

# A new free-living nematode, *Actinonema falciforme* sp. nov. (Nematoda: Chromadoridae), from the continental shelf of the East China Sea

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## Abstract

*Actinonema falciforme* sp. nov. was discovered from the continental-shelf sediments of the East China Sea. It is characterized by six outer labial setae and four cephalic setae in one circle, complex and heterogeneous cuticular ornamentation with lateral differentiation, large and conspicuous amphideal fovea which is transversely oval-shaped, a single anterior testis, two opposed reflexed ovaries, falciform telamon (lateral pieces of gubernaculum), and the lack of spicule and gubernaculum. Within the genus *Actinonema*, only *A. longicaudatum* and the new species possess telamon and lack spicule and gubernaculum. *Actinonema falciforme* sp. nov. can be easily differentiated from *A. longicaudatum* by its much shorter body length, the peculiar shape of the telamon and a shorter tail.

**Key words:** East China Sea, free-living marine nematodes, new species

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## 1 Introduction

The family Chromadoridae Filipjev, 1917 can be distinguished by two synapomorphies: males possessing only the anterior testis; females having two antidromously reflexed ovaries, with the anterior gonad right of the intestine and the posterior one left of the intestine (Lorenzen, 1994). Chromadoridae is a large family, containing five subfamilies and 38 genera (Tchesunov, 2014). The five subfamilies can be separated from each other by the shape of the amphideal fovea, the stoma armature, the arrangement of anterior sensilla, the cuticular ornamentation with or without differentiations, and presence or absence of precloacal supplements in males (Decraemer and Smol, 2006). The subfamily Euchromadorinae Gerlach and Riemann, 1973 can be easily distinguished by the cuticle with complex heterogeneous ornamentation (rarely homogeneous), often with lateral differentiation; the amphideal fovea large, transverse slit-like or oval, located posterior to the cephalic setae; the gubernaculum usually with hammer- or L-shaped lateral pieces (telamon); and the absence of precloacal supplements.

Within the subfamily Euchromadorinae, the genus *Actinonema* Cobb, 1920 is most similar to the genus *Rhyps* Cobb, 1920. *Actinonema* has simple spicules, while *Rhyps* has long and double-jointed spicules (Tchesunov, 2014). Platt and Zhang (1982) considered the spicules of *Actinonema* to be homologous to the

lateral pieces (telamon) of *Rhyps* and stated that the two genera are very closely related, except for the double-jointed spicules of *Rhyps*. Muthumbi and Vincx (1998) assessed the taxonomic importance of the generic features of the two genera and considered that some species of *Actinonema* lack spicules totally.

So far, the full scope of nematodes diversity in the sea areas of China is largely unknown due to insufficient investigations, especially in the East China Sea. During the examination of free-living nematode diversity in the East China Sea, we discovered a nematode belonging to the subfamily Euchromadorinae. The species is peculiar in the absence of spicule and gubernaculum. Detailed investigation suggests the nematode is a new species of the genus *Actinonema*, which is described herein.

## 2 Materials and methods

Sediment samples were collected from sediments on the continental shelf of the East China Sea in July 2012, using box corer, from which the samples used for meiofaunal analysis were taken using a modified syringe tube and preserved with formalin (5% final concentration) on board. In the laboratory, the fixed samples were stained with 0.1% Rose Bengal for 12 h, washed on a 500 µm sieve to remove large particles and a 31 µm sieve to retain meiofauna. The silica sol Ludox HS 40 was used to extract meiofauna from the remaining sediments by centrifugation. The extracted

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samples were sorted out under a dissecting microscope. Nematodes were transferred into 9:1 (v/v) solution of 50% alcohol-glycerol in an embryo dish to slowly evaporate to pure glycerol, and then mounted into permanent slides (Platt and Warwick, 1983).

The descriptions were made from the glycerin mounts (Platt and Warwick, 1983) using differential interference contrast (DIC) microscope (Nikon E80i). Line drawings were made with the aid of a drawing device. Type specimens are deposited in the Marine Biological Museum of Chinese Academy of Sciences (MBMCAS) at Qingdao, China. All measurements are in  $\mu\text{m}$ , and all curved structures are measured along the arc. The terminology used for describing the arrangement of morphological features follows Coomans (1979).

Abbreviations used in the paper are as follows: *L*, body length; *T*, tail length; *abd*, anal body diameter; *cbd*, corresponding body diameter; *mbd*, maximum body diameter; *a*, *L*/*mbd*; *b*, *L*/pharynx length; *c*, *L*/*T*; *c'*, *T*/*abd*; *V*, distance from anterior end to vulva; and *V*%, *V*×100/*L*.

