



A new *Spadella* (Chaetognatha) from shallow waters of La Graciosa (Lanzarote, Canary Islands). Biogeographical remarks

Jean-Paul CASANOVA and Xavier MOREAU¹

ER "Biodiversité et Environnement", Biologie animale (Plancton), case 18
3, Place Victor Hugo, 13331 Marseille cedex 3, France.

⁽¹⁾ Corresponding author, E-mail: xavier.moreau@up.univ-mrs.fr
Fax: 33+4. 91. 10. 62. 65.

Abstract: A small benthic chaetognath, *Spadella nunezi* sp. nov., living on organogenous sandy bottom of La Graciosa (Lanzarote, Canary Islands), is described. It is one of the smallest known species, and its narrow lateral fins, like the reduction of the pigment cell of the eyes, are probable indications of a more or less interstitial way of life. It is the third shallow benthic species known in the East side of the Atlantic Ocean. By comparison, the American side of this ocean has a higher diversity since it houses two genera and six species of benthic neritic chaetognaths. It is suggested that this relative richness results from the paleogeography, since the Caribbean Region was in relation with the Indo-Pacific Ocean, where the number of species is the highest in the world, before the erection of the Panama Isthmus.

Résumé : Un nouveau *Spadella* (*Chaetognatha*) des eaux côtières de la Graciosa (Lanzarote, Iles Canaries). Remarques biogéographiques. Un petit chaetognathe benthique, *Spadella nunezi* sp. nov., vivant sur les fonds de sable organogène de la Graciosa (Lanzarote, îles Canaries), est décrit. C'est l'une des plus petites espèces connues et ses nageoires latérales étroites, de même que la réduction de la cellule pigmentée de l'oeil, traduisent probablement un mode de vie en partie interstitiel. C'est la troisième espèce benthique signalée dans l'Atlantique oriental. Par comparaison, les côtes américaines de cet océan ont une plus grande diversité puisqu'elles abritent deux genres et six espèces de chaetognathes côtiers benthiques. Cette richesse relative pourrait résulter de la paléogéographie, puisque la région des Caraïbes était en relation avec l'Océan Indo-Pacifique, où le nombre d'espèces est le plus élevé au monde, avant la surrection de l'isthme de Panama.

Keywords: Chaetognatha, *Spadella*, Canary Islands, Taxonomy, Biogeography

Introduction

As part of the project research "Macaronesia 2000" which aim is to study the interstitial communities of the islands of the Macaronesian Region, about 50 specimens of a new

Spadella were sorted by Dr Jorge Núñez (Dep. de Biología Animal-Zoología, Universidad de la Laguna, Tenerife, Islas Canarias, España), who asked us to describe it. Moreover, it was interesting to synthesize the knowledge of the biodiversity of benthic chaetognaths in the coastal waters of the East Atlantic in view to compare with the Western side where the phylum has been more studied.

Reçu le 16 juillet 2004 ; accepté après révision le 27 novembre 2004.
Received 16 July 2004; accepted in revised form 27 November 2004.

Materials

All the individuals were found in Herago Bay on La Graciosa, an islet situated at the north of Lanzarote, in the Canary Archipelago (Fig. 1). The sample (coordinates: 29°16.129' N – 13°28.331' W) was done on 25/09/2002, at a depth of 22 m. The bottom was constituted of organogenous sand, characterized by the presence of specimens of *Amphioxus*. Samples were preserved in 5% formalin. In spite of the fact that specimens were not adequately preserved for histology, semi-thin sections were done in view to observe the gross anatomy of the ventral ganglion. For scanning electron microscope studies, specimens were critical point-dried, sputter coated with gold and examined with an environmental SEM (Philips XL 30).

Results

Spadella nunezi, sp. nov.

Types

The holotype and five paratypes are deposited at the Marine Biology Department, Natural Sciences Museum of Tenerife (Reg. number TFMCZP/002607 and TFMCZP/002608, respectively) and five other paratypes at the Muséum National d'Histoire Naturelle, Paris (Reg. number MNHN MA 19).

Etymology

The new species is dedicated to Dr J. Núñez who has recognized the interest of this discovery and who has sent us the individuals for identification.

