

SHORT COMMUNICATION

Calispadella alata n. gen., n. sp., the first chaetognath recorded from a hydrothermal vent site (Mid-Atlantic Ridge)

JEAN-PAUL CASANOVA AND XAVIER MOREAU*

E.R. 'BIODIVERSITE ET ENVIRONNEMENT', LABORATOIRE DE BIOLOGIE ANIMALE (PLANCTON), CASE 18, UNIVERSITÉ DE PROVENCE, 3 PLACE VICTOR HUGO, 13331 MARSEILLE CEDEX 3, FRANCE

*CORRESPONDING AUTHOR: xavier.moreau@up.univ-mrs.fr

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Calispadella alata n. gen., n. sp., is the first chaetognath described from a hydrothermal vent field (Mid-Atlantic Ridge, depth ~1600 m). It belongs to the family Spadellidae (presence of transverse muscles in trunk and long tail segment). There is a pair of lateral fins making no contact with the body posteriorly; these free wing-like extensions end in festoons provided distally with patches of adhesive cells. This unique feature in a deep benthoplanktonic species can be seen as an adaptation to adhere at times to the substrate to resist local turbulences produced by the hydrothermal fluids. This may also indicate that this new genus is phylogenetically close to the neritic genus *Paraspadella*, which has adhesive finger-like processes. *Calispadella alata* is sexually precocious as reported for other deep chaetognaths, contrary to most deep living organisms which exhibit delayed sexual maturity. This feature might be a means to increase the possibility of mating in scarce populations.

INTRODUCTION

During the ATOS cruise organized by Ifremer (July 2001), particle traps of 1 m² were deposited for a one-year period at the base of hydrothermal vents in two Atlantic hydrothermal vent fields, Rainbow and Lucky Strike. In the latter field, there was an adult specimen of Chaetognatha, the study of which has revealed that it belongs to a new genus and species. A careful observation of its characteristics has allowed the recognition of an immature individual in the same hydrothermal site sampled a few years earlier.

RESULTS AND DISCUSSION

The two specimens were caught in the Lucky Strike hydrothermal vent field, on the Mid-Atlantic Ridge.

Immature specimen: 'Lucky Strike/Alvin Expedition,' RV Atlantis II, submersible Alvin, dive # 2607, St. 3,

gear = slurp gun, 2-VI-1993, 37°17.54' N–32°16.49' W, 1625 m.

Adult Specimen: ATOS cruise, RV *Atalante*, ROV *Victor*, particle trap ML3-13, moored on 3-VII-2001, close to the vent site SINTRA (Lucky Strike field), 37°17.539 N, 32°16.404 W, 1630 m. The trap, deployed at 15 m between two translucent smoker vents, was recovered on 3-VII-2002. Its aperture, turned upward, was at 2.5 m above the sea floor. The collecting method was completely described previously (Khripounoff *et al.*, 2000). The specimen was preserved in alcohol (60°).

Calispadella alata n. gen., n. sp.

Types: The holotype (adult) and paratype (young specimen) are deposited at the Museum National d'Histoire naturelle, Paris (Reg. number MNHN MA 20 and MA 21, respectively).

Etymology: The first part of the generic name is derived from the Greek word 'kallos' meaning beauty, and the

specific name is a Latin word meaning provided with wings. This new genus and species, indeed, looks like *Spadella* having fins evoking wings.

Description

The complete description concerns the adult individual. It is followed by data on the juvenile. Body very elongated and rigid (Figs 1 and 2A). Total body length = 3.95 mm without the tail fin. Tail segment represents 57% of the total body length.

Head elongated resembling that of a snake. Hood allowing a small aperture in front of the mouth when totally developed. Hooks, 12/13, are gently curved and clear amber colored. Anterior teeth only, 2/1, long and thin (Fig. 2C and D), ornamented with asperities. Vestibular organs rounded, bordering anteriorly the

mouth, scattered with prominent blunt spines (Figs 2D and E). Posterior to the mouth, there is a bracket-shaped fold (Fig. 2D).

There are no eyes. The corona ciliata is located on the neck; it is small and perfectly rounded (Figs 1 and 2B). Collarette thin on the whole body, but more marked in the neck region; it bears many sensory spots, particularly on the anterior part of the body. The ventral ganglion is well developed, prominent (Fig. 2B), and represents about 43% of the trunk length. The lateral fins, one pair, begin at the level of the trunk-tail transverse septum (Fig. 1). Posteriorly, they are separated from the body as two wing-like extensions (which represent ~20% of their length), ending abruptly in festoons without narrowing (Figs 1, 2A and F). The festoons are provided with some patches of adhesive cells on their edges (Fig. 2F). The caudal fin is spatulate. All fins are rayed throughout and scattered with sensory spots.

