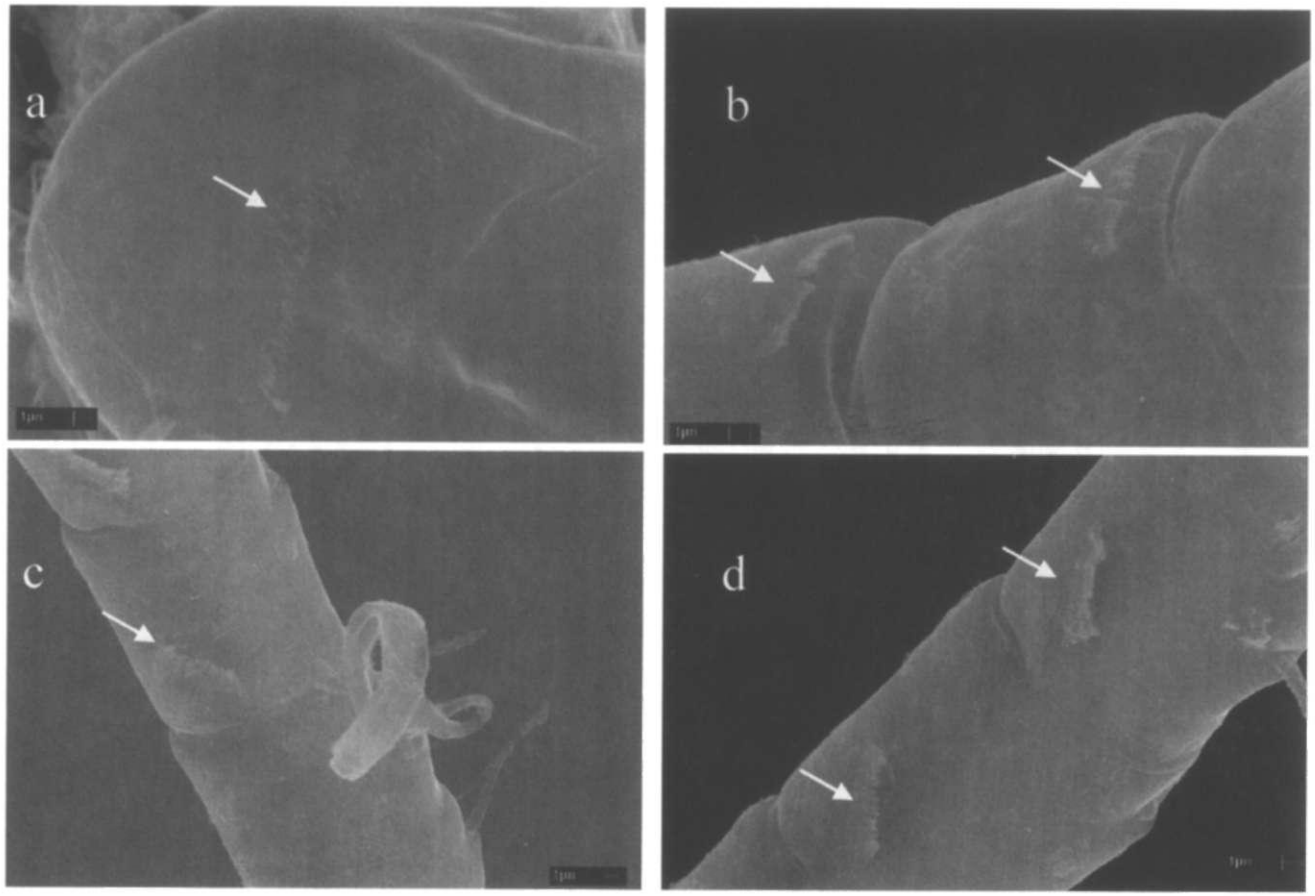

Fig. 6. *Stephos cryptospinosus* sp. nov., female, scanning electron micrographs. (**a**) Antennule segment 1; (**b**) segments 4 and 5; (**c**) segments 11 and 12; (**d**) segments 12 and 13, showing comb of spinules (arrowed) on ventral surface.

(Campolmi, 1998; Campolmi *et al.*, 1999). The species *S.cryptospinosus, Stephos* sp. and *Paramisophria* sp. have morphological characters that link them phylogenetically with *S.pacificus, S.robustus* (Ohtsuka and Hiromi, 1987), and *Paramisophria reducta* (Ohtsuka *et al.*, 1993), respectively. The latter two species of *Stephos,* together with *M.acutioperculum,* are distributed in the Indo-Pacific Ocean. *Ridgewayi marki* and *Preducta,* on the contrary, are distributed in the Western and Eastern areas of the Atlantic Ocean, respectively. In addition, *R.marki minorcaensis* has recently been recorded also from the Western Mediterranean (Razouls and Carola, 1996).

The separation and isolation of these species of hyperbenthic copepods as a result of continental drift, interrupting gene flow between the ancient populations, may have encouraged allopatric speciation. Following separate evolutionary lineages, they constitute the current hyperbenthic copepod fauna of the Mediterranean.

These observations suggest that the present hyperbenthic copepod populations of the Mediterranean possess both their own original characters that distinguish them from the populations of the Atlantic and Indo-Pacific Oceans, and characters that are common to all the populations. The strong geographical isolation of the foregoing hyperbenthic species, due to their particular habitat, raises some interesting questions on their primary habitat and subsequent spread.

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