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Spiochaetopterus creoceanae, a new species of Chaetopteridae (Polychaeta) from the Persian Gulf belonging to the *costarum* complex*

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SUMMARY: Examination of a collection of Chaetopteridae (Annelida: Polychaeta) from the Iranian coast of the Persian Gulf led to the erection of a new species of *Spiochaetopterus*: *S. creoceanae* sp. nov. This is a small, oculate *Spiochaetopterus* with a single specialised, enlarged cutting seta on each A4 parapodium; this seta is roughly heart-shaped (cordate) in end view and with the outer lobe of the oblique section more developed than the inner one. The new species is mainly characterised by the presence of 10 segments in the anterior region, while all other species described to date have only 9. The description of this new species of *Spiochaetopterus* is a contribution to the growing evidence supporting the hypothesis that *Spiochaetopterus costarum*, formerly considered to be a cosmopolitan species, has in fact been used for several distinct species. In addition, the habitat preferences of the new species are also discussed.

Key words: new species, chaetopterid, Annelida, species complex, distribution, habitat preferences.

RESUMEN: *SPIOCHAETOPTERUS CREOCEANAE*, UNA NUEVA ESPECIE DE CHAETOPTERIDAE (POLYCHAETA) DEL GOLFO PÉRSICO, PERTENECIENTE AL COMPLEJO *COSTARUM*. – El estudio de una colección de Chaetopteridae (Annelida: Polychaeta) procedente de la costa iraniana del Golfo Pérsico nos ha llevado a describir una especie nueva de *Spiochaetopterus*: *S. creoceanae* sp. nov. Se trata de una especie pequeña, provista de ojos y con una única seda especializada en cada parápodo A4. dicha seda, vista apicalmente, es acorazonada y presenta el lóbulo externo de la sección oblicua más desarrollado que el interno. La característica principal de la nueva especie es, sin embargo, la presencia de 10 segmentos en la región anterior, mientras que las especies descritas con anterioridad poseen sólo 9. La descripción de esta nueva especie es una contribución adicional al constante incremento de pruebas que evidencian que *Spiochaetopterus costarum*, anteriormente considerada como una especie cosmopolita, se ha venido usando para denominar lo que, de hecho, han resultado ser especies distintas. Asimismo, se discuten las características del hábitat de la nueva especie.

Palabras clave: especie nueva, quetoptérido, Annelida, complejo de especies, distribución, preferencias de hábitat.

INTRODUCTION

The chaetopterid polychaete *Spiochaetopterus costarum* (Claparède, 1868) was traditionally considered a cosmopolitan species (Okuda, 1935; Day, 1967; Blake, 1996). Recently, however, Bhaud (1998a) showed the existence of similar but clearly different species on both western and eastern coasts of the North Atlantic Ocean, where previous studies had only reported different subspecies of *S. costarum* (Gitay, 1969). Accordingly, Bhaud

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(1998a) pointed out the limited geographical distribution of adult populations, in spite of the possible ability of their planktonic larvae to disseminate throughout the whole ocean.

Careful observations have been addressed to the available specimens corresponding to the multiple worldwide reports of *S. costarum*. As a consequence, marked morphological differences have been identified, supporting the existence of distinct species of *Spiochaetopterus* in geographical areas as diverse as Japan (Nishi *et al.*, 1999; Nishi and Bhaud, 2000), Brazil (Bhaud and Petti, 2001), the Yellow Sea (Bhaud *et al.*, 2002) and the Persian Gulf (present paper).

Based on the previous knowledge of the relevant morphological characters distinguishing the different species within the genus *Spiochaetopterus*, the present paper describes a new species, *S. creoceanae*, from the Iranian coast of the Persian Gulf. Additional data on the habitat preferences of the new species at the study site are also provided.

MATERIALS AND METHODS

Samples were taken by the French company CREOCEAN with a van Veen grab of about 0.1 m^2, as part of an environmental baseline study carried out off Asaluyeh and Nakhl e Taqi (Iranian shoreline of the Persian Gulf) during August 1998. Among the sediment samples collected for this study, 7 contained specimens of the new species (Table 1). The density of worms was estimated on the basis of a total sampling area of 0.3 m^2 (i.e. three grabs). The grab contents were mixed in a sufficiently large container, and then sieved out on board by pouring the contents through a 1 mm mesh sieve. The retained sediment was then transferred to a plastic bag, fixed with a 4% formaldehyde/seawater solution, stained with Rose Bengal and stored until sorted. An initial sorting was done under a stereomicroscope (Zeiss Stemi 2000-C) to separate the tubes containing *Spiochaetopterus* worms, which were then counted to express their densities as number of individuals per m^2, from the empty tubes.