Description

Body slender and rigid. Maximal length: 2.3 mm without to include tail fin. Maturity reached as soon as 1.75 mm. Tail segment is about 47 to 50% of total body length in mature individuals.

Head more or less rounded (Figs. 2, 3A). Hooks clear amber coloured; they are numerous, generally 8 to 9, but sometimes a supplementary short one is seen anteriorly; the posterior ones are the thinnest (Fig. 3A). Anterior teeth generally less numerous, one to two, than the posterior teeth, three to four; a third one, very short, is sometimes present posteriorly in the anterior set (Fig. 3B). All are stout and provided with ridges with irregular indentation. Vestibular organs are seen just behind the posterior teeth. A second set of these organs are observed as two swollen masses located before the mouth with paired small hard cones scattered on their surface; some of these have a terminal pore (Fig. 3B, C). Eyes hardly visible since the pigment cell is reduced; indeed, it has only three short and thin branches very weakly coloured (Fig. 3D). Corona ciliata small and slightly oval on the dorsal side of the neck (Figs. 2, 3E). Collarette tissue not abundant, mainly visible on the

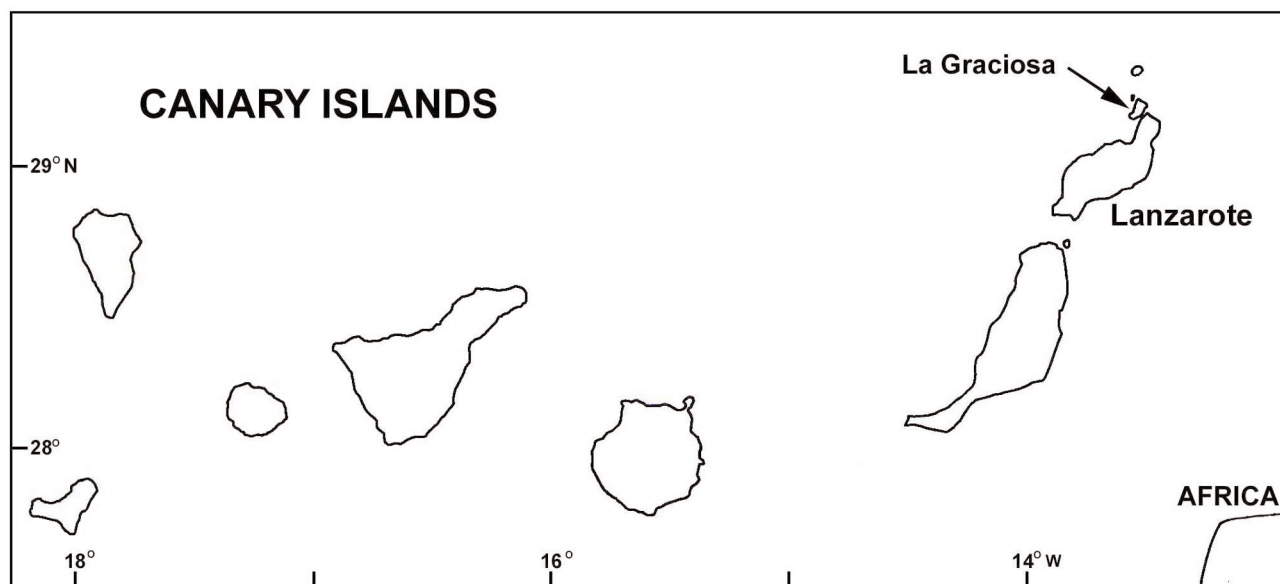


Figure 1. Location of the sampling area of *Spadella nunezi* sp. nov. in the Canarian waters.

Figure 1. Localisation de la zone de récolte de *Spadella nunezi* sp. nov. dans les eaux canariennes.