The anterior gut cannot be observed owing to the opacity of the body due to the longitudinal muscles. Anus slightly protruding (Fig. 2A). Seen through a lateral cut in the posterior part of the trunk, the transverse musculature reaches the level of the posterior edge of the ventral ganglion and the empty ovaries. The left female aperture is blocked with a plug of spermatozoa. Seminal vesicles are indicated by a weak swelling of the epidermis. They are surely well apart from the lateral fins and perhaps in contact with the tail fin when mature.

Characteristics of the young specimen (Fig. 3) are as follows: length = 2.6 mm, tail length = 57% of the total body length, hooks = 7/9, anterior teeth = 3/2 (Fig. 3B), posterior teeth absent, ventral ganglion occupying all the lateral and ventral sides of the trunk, fins damaged and seminal vesicles as two ovoid pouches opening anteriorly to the exterior through a small canal (Fig. 3C).

Comparisons with related genera

Calispadella alata is undoubtedly a member of the family Spadellidae. Indeed, it has transverse muscles only in the trunk, belonging thus to the order Monophragmophora. This order comprises two families, the Spadellidae, more or less linked with the bottom, characterized by a long tail segment, ~50% of the total body length or slightly more, and the pelagic Eukrohniidae, characterized by a shorter tail segment, <35% of the total body length, and weakly developed transverse muscles.

The family Spadellidae comprised four genera. *Spadella* and *Paraspadella* are the best known, represented by many species, 11 and 10, respectively. The single specimen of *Bathyspadella edentata* from the Japanese deep waters (~1000 m) (Tokioka, 1939) is devoid of teeth and has a pair of glandular canals on the lateral sides of the neck. The large *Hemispadella dawvini* (up to 18.5 mm)

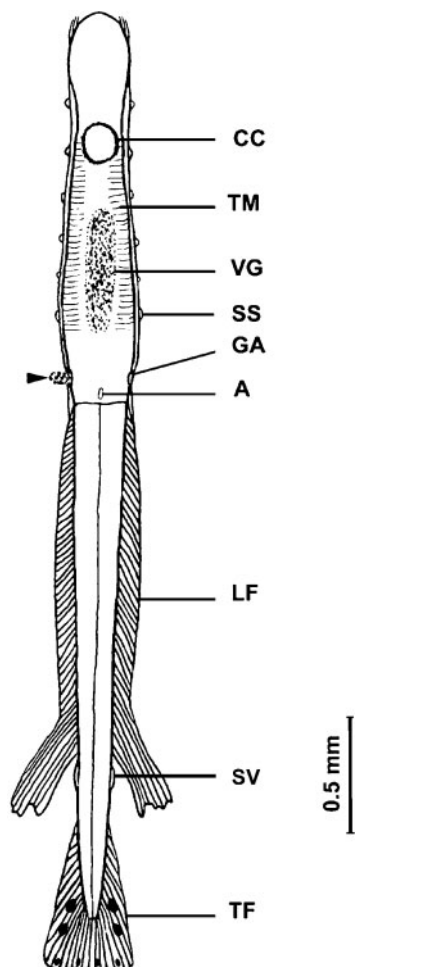


Fig. 1. Habitus of *Calispadella alata* n. gen., n. sp. (dorsal view). The transverse musculature (TM), ventral ganglion (VG) and anus (A) are supposed to be seen by transparency; note the mass of spermatozoa (arrowhead) plugging the left female genital aperture (GA). CC: corona ciliata, LF: lateral fins, SS: sensory spots, SV: seminal vesicles, TF: tail fin.