For the morphological observations, more than 50 worms were carefully extracted by cutting their tubes under the stereomicroscope. Size measurements were estimated for the 20 most complete worms. For light microscope observations (LM), the specimens were placed on slides with a solution of glycerine and distilled water. LM drawings were made with a Wild M3Z compound microscope equipped with a camera lucida. LM micrographs of uncini were made by dissecting a fragment from a parapodium and squashing it directly between the slides. The LM micrograph of a region-C parapodium was obtained after simple dissection. LM micrographs of a tube were made on empty fragments. LM micrographs were made with a Leica-Wild MPS 32 through a Diaplan Leitz LM or through a Wild M3Z compound microscope.

For SEM observations of the specialized, enlarged cutting setae (referred to as "the specialized setae"), an A4 parapodium was dissected from the body and isolated in a glass dish containing a nearly saturated solution of potassium peroxide. Once transparent (about 12 hours later), the parapodia were rinsed with distilled water, dissected and the specialised seta was removed by slight pressure with fine forceps under a compound microscope. The isolated setae were then rinsed three times in distilled water (30 min each), run through a series of ethanol concentrations, and stored in 90% ethanol until observation. Immediately prior to viewing in a Hitachi S.520 SEM (University of Perpignan, Centre of Electron Microscopy), they were transferred to 100% alcohol, critical-point dried, attached to a stub, and coated.

The morphological description of the new species is structured in three different sections corresponding to the three body regions that charac-

TABLE 1. – *Spiochaetopterus creoceanae* sp. nov. Geographical location of the sampling stations and main environmental parameters of the inhabited sediments. The asterisk indicates the Type Locality for the new species.

Station	Coordinates North	Coordinates East	Depth (m)	Gravel (%)	Silt (%)	Organic Matter (%)	Pore water (%)	Density (ind. m^{-2})
8	52°33.574'	27°30.229'	19	45.1	7.84	3.4	24.5	350
9	52°33.323'	27°30.064'	21	41.6	7.17	4	23.6	3
13	52°33.831'	27°29.948'	15	45.9	5.96	3.7	20.8	520
14	52°33.591'	27°29.677'	19	52	4.41	3.6	26.3	427
18*	52°33.244'	27°29.406'	16	46.2	3.9	3.2	19.7	2693
19	52°34.003'	27°29.156'	19	34.9	5.81	3.3	26.3	423
24	52°34.168'	27°28.797'	18	22.4	6.85	2.7	30.4	3

terise the genus *Spiochaetopterus*: Anterior (region-A), mid-body (region-B) and posterior region (region-C) following Bhaud *et al.* (1994). Thus, for instance, A4 = setiger 4 in region-A and 10A = 10 setigers in region-A. As all specimens were incomplete, the potential length for the maximum number of setigers at region-C was estimated on the basis of the only 4 specimens having measurable segments. Potential length for region C is then given as an average.

RESULTS

Systematic account

Family CHAETOPTERIDAE
Spiochaetopterus Sars, 1853

Spiochaetopterus creoceanae sp. nov.
(Figs. 1, 2)

Material examined. A total of 1325 specimens were collected by E. Dutrieux off Asaluyeh and Nakhl e Taqi, north Nay Band Bay, 250 km south of Bandar Bousher, Iranian shoreline along the east coast of the Persian Gulf (Table 1). Among the 7 stations containing the new species, the most densely populated one, station 18, is designated the type locality.

Type material. Holotype: Museo Nacional de Historia Natural, Madrid, number MNCN 16.01/9023a; paratypes: Museo Nacional de Historia Natural, Madrid, number MNCN 16.01./9023b. The remaining specimens are in the authors' collections.

Etymology. The specific name refers to CREOCEAN (France), the company responsible for the environmental survey, which collected the samples with the new species.