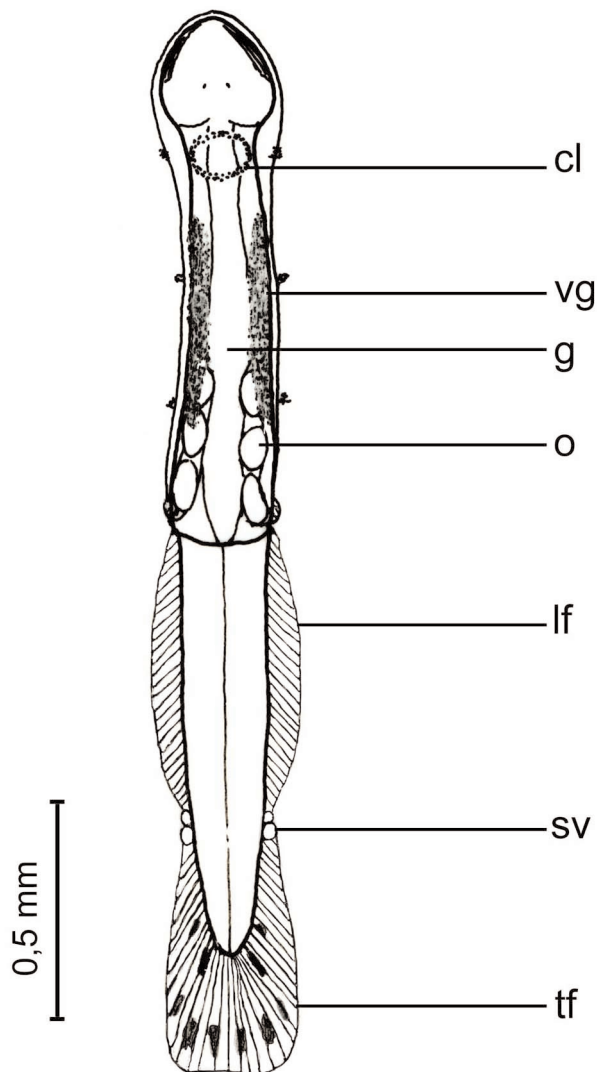


Figure 2. Habitus of *Spadella nunezi* sp. nov. (dorsal view). (*cl*) ciliary loop, (*g*) gut, (*lf*) lateral fins, (*o*) ovaries, (*sv*) seminal vesicles, (*tf*) tail fin, (*vg*) ventral ganglion.

Figure 2. Habitus de *Spadella nunezi* sp. nov. (vue dorsale). (*cl*) couronne ciliaire, (*g*) intestin, (*lf*) nageoires latérales, (*o*) ovaires, (*sv*) vésicules séminales, (*tf*) nageoire caudale, (*vg*) ganglion ventral.

neck area, and also at the level of the seminal vesicles; it bears three sets of sensorial organs on the trunk. A pair of short longitudinal canals is visible on transverse sections in the dorsal part of the collar, from the posterior part of the head to the beginning of the trunk (Fig. 4A-D). The ventral ganglion lies on about 50% of the trunk length, and begins slightly after the level of the corona ciliata (Figs. 2, 3E, 4E). It appears as two elongated and narrow dark masses (cells) in latero-ventral position, connected ventrally by a clearer tissue (nerve fibres) so that the gut is visible in

ventral view between the two masses. Observation of the gut is moreover facilitated by the narrowness of the four quadrants of the primary muscles, which transverse sections are often smaller than each of the three parts of the ventral ganglion (Fig. 4E). Gut with an unpaired intestinal diverticulum (Fig. 4B). Transverse musculature thin, stretching in trunk from the neck to the level of the end of the ventral ganglion (Fig. 4C-E). Ventral side of the trunk and tail segment provided with numerous adhesive papillae.

Lateral fins very narrow, particularly at their beginning slightly before the opening of the female genital orifice on the posterior part of the trunk (Fig. 3F); they end sheathing the anterior part of the seminal vesicles. Tail fin elongated, spade-shaped, beginning against the seminal vesicles (Fig. 3F). All fins totally rayed. Seminal vesicles more or less elongated, depending on their stage: hook-shaped when small, they look like "chinese spoons" when mature (Fig. 3F). Mature ovaries with two to four large ova (diameter up to 0.15 mm).