### 3 Taxonomy

Order Chromadorida Filipjev, 1929

Family Chromadoridae Filipjev, 1917

Subfamily Euchromadorinae Gerlach and Riemann, 1973

Genus *Actinonema* Cobb, 1920

*Actinonema falciforme* sp. nov.

(Figs 1 and 2; Table 1)

#### 3.1 Diagnosis

Six outer labial setae and four cephalic setae in one circle. Cuticular ornamentation heterogeneous and complex, regular lateral differentiation beginning just anterior to pharyngeal base. Buccal cavity conical, with a distinct sharply pointed dorsal tooth. Amphideal fovea conspicuous, transversely oval, with a central slit. Posterior pharyngeal bulb present. Single anterior testis, reflexed. Spicule and gubernaculum absent. Telamon (lateral piece of gubernaculum) falciform and cuticularized. Two opposite and reflexed ovaries. Tail conical with pointed tip.

#### 3.2 Type materials

Holotype: one male on slide DH3-4-05-07-07. Paratypes: four males on slides DH3-4-04-03-02, DH2-4-03-16-2, DH2-4-05-13-3, and DH3-2-04-9-3; two females on slides DH2-4-06-8-3 and DH2-4-07-20-3.

#### 3.3 Type locality and habitats

Benthic sediments at Stas DH3-4 (30°00'N, 124°01'E), DH2-4 (31°00'N, 124°31'E) and DH3-2 (30°00'N, 123°00'E) in the East China Sea. Station DH3-4, water depth 64.1 m, water temperature at the sediment-water interface 18.2°C, salinity 34.4, median particle diameter 3.7  $\mu\text{m}$ , silt-clay 44.6%. Station DH2-4, water depth 50 m, water temperature at the sediment-water interface 21.7°C, salinity 33.2, median particle diameter 6.3  $\mu\text{m}$ , silt-clay 41.3%, organic matter 0.26%. Station DH3-2, water depth 52 m, water temperature at the sediment-water interface 19.0°C, salinity 34.3, median particle diameter 3.9  $\mu\text{m}$ , silt-clay 48.9%, organic matter content 0.31%.

#### 3.4 Etymology

Derived from the Latin adjective *falciformis* (falciform), referring a main feature of the species, i.e., the falciform telamon.