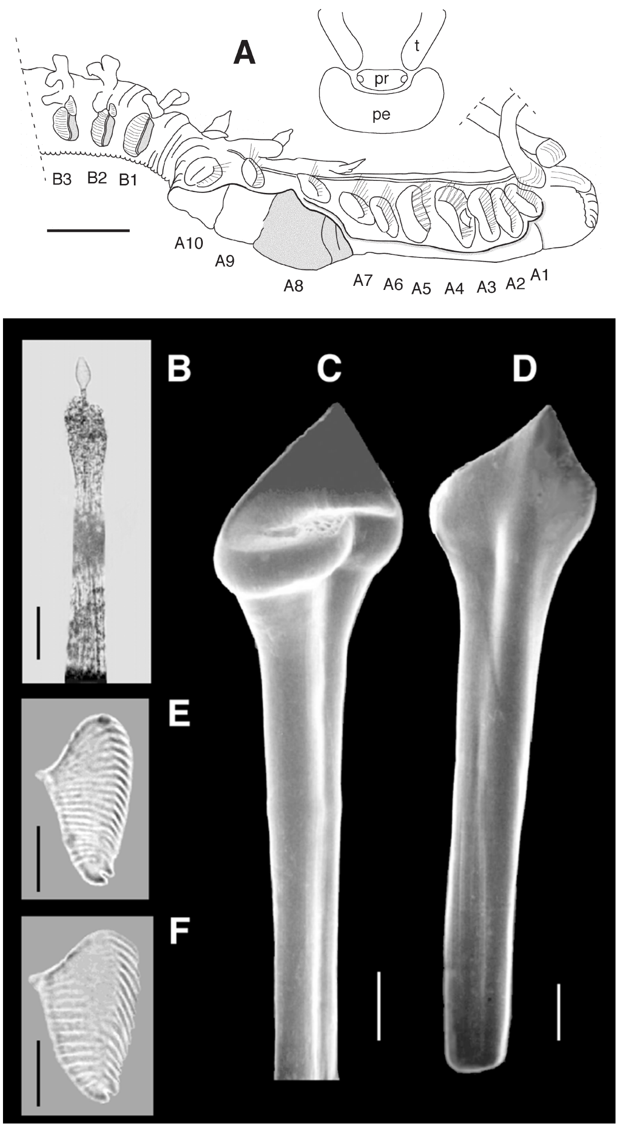

FIG. 1. – *Spiochaetopterus creoceanae* sp. nov. **A**, Anterior end drawn from SEM picture (the A4 specialized setae may be seen in apical view), including a frontal view of pr (prostomium with the two eyespots) and pe (peristomium) and a dorsal view of t (tentacles); **B**, Notopodia of region-C; **C-D**, Specialized A4 seta in ventral (C) and dorsal (D) views; **E-F**, Uncinal plates of segment B1. Scale bars: A = 1 mm; B = 30 µm; C, D = 50 µm; E, F = 8.5 µm.

Species diagnosis. A large, oculate *Spiochaetopterus* with 10A (invariate) + up to 27B + at least 43C (all specimens incomplete), measuring up to 28 mm long and 0.76 mm wide for over 79 segments. A4 specialised seta enlarged asymmetrically (cordate), heart-shaped in distal view; shaft with two grooves, a ventral one all along its length and another on dorsal face, just below the more developed lobe. Neuropodia uniramous on B1 and biramous on all remaining setigers. Tube unbranched, smooth, transparent, with distinct articulations, 750-800 µm in diameter.

Description:

Region-A (Fig. 1A). All examined specimens with 10A (n = 53). Region-A measuring 0.69 ± 0.063 mm wide and 3.89 ± 0.41 mm long (n = 20). Peristomium horseshoe, surrounding the prostomium ventrally and laterally. Prostomium blunt, relatively broad frontally. Both prostomium and peristomium finish at same level. Two well-separated black ocular spots are located facing the tentacles, on the lateral edge of the prostomium. Ventral shield long, divided into several sections, each with a different colour on preserved specimens. Glandular tissues occasionally pink to reddish due to the use of Rose Bengal during the sample fixation process. The ventral surfaces of both peristomium and A1 have a whitish glandular tissue; a white, non-glandular circle is present at the level of A1 and A2; from A2 to A7, the surface is whitish and glandular again. These glandular areas can only be distinguished from non-glandular ones in stained worms; otherwise, all of them look whitish. At the level of A7, there is a brownish crescent-like structure, extending just after A8. The height of this structure is variable: low in the anterior part (at the level of A7), maximum at the level of A8 and decreasing towards the posterior part. The ventral surface is then occupied by a series of white areas, which may be divided into two parts: a nacreous-whitish crescent up to A9 and a pale white crescent up to A10. The brown ventral shield is indistinct to the naked eye, unlike the white region which is clearly distinguishable. A longitudinal line on each side of region-A, extending from A1 to A8, defines the ventral limit between the muscular masses, which are responsible for setal functioning, and the ventral shield. This line describes an arch with the ventral surface.