Discussion

Comparison with related species and other chaetognaths

The taxonomical characteristics of the eleven species of *Spadella* previously described have been lengthily discussed in three papers these last years (Casanova, 1991, 1993; Casanova & Perez, 2000). Only four of these species have posterior teeth: *Spadella ledoyeri* Casanova, 1986, *S. birostrata* Casanova, 1987, *S. equidentata* Casanova, 1987, and *S. antarctica* Casanova, 1991. All of them are larger than *S. nunezi*; the smallest is the latter which nevertheless reaches a maximal length of 6.2 mm. *Spadella ledoyeri* is a cave species; it has short rounded lateral fins; moreover, its seminal vesicles do not touch the lateral and the caudal fins. *Spadella birostrata* and *S. equidentata* are deep species, living at > 150 m depth; in both two species, the lateral fins begin at the posterior part of the trunk, before the transverse septum. *Spadella antarctica* is also a deep species; its lateral fins begin as in *S. nunezi*, but they are wider; the eyes are devoid of pigment cell; the teeth are different, less numerous and longer, and the seminal vesicles are egg-shaped; lastly, the corona ciliata is triangular. The uniqueness of *Spadella nunezi* lies in the aspect of the ventral ganglion which exhibits a larval organization since constituted of two latero-ventral masses. Indeed, the adult chaetognaths have a more or less important ventral ganglion, which name precisely indicates its position on the body; in newly hatched specimens, this ganglion is enormous, occupying all the length of the trunk, and constituted of two large masses of cell bodies in lateral position sepa-