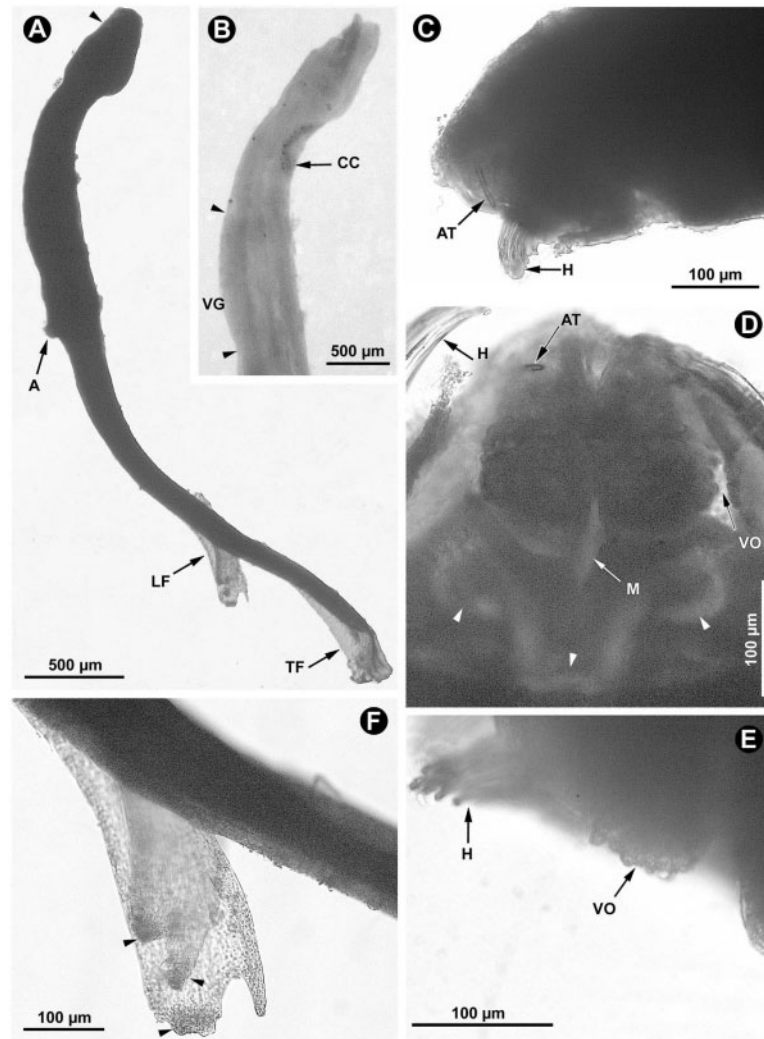


Fig. 2. *Calispadella alata* n. gen., n. sp., holotype, light photographs. (A) Whole left lateral view before removal of the hood (its aperture in front of the mouth is indicated by an arrowhead); (B) anterior part of the specimen showing the corona ciliata (CC) and the ventral ganglion (VG), coloured with methylene blue, whose limits are indicated by arrowheads; (C), (D) and (E) different views of the head showing the buccal armature, i.e. the anterior teeth (AT), hooks (H) and vestibular organs (VO). Note in D the bracket-shaped fold (arrowheads); (F) posterior free part of the lateral fins showing the patches of adhesive cells (arrowheads). A: anus, M: mouth, TF: tail fin.

lives at great depth (~2000 m) between the Azores and the Canary Islands (Casanova, 1996); it has numerous anterior and posterior teeth, which are morphologically very different, and its lateral fins are very short.

The most striking characteristics of *C. alata* are its long tail segment and the aspect of the distal part of its lateral fins. Such a large tail segment (57% of the total body length) is unusual and characterizes the species of the genus *Archeterokrohnia* (Casanova, 1991), and also species of *Spadella* (*Spadella cephaloptera*, *Spadella angulata* Tokioka, 1951 and *Spadella gaetanoi* Alvarino, 1978).

Calispadella alata has other characteristics of the Spadellidae: the long and very thin anterior teeth, only known in two deep *Spadella*, *Spadella birostrata* Casanova,

1987 and *Spadella antarctica* Casanova 1991; and also a rounded corona ciliata, as observed in numerous species of *Spadella*.

The long free posterior parts of the lateral fins bring *C. alata* nearer to the genus *Paraspadella*. Indeed, in most of the chaetognath species, the lateral fins or the posterior ones when there are two pairs of lateral fins, end against the body wall. In a few of them, such as *Sagitta lya* Krohn, 1853 or those of the genus *Eukrohnia*, their posterior extremities are just slightly apart from the body wall.