Region-B (Fig. 1A). This region always has more than 2 segments, with a maximum of 27 (average 11.5 ± 2.4 mm in length, n = 18), each with two rami. The notopodia, like in many other species, have a bilobed Y-shaped inner part and a small unilobed foliaceous outer part. The neuropodia are unilobed on B1 and bilobed on B2 and following segments, always transversally oriented.

Region-C (Fig. 1B). A maximum of 43 segments were observed in this region, with a potential maximum length of 14.2 ± 2.9 mm (n = 4). The structure of both noto- and neuropodia is the typical one of the genus. The notopodia are erect, slightly inflated distally, with no or 1 particularly evident lancet-like notoseta projecting outside the terminal lobe. The neuropodia have two fleshy lobes bearing uncini: an upper, short, anteriorly directed lobe and a lower, posteriorly oriented, vertically extended lobe, as on neuropodia posterior to segment B2**.** Mature segments were observed in region-C.

Specialised seta of A4 (Fig. 1C, D). Each A4 parapodium has a single straw-coloured to yellowish specialised seta, with a swollen, obliquely truncated distal end, which is roughly heart-shaped (cordate) in distal view. The outer lobe of the oblique section is more developed than the inner one. The setal shaft has a ventral groove all along its length and another groove on the dorsal face just below the more developed lobe.

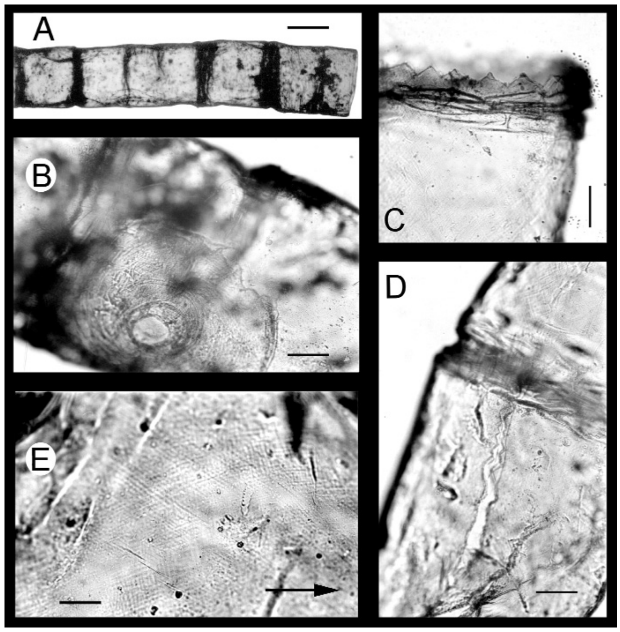

FIG. 2. – *Spiochaetopterus creoceanae* sp. nov. Tube. **A**, Part of the tube with marked joints, observed at low magnification; **B**, A one-hole septum removed by the worm and then attached to the tube wall; **C**, Serrated opening at border between two successive tube sections; **D**, Lengthwise tear; **E**, Traces of the two directions of mucus-layer deposition, observed at high magnification: arrow indicates top direction. Scale bars: A = 400 µm; B = 100 µm; C, D = 115 µm; E = 80 µm.

Uncini (Fig. 1E, F). Uncini elongate-triangular, particularly small (22 µm long, 12-13.5 µm wide at B1; 20 µm long, 11.8-12 µm wide on last segments of region-C). The number of uncini vary between 340 at B1 and 20-30 at the last setigers of region-C (but being only 4-10 in pre-pygidial setigers). The teeth are small but visible under 100x magnifications. There are 15 to 17 teeth, 8 of which are located on the straight median section (of 10 µm in length).

Tube (Fig. 2A–E). Tube unbranched, smooth, transparent, with distinct articulations and 750-800 µm in diameter. Several free transverse partitions with a single, median hole are observed inside the tube. The differences observed in tube transparency are directly related to the number of mucopolysaccharide layers (i.e. fewer in the more transparent tubes). Longitudinal and transverse serration marks may be observed between two successive tube sections.