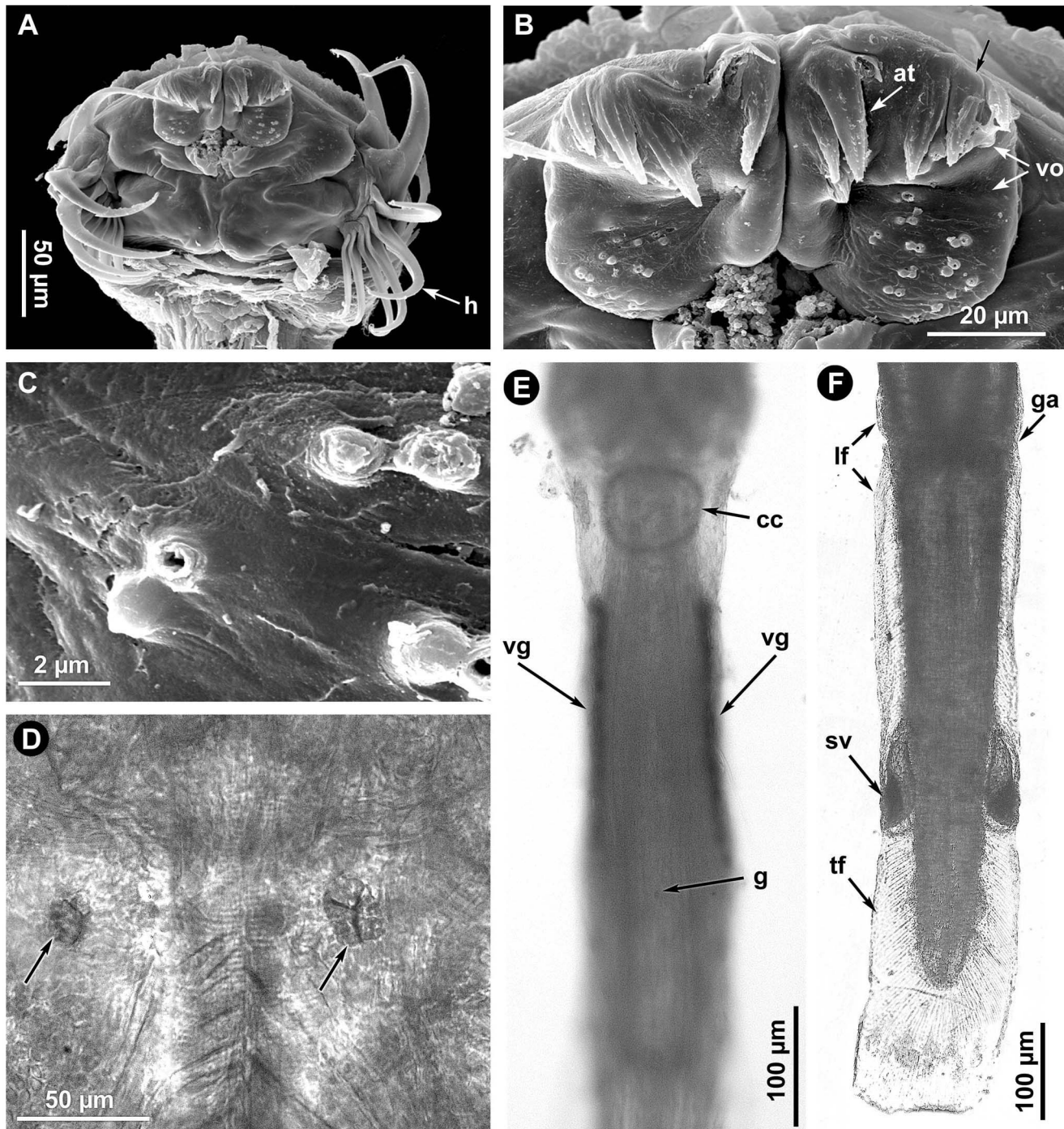


Figure 3. *Spadella nunezi* sp. nov. **A-C.** Scanning electron micrographs. **A.** Head in ventral view. **B.** Mouth area in antero-ventral view. **C.** Details of the vestibular organs. **D-F.** Light micrographs. **D.** Eyes (*arrows*). **E.** Anterior part of the body in dorsal view showing the corona ciliata (*cc*) and the ventral ganglion (*vg*) in lateral position. **F.** Posterior part of the body in dorsal view. (*at*) anterior teeth, (*g*) gut, (*ga*) female genital aperture, (*h*) hooks, (*lf*) lateral fins, (*pt*) posterior teeth, (*sv*) seminal vesicles, (*tf*) tail fin, (*vo*) vestibular organs.

Figure 3. *Spadella nunezi* sp. nov. **A-C.** Micrographies de microscopie électronique à balayage. **A.** Tête en vue ventrale. **B.** Région buccale en vue antéro-ventrale. **C.** Détail des organes vestibulaires. **D-F.** Photomicrographies. **D.** Yeux (*flèches*). **E.** Partie antérieure du corps en vue dorsale montrant la couronne ciliare (*cc*) et le ganglion ventral (*vg*) en position latérale. **F.** Partie postérieure du corps en vue dorsale. (*at*) dents antérieures, (*g*) intestin, (*ga*) ouverture génitale femelle, (*h*) crochets, (*lf*) nageoires latérales, (*pt*) dents postérieures, (*sv*) vésicules séminales, (*tf*) nageoire caudale, (*vo*) organes vestibulaires.