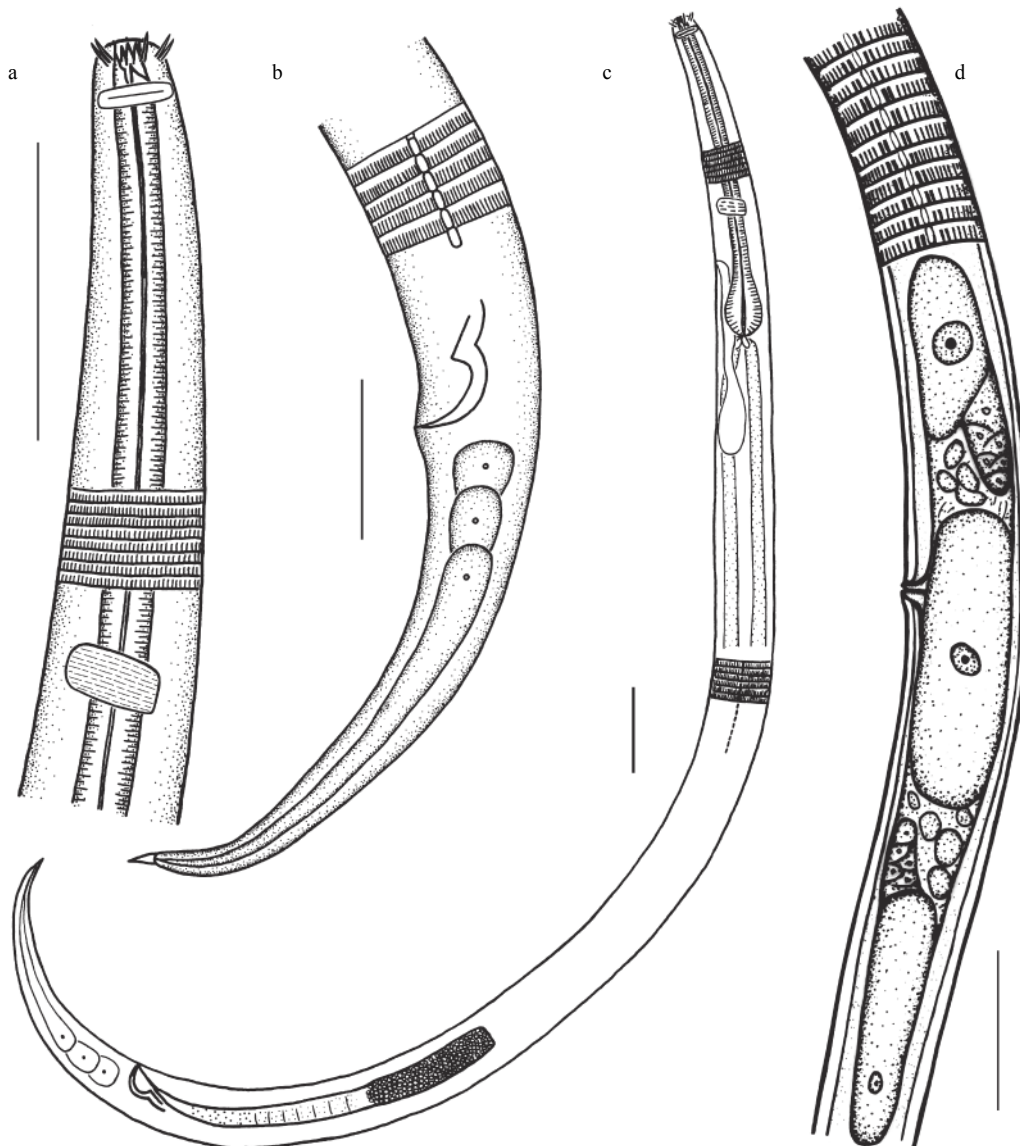
#### 3.5 Description

Measurements shown in Table 1. Body cylindrical and gradually tapering towards tail end, with head region narrower than body trunk (Fig. 1c). Buccal cavity conical, with a distinct sharply pointed dorsal tooth (Figs 1a and 2c). Six inner labial papillae, minute and inconspicuous. Six outer labial setae and four cephalic setae in one circle, almost of same length, 25%–43% of head diameter (Figs 1a and 2c). Amphideal fovea conspicuous, transversely oval, with a central slit; occupying 76%–95% of corresponding body diameter (Figs 1a, 2a and b).

Cuticular ornamentation heterogeneous and complex (Figs 1a, b, 2e and f): transverse dots in the anterior part of pharynx, with irregular lateral differentiation beginning just anterior to the nerve ring (about 41  $\mu\text{m}$  to anterior body end); regular lateral dif-

**Table 1.** Individual measurements (in  $\mu\text{m}$ ) of male holotype and male and female paratypes of *Actinonema falciforme* sp. nov.

Characters	Holotype			Paratypes			
	♂1	♂2	♂3	♂4	♂5	♀1	♀2
Body length ( <i>L</i> )	560	494	428	499	506	521	483
<i>a</i>	29.3	22.8	21.4	23.1	24.3	19.8	19.3
<i>b</i>	5.8	5.3	5.6	5.5	5.5	5.0	4.5
<i>c</i>	6.5	5.7	5.3	6.6	7.1	6.4	5.9
<i>c'</i>	5.3	5.2	5.2	4.6	4.3	5.6	5.6
Head diameter	7	8	8	8	8	6	7
Outer labial setae length	3	2	2	2	2	2	2
Cephalic setae length	3	2	2	2	2	2	2
Amphideal fovea diameter	8	8	8	8	8	7	8
Amphideal fovea from anterior end	4	7	7	6	6	4	4
(Amphideal fovea diameter/ <i>cbd</i> )/%	95	91	91	83	82	76	86
Nerve ring from anterior end	60	45	39	54	54	50	50
Pharynx length	96	93	76	90	92	104	108
Maximum body diameter	19	22	20	22	21	26	25
Anal body diameter	16	17	15	16	17	15	15
Telamon length	22	23	23	24	23	-	-
Telamon length/ <i>abd</i>	1.3	1.4	1.5	1.5	1.4	-	-
Vulva from the anterior end	-	-	-	-	-	276	260
(Vulva from the anterior end ×100/ <i>body length</i> )/%	-	-	-	-	-	53.1	53.7
Tail length	86	87	80	75	71	82	83



**Fig. 1.** *Actinonema falciforme* sp. nov.. Male holotype (a–c) and female paratype (d). a. The six outer labial setae and four cephalic setae in one circle, the large and conspicuous amphideal fovea, the conical buccal cavity with a large dorsal tooth; b. the lateral differentiation of the cuticle, the falciform telamon and the conical tail with tapering tip; c. the slender body, the posterior pharyngeal bulb, and a single anterior