Biological remarks

Some specimens have intra-coelomic oocytes (80-85 µm in diameter), but neither the extent of the reproductive period nor the current phase of the cycle can be determined due to the brevity of the collecting period. For the same reason, it is not known whether the species reproduces asexually or not. However, there is only one worm inside each tube and no signs of regeneration are observed.

Ecological remarks

The characteristics of the water column over the type locality during the sampling period (i.e. August) may be summarised as follows: temperature ranging from 35°C (bottom) to 36.8°C (surface), water salinity always around 37‰, water turbidity ranging from 2.5 mg (surface) to 6.5 mg (bottom) of suspended solids per litre. The density of *S. creoceanae* sp. nov. (average of 630 ind. m^{-2}) was characterised by a patchy distribution, with a maximum of more than 2600 ind. m^{-2} at a single station, surrounded by areas with intermediate densities (430 ± 70 ind. m^{-2}), and a few sites far from the main station having less than 5 ind. m^{-2} (Table 1). Along the Iranian coast, hard bottoms are often present from the beach shoreline down to 12-15 m in depth. In most cases, the limestone rock is covered with dead coral colonies (Price *et al.*, 1993). At the study site, the population of *S. creoceanae* sp. nov. was mainly located seaward of this dead coral reef barrier. The presence of hard bottoms near the shoreline prevented the worms from occurring in shallower bottoms (i.e. less than 15 m deep). Thus, the population was mainly concentrated at medium-depth bottoms (around 17.6 ± 1.9 m in depth). These bottoms were characterised by having compact sediments with low contents of silt, pore water and organic matter (average of 5.6 ± 1.6%, 23.5 ± 3.1% and 3.4 ± 0.2% respectively) and intermediate values for gravel content (average of 44.8 ± 6.2%) (Table 1). The worms were absent in all samples below 20 m in depth.

DISCUSSION

The Persian Gulf has been considered as a concentration basin (Tchernia, 1978), in which the evaporation processes dominate the evaporation/rainfall ratio (Sheppard *et al.*, 1992). Seawater thus tends to be salty and warm. The hydrological spatial and temporal gradients are usually marked and sometimes complex, often showing extreme temperatures and salinities (high or low depending on the season). Although the local environmental data registered during this study cannot be extrapolated to the whole year, they certainly correspond to ecological conditions that may be considered as extreme for marine life. The water column over the area inhabited by the studied population of *Spiochaetopterus creoceanae* sp. nov. was characterised by a very low oxygen concentration (Eric Dutrieux, pers. comm.), as well as by high salinity rates and extreme seasonal thermal oscillations (which are particularly high in summer). The observed bathymetrical differences in temperature and salinity (both being slightly higher at the surface) cannot be attributed to a real water-mass stratification. As occurs in the whole Gulf, the influence of a high irradiation level is probably a better explanation. The only significant difference with depth was the high content in suspended matter near the bottom. As in the whole Gulf (Sheppard, 1993), continental inputs seldom occur in the study site during summer (E. Dutrieux, pers. comm.). Thus, the presence of particulate matter can probably be attributed to hydrographical processes causing a slight but significant increase of re-suspension near the bottom.

Among the corresponding habitat preferences of *Spiochaetopterus creoceanae* sp. nov., the low organic matter content in the sediments was particularly relevant. Recent studies carried out in a Galician estuary (NW Atlantic coast of the Iberian peninsula) on a population refering to *Spiochaetopterus costarum* postulated that the species could be considered as an indicator of organically polluted sediments (López-Jamar, 1985; Nozais, 1991). The main reason was the observation of a gradient of decreasing density towards the mouth of the estuary, in parallel with decreasing silt and organic matter content in the sediment. A more reliable explanation, however, could be a reduction of larval losses inside the estuary. In fact, some topographical conditions particularly favourable to the existence of a hydrographical regime may generate retention structures, as reported in other species with a theoretically high dispersal capability linked to long-living planktonic larvae (Bhaud, 1998b). Although our study did not allow us to define the existence of retentive hydrographical structures, the presence of a nearby harbour at Nakhl e Taqi, as well as the particular position of the dead coral reefs facing the studied shoreline, may support their possible presence. More likely, the main concentration of worms could be explained by the combination of an adequate hydrographical regime, suitable sediments and protection by the hard bottoms and coral reefs.