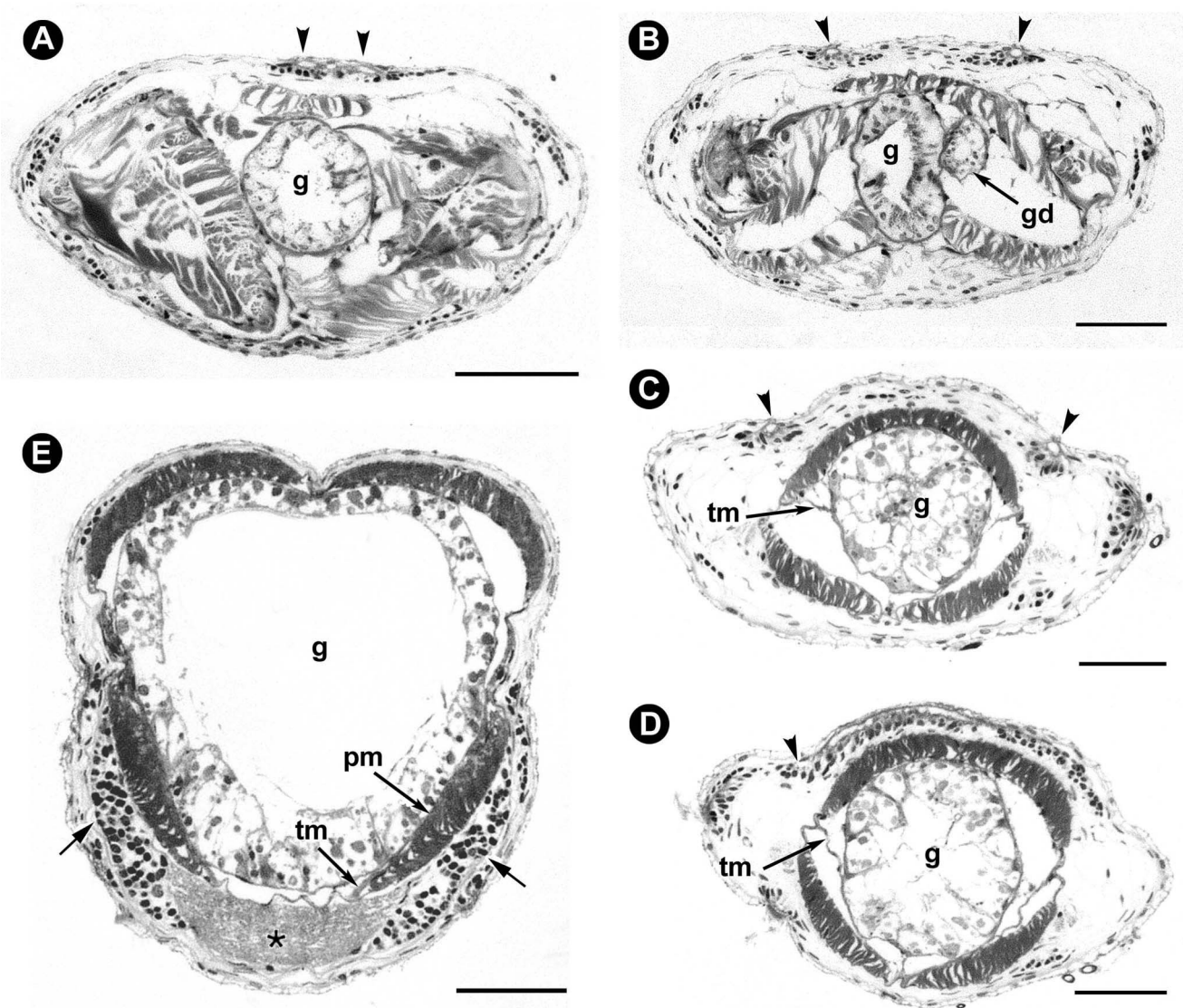


Figure 4. *Spadella nunezi* sp. nov. Semi-thin sections at different levels of the body. **A-D.** From the head (**A, B**) to the beginning of the trunk (**C, D**) showing the course of the paired canals in the dorsal epidermis (*arrowheads*). **E.** at the level of the ventral ganglion, showing the lateral position of the cell masses (*arrows*) separated by the clear fibre mass (*asterisk*). (*g*) gut, (*gd*) gut diverticulum, (*pm*) primary muscle, (*tm*) transverse muscle. Scale bars: 50 μ m.

Figure 4. *Spadella nunezi* sp. nov. Coupes semi fines à différents niveaux du corps. **A-D.** De la tête (**A, B**) au début du tronc (**C, D**) montrant le trajet des canaux pairs dans l'épiderme dorsal (*pointes de flèches*). **E.** au niveau du ganglion ventral, montrant la position latérale des masses cellulaires (*flèches*) séparées par la masse claire des fibres (*astérisque*). (*g*) intestin, (*gd*) diverticule intestinal, (*pm*) muscle primaire, (*tm*) muscle transversal. Echelles : 50 μ m.

rated by a ventral fibrous mass. This arrangement is kept in the adults of *S. nunezi*, except that the ganglion is less voluminous than in hatchlings.

The short canals observed in the dorsal neck area probably correspond to the glandular canals known in some genera: *Archeterokrohnia*, *Heterokrohnia*, *Eukrohnia* and *Bathyspadella*. These canals run mostly on the lateral sides of the neck in all these genera but the latter for which this

data is missing; in every case, they end opening dorsally. According to Tokioka (1939), they "seem to terminate anteriorly into the cephalic coelom" in *Bathyspadella edentata*. As cilia are observed in their lumen in *Archeterokrohnia* and *Eukrohnia*, they would be coelomoducts (Casanova, 1999).

The presence of a small unpaired gut diverticulum must be emphasized since only *Xenokrohnia sorbei* Casanova,

1993 has this feature. Indeed, chaetognaths have a gut either provided with a pair of diverticula or devoid of such structures.