The *Paraspadella* species are characterized by the lateral fins extended posteriorly by finger-like processes with adhesive cells at their tip. These processes are more

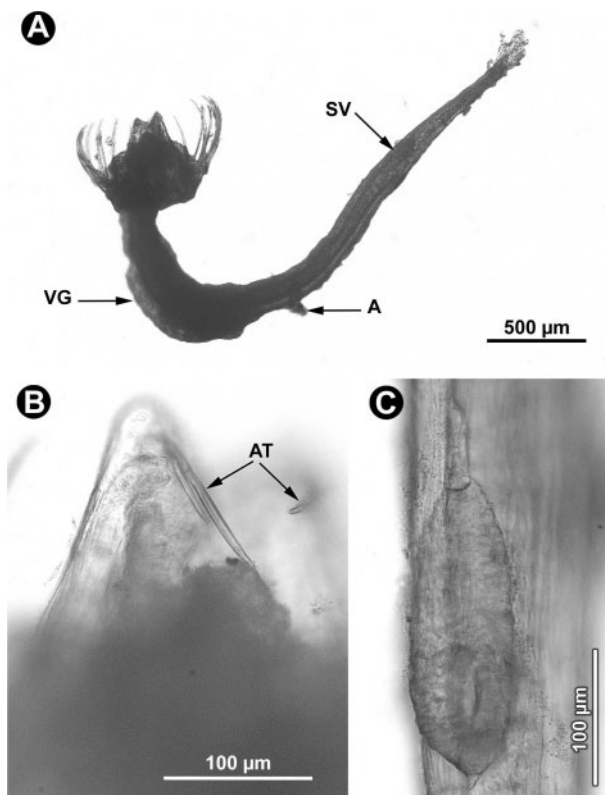


Fig. 3. *Calispadella alata* n. gen., n. sp., paratype (juvenile specimen), light photographs. (A) Whole view; (B) ventro-lateral view of the head showing the anterior teeth (AT); (C) right seminal vesicle. A: anus, SV: seminal vesicle, VG ventral ganglion.

or less numerous and considered as modified parts of the fins in *Paraspadella gotoi* (Casanova, 1990). In this species, there are two stout processes fused at their base on each side. Their position recalls that of the free part of the lateral fins of *C. alata*, although they are not in obvious continuity with the fins as in the latter.

Phylogenetical remarks

Casanova *et al.* (Casanova *et al.*, 1995) have shown that the species of the two truly benthic genera, *Spadella* and *Paraspadella*, have modified a muscle particular to the phylum, the secondary muscle, so that one species of the latter, *P. gotoi*, considered to be the most evolved of the genus, can elaborate a true courtship when mating, with help of its adhesive processes transformed into a pair of limb-like appendages. The evolutionary trends in the phylum have been schematized (Casanova and Duvert, 1996); they indicate a probable adaptative radiation from *Archeterokrohnia* to *Paraspadella* via *Spadella*. This view has been strengthened later by ultrastructural studies on the locomotory muscles (Casanova and Duvert, 2002). Information on the ultrastructure of the muscles of *C. alata* is needed to determine its position within this

radiation. It can be hypothesized that it is perhaps an offshoot branching between *Archeterokrohnia* and *Spadella*.

Biological remarks

The original features of the lateral fins of *C. alata* are certainly not related with the reproductive habit, as described for *Eukrohnia* (Alvariño, 1968; Terazaki and Miller, 1982), since the fins are not enlarged to protect the brood. They are more probably related to buoyancy and fixation on the substrate. Indeed, the deep oceanic waters are generally calmer than the shallow neritic waters. That is why none of the deep benthic species of *Spadella* (*S. antarctica*, *S. birostrata* and *Spadella equidentata* Casanova, 1987) has adhesive cells, whereas all those living in shallow waters are provided with such cells. The presence of a few patches of adhesive cells on the edges of the free extremities of the lateral fins certainly allows *C. alata* to adhere to the substrate at times to resist the local turbulence in the hydrothermal vent fields. Indeed, although the vent emission is weak at Lucky Strike, the hydrothermal plume extends between 100 and 300 m above the bottom (Klinkhammer *et al.*, 1995), i.e. well above the level of collection (2.5 m a.b) of the large specimen. Moreover, this level indicates that *C. alata* is more probably benthoplanktonic than strictly benthic. This view is strengthened by the presence of euphausiids and planktonic copepods in the trap. Lastly, the fact that the two specimens have been caught in the same restricted area at an interval of nine years indicates that this species is a permanent component of this hydrothermal vent fauna.