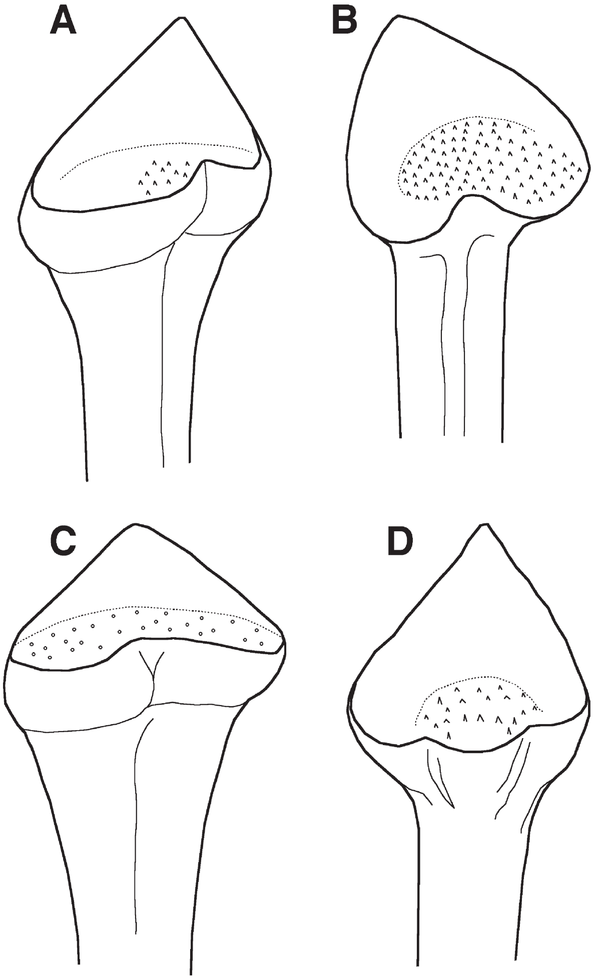

FIG. 3. – Comparison of A4 specialized setae of the small-sized *Spiochaetopterus* species most closely resembling *S. creoceanae* sp. nov. (**A**): **B**, *S. solitarius*; **C**, *S. koreana*; **D**, *S. bergensis*.

At a larger geographical scale, the circulation pattern in the Persian Gulf is characterised by a main current coming from the Strait of Ormuz and drifting along the Iranian coastline towards the inner regions of the Gulf. The current then turns back and runs along the Arabian coast before again reaching the strait (Sheppard *et al.*, 1992). This pattern may certainly contribute to submitting the studied Iranian population to some degree of isolation inside the Gulf.

In fact, the morphological differences between *Spiochaetopterus creoceanae* sp. nov. and the previously known species of the genus cannot be underestimated and undoubtedly support the erection of the new taxon. The main difference between *S. creoceanae* and the other known species is the existence of 10 segments in the region-A. The new species belongs to the group of small-sized *Spiochaetopterus*, among which it closely resembles *S. solitarius* (Rioja, 1917), *S. bergensis* Gitay, 1969 and *S. koreana* Bhaud *et al.*, 2002. A second relevant character, the morphology of the A4 specialized setae, confirms the validity of the new species. Effectively, *S. creoceanae* has specialised setae roughly heart-shaped in distal view, with the outer lobe of the oblique section being more developed than the inner one. *S. solitarius* and *S. koreana* both have two similar-sized lobes while *S. bergensis* has three similar-sized lobes (Fig. 3).

The presence of a new species of *Spiochaetopterus* in the Persian Gulf is an additional evidence supporting the existence of phyletic radiations within the genus (Bhaud, 1998a). In fact, *Spiochaetopterus costarum*, which was considered as a single cosmopolitan species by several authors, turned out to be a complex species with a still undefined number of members (but probably more than 10-15 known to date). The main reasons that supported *S. costarum* as a cosmopolitan species were the existence of a long-living planktonic larva having a large dispersal ability (Scheltema, 1974), and too many authors willing to ignore specific differences. As was recently pointed out by Bhaud (1998b) for other polychaete species, the increasing number of descriptions of new species of *Spiochaetopterus* from all around the world (e.g. Japan, Brazil, Yellow Sea, Persian Gulf) strongly supports the existence of a discontinuity between the existence of long-living swimming larvae and the specific area of adult distribution. Thus, it seems evident that careful studies using different approaches (from classical but fine morphological observations to genetic analyses) should be carried out prior to attributing a cosmopolitan status to a given species.