Habitat

Spadella nunezi is one of the smallest species of the genus, with *S. boucheri* Casanova & Perez, 2000 (1.3 mm) and *S. nana* Owre, 1963 (2.4 mm). In addition to its small size, it has many convergent characters with the former, i.e. body slender and narrow fins. This allows considering *S. nunezi* as a probable member of the interstitial fauna, at least during certain parts of its biological cycle, as it has been suggested for *S. cephaloptera* (Busch, 1851) (John, 1933; Nouvel, 1935; Ghirardelli, 1963; Furnestin & Brunet, 1965; 1968) and for *S. boucheri* (Casanova & Perez, 2000). The small size of the pigment cell of the eyes is perhaps the most convincing argument in favour of such a way of life. Indeed, till now, chaetognaths with reduced eyes or devoid of eyes were those living either in deep waters (numerous species) or in dark submarine caves (*Paraspadella anops* Bowman & Bieri, 1989). Moreover, it is well known that many interstitial species belonging to other phyla have such eye characteristics. Lastly, all the *Spadella* species living in shallow waters have well developed eyes, even *Spadella cephaloptera* and *S. boucheri* mentioned above.

Biogeography

Spadella nunezi is the third benthic chaetognath living in the very shallow neritic waters of the East Atlantic. *Spadella cephaloptera* was already mentioned off the British and the French coasts for a long time, and also in the Canarian waters together with *Spadella* aff. *ledoyeri* Hernandez & Jimenez, 1998. This contrasts with the relative richness of the American side of the Atlantic, where two genera and six species of benthic chaetognaths are observed: *Spadella cephaloptera* (Owre, 1963, 1972) and a *Spadella* from Belize, described but unnamed by Salvini-Plawen (1986); *Paraspadella schizoptera* (Conant, 1895), *P. nana* (Owre, 1963), *P. pulchella* (Owre, 1963) and *P. anops*. Concerning *P. hummelincki*, described as a *Spadella* by Alvaríño (1970) (since the two genera were not yet separated at this date), it is certainly synonymous of *P. pulchella* as demonstrated by Owre (1973).

How to explain these differences between the two sides of the Atlantic Ocean? A first reason lies perhaps in the fact that the biodiversity is higher in the tropical waters and that there is no important marine laboratory on the African coast of the Atlantic Ocean as those existing on the American coast. This means that a few new species are expected to be described during further investigations. Another explanation is perhaps that the benthic chaetognaths are effectively more numerous on the American coast of the Atlantic.

Indeed, they have already been studied in the Canarian waters, where only *Spadella cephaloptera* was found on sea grass and algae (Hernandez & Jiménez, 1986), and a cave species looking like *S. ledoyeri* in a dark marine cave of Tenerife (Hernandez & Jimenez, 1998). Species of the genus *Paraspadella*, well recognizable owing to their finger-like adhesive processes, would have not been overlooked if present. In his comprehensive overview of the world biogeography of chaetognaths, Tokioka (1952) wrote that the "Indo-Pacific is occupied by the greater part of the chaetognath fauna in the world," i.e. "6/7 of all the valid species" known at this date. That is particularly true for the benthic species. Indeed, in the Japanese shallow waters, for example, there are four species of *Spadella* and two of *Paraspadella* described today (Casanova, 1990; Casanova & Perez, 2000). As for the East Australian neritic waters where reports are few (two sampled localities), these numbers are respectively 1 and 3 (Johnston & Taylor, 1919; Mawson, 1944). The plate tectonics helps to understand the biogeography of the benthic chaetognaths in the Atlantic. Before the erection of the Panama isthmus that occurred about 7 M.A. ago, the rich Indo-Pacific fauna entered freely in the Caribbean Sea. So, it is not surprising to find many species of *Spadella* and *Paraspadella* in the warm neritic Atlantic American waters, although the communication between the two oceans is now interrupted, as opposed to the low number in the East Atlantic side.

Acknowledgements

The authors thank Dr J. Núñez who provided the specimens studied. They were collected during the Research Project "Macaronesia 2000" whose coordinator was Dr Juan J. Bacallado, Director of the Museum of Science of Tenerife (Canary Islands, Spain).