The other biological remark concerns the sexual precociousness of *C. alata*. Indeed, the small individual is undoubtedly a juvenile (large ventral ganglion wrapping up all the ventral and lateral parts of the trunk). Nevertheless, its seminal vesicles are already well developed. The same observations on a very small juvenile of *Archeterokrohnia* sp. have been previously reported in the East Pacific, suggesting thus that early sexual development does characterize not only the Heterokrohniidae (Casanova, 1992) but also a deep species of Spadellidae. This fact further highlights the uniqueness of chaetognaths (For review see Duvert, 1989), at least of some of them, since deep living organisms are usually thought to have delayed sexual maturity due to the low temperature of the ocean depths (Pérès, 1961; Raymond, 1982). Breeding of a deep living euphausiid, *Thysanopoda comuta*, would also argue against this rule. Mauchline (Mauchline, 1972) reported the case of a large unmated female whereas a smaller one already had a spermatophore indicating mating though its ovaries were not yet ripe. This might be a response to the low population density typical of some deep-sea forms in which

opportunity for mating must be limited. This trend is well marked in the chaetognaths mentioned above since advanced maturity concerns very young specimens. Chaetognaths are known to be protandric hermaphrodite, but this phenomenon is considerably less pronounced in species living shallower.

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REFERENCES

- Alvariño, A. (1968) Egg pouches and other reproductive structures in pelagic Chaetognatha. *Pacif. Sci.*, **22**, 488–492.
- Casanova, J.-P. (1990) A new species of *Paraspadella* (Chaetognatha) from the coastal waters of Japan. *Proc. Biol. Soc. Wash.*, **103**, 907–912.
- Casanova, J.-P. (1991) Chaetognaths from the Alvin dives on the Seamount Volcano 7 (east tropical Pacific). *J. Plankton. Res.*, **13**, 539–548.
- Casanova, J.-P. (1992) Chaetognaths from Alvin dives in the Santa Catalina Basin (California), with description of two new *Heterokrohnia* species. *J. Nat. Hist.*, **26**, 663–674.
- Casanova, J.-P., Duvert, M. and Goto, T. (1995) Emergence of limb-like appendages from fins in chaetognaths. *C. R. Acad. Sci. Paris, Sci. vie.*, **318**, 1167–1172.
- Casanova, J.-P. (1996) A new genus and species of deep benthic chaetognath from the Atlantic: a probable link between the families Heterokrohniidae and Spadellidae. *J. Nat. Hist.*, **30**, 1239–1245.
- Casanova, J.-P. and Duvert, M. (1996) Biodiversity and evolutionary trends in the phylum Chaetognatha. *Bull. Soc. Zool. Fr.*, **121**, 83–86.
- Casanova, J.-P. and Duvert, M. (2002) Comparative studies and evolution of muscles in chaetognaths. *Mar. Biol.*, **141**, 925–938.
- Duvert, M. (1989) Etude de la structure et de la fonction de la musculature locomotrice d'un invertébré. Apport de la biologie cellulaire à l'histoire naturelle des chaetognathes. *Cuad. Invest. Biol. Bilbao*, **15**, 1–130.
- Khripounoff, A., Comtet, T., Vangriesheim, A. *et al.* (2000) Near-bottom biological and mineral particle flux in the Lucky Strike hydrothermal vent area (Mid-Atlantic Ridge). *J. Mar. Syst.*, **25**, 101–118.
- Klinkhammer, G. P., Chin, C. S., Wilson, C. *et al.* (1995) Venting from the Mid-Atlantic Ridge at 37°17'N: the Lucky Strike Hydrothermal Site. In Parson, L. M., Walker, C. L. and Dixon, D. R. (eds), *Hydrothermal vents and processes*. Geological Society, London, pp. 87–96.
- Mauchline, J. (1972) The biology of bathypelagic organisms, especially Crustacea. *Deep-Sea Res.*, **19**, 753–780.
- Pérès, J.-M. (1961) *Océanographie Biologique et Biologie Marine. I. La vie benthique.*, Presses Universitaires de France, Paris.
- Raymont, J. E. G. (1982) *Plankton and productivity in the oceans*, 2nd edn, Vol. II. *Zooplankton*. Pergamon Press, Oxford.
- Terazaki, M. and Miller, C. B. (1982) Reproduction of meso- and bathypelagic chaetognaths. *Mar. Biol.*, **71**, 193–196.
- Tokioka, T. (1939) Three new chaetognaths from Japanese waters. *Mem. Imp. Mar. Obs.*, **7**, 129–139.