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REFERENCES

Bhaud, M. – 1998a. Species of *Spiochaetopterus* (Polychaeta, Chaetopteridae) in the Atlantic-Mediterranean biogeographic area. *Sarsia*, 83: 243-263.

Bhaud, M. – 1998b. The spreading potential of polychaete larvae does not predict adult distributions, consequences for conditions of recruitment. *Hydrobiologia*, 375/376: 35-47.

Bhaud, M. and M. Petti. – 2001. *Spiochaetopterus nonatoi,* a new species of Chaetopteridae (Polychaeta) from Brazil: biogeographical consequences. *J. Mar. Biol. Assoc. U.K.*, 81: 225-234.

Bhaud, M., M.C. Lastra and M.E. Petersen. – 1994. Redescription of *Spiochaetopterus solitarius* (Rioja, 1917), with notes on tube structure and comments on the generic status (Polychaeta: Chaetopteridae). *Ophelia*, 40: 115-133.

Bhaud, M., B.S. Koh and J.S. Hong. – 2002. Contribution to the present status of *Spiochaetopterus costarum*: description of *Spiochaetopterus koreana*, a new species of Chaetopteridae (Polychaeta) from the West Coast of Korea. *Proc. Biol. Soc. Wash.*, 115: 350-358.

Blake, J.A. – 1996. Family Chaetopteridae Malmgren, 1867. In: J.A. Blake, B. Hilbig and P.H. Scott (eds.), *Taxonomic atlas of the benthic fauna of the Santa Maria Basin and Western Santa Barbara Channel*, pp. 233-251. Santa Barbara Museum of Natural History, Santa Barbara, California.

Day, J.H. – 1967. A monograph on the Polychaetes of Southern Africa. Part 1. Errantia. *T. British Mus. (Nat. Hist.)*, 656: 1-656.

Gitay, A. 1969. A contribution to the revision of *Spiochaetopterus* (Chaetopteridae, Polychaeta). *Sarsia* 37: 9-20.

López-Jamar, E. – 1985. Distribución espacial del poliqueto *Spiochaetopterus costarum* en las Rías Bajas de Galicia y su posible utilización como indicador de contaminación orgánica en el sedimento. *Bol. Inst. Esp. Oceanogr.*, 2: 68-76.

Nishi, E. and M. Bhaud. – 2000. Two new species of *Spiochaetopterus* (Polychaeta: Chaetopteridae) from Okinawa, Japan, with notes on Pacific *Spiochaetopterus*. *Pacif. Sci.*, 54: 15-26.

Nishi, E., T. Miura and M. Bhaud. – 1999. A new species of *Spiochaetopterus* (Chaetopteridae: Polychaeta) from a cold-seep site off Hatsushima in Sagami Bay, central Japan. *Proc. Biol. Soc. Wash.*, 112: 210–215.

Nozais, C. – 1991. *Téchniques actographiques appliquées à l'étude des performances des stades larvaires précoces*. D.E.A Océanographie biologique, Universitée P. et M. Curie (Paris VI).

Okuda, S. – 1935. Chaetopterids from Japanese waters. *J. Fac. Sci., Hokkaido Imp. Univ., Ser. 6, Zool.*, 4: 87-102.

Price, A.R.G., C.R.C. Sheppard and C.M. Roberts. – 1993. The Persian Gulf: its biological setting. *Mar. Poll. Bull.*, 27: 9-15.

Scheltema, R.S. – 1974. Relationship of dispersal to geographical distribution and morphological variation in the polychaete family Chaetopteridae. *Thalassia jugoslavic*a. 10(1-2): 297-312.

Sheppard, C.R.C. – 1993. Physical environment of the Persian gulf relevant to marine environment: an overview. *Mar. Poll. Bull.*, 27: 3-8.

Sheppard, C.R.C., A. Price and C.M. Roberts. – 1992. *Patterns and processes in extreme tropical environments: Marine ecology of the Arabian region*. Ed. Academic Press, London.

Tchernia, P. – 1978. Chaper VII. Océan Indien. *Oceanographie régionale. Description physique des océans et des mers*, pp. 165-210. E.P.H.E., Paris.

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