References

- Alvaríño A. 1970. A new species of *Spadella* (benthic Chaetognatha). *Studies on the fauna of Curaçao and other Caribbean Islands*, **34**: 73-89.
- Bowman T.E. & Bieri R. 1989. *Paraspadella anops*, new species, from Sagittarius cave, Grand Bahama Island, the second trogloditic chaetognath. *Proceedings of the Biological Society of Washington*, **102**: 586-589.
- Casanova J.-P. 1990. A new species of *Paraspadella* (Chaetognatha) from the coastal waters of Japan. *Proceedings of the Biological Society of Washington*, **103**: 907-912.
- Casanova J.-P. 1991. The first record of a benthic polar chaetognath: a new *Spadella* from the Antarctic. *Journal of Natural History*, **25**: 1355-1362.
- Casanova J.-P. 1993. *Spadella japonica*, a new coastal benthic chaetognath from Japan. *Proceedings of the Biological Society of Washington*, **106**: 359-365.

- Casanova J.-P. 1999.** Chaetognatha. In: Boltovskoy D. (eds). South Atlantic Zooplankton. pp 1353-1374. Backhuys Publishers
- Casanova J.-P. & Pérez Y. 2000.** A dwarf *Spadella* (Chaetognatha) from Bora Bay (Miyako Island, Japan). *Cahiers de Biologie Marine*, **41**: 137-141.
- Furnestin M.-L. & Brunet M. 1965.** Sur une station à *Spadella cephaloptera* dans le golfe de Marseille. *Rapports et Procès-verbaux des Réunions. Commission Internationale pour l'Exploration scientifique de la Mer Méditerranée*, **18**: 445-450.
- Furnestin M.-L. & Brunet M. 1968.** Sur une nouvelle mention de *Spadella cephaloptera* dans le golfe de Marseille. *Rapports et Procès-verbaux des Réunions. Commission Internationale pour l'Exploration scientifique de la Mer Méditerranée*, **19**: 471-473.
- Ghirardelli E. 1963.** Stades de maturité sexuelle chez les chaetognathes. Observations préliminaires sur *Spadella cephaloptera*. *Rapports et Procès-verbaux des Réunions. Commission Internationale pour l'Exploration scientifique de la Mer Méditerranée*, **17**: 621-626.
- Hernandez F. & Jiménez S. 1986.** Biometric observations on *Spadella cephaloptera* in Tenerife (Canaries). *Boletín do Museu Municipal do Funchal*, **38**: 220-242.
- Hernandez F. & Jiménez S. 1998.** Cave chaetognaths in the Canary Islands (Atlantic Ocean). *Proceedings of the Biological Society of Washington*, **111**: 916-920.
- Johnston T.H. & Taylor B.B. 1919.** Notes on Australian chaetognatha. *Proceedings of the Royal Society of Queensland*, **31**: 28-41.
- John C.C. 1933.** Habits, structure and development of *Spadella cephaloptera*. *Quarterly Journal of Microscopical Sciences*, **75**: 625-696.
- Mawson P.M. 1944.** Some species of the chaetognath genus *Spadella* from New South Wales. *Transactions of the Royal Society of South Australia*, **68**: 327-333.
- Nouvel H. 1935.** Notes sur la faune marine de la région de Roscoff. *Travaux de la station Biologique de Roscoff*, **13**: 216-218.
- Owre H.B. 1963.** The genus *Spadella* (Chaetognatha) in the western North Atlantic Ocean, with descriptions of two new species. *Bulletin of Marine Science of the Gulf and Caribbean*, **13**: 378-390.
- Owre H.B. 1972.** Marine biological investigations in the Bahamas. 18. The genus *Spadella* and other Chaetognatha. *Sarsia*, **49**: 49-58.
- Owre H.B. 1973.** A new chaetognath genus and species, with remarks on the taxonomy and distribution of others. *Bulletin of Marine Science*, **23**: 948-963.
- Salvini-Plawen L.v. 1986.** Systematic notes on *Spadella* and on the Chaetognatha in general. *Sonderdruck aus Zeitschrift für Zoologische Systematik und Evolutionsforschung*, **24**: 122-128.
- Tokioka T. 1939.** three new chaetognaths from Japanese waters. *Memoirs of the Imperial marine Observatory*, **7**: 129-139.
- Tokioka T. 1952.** Chaetognaths of the Indo Pacific. *Annotationes zoologicae japonenses*, **25**: 307-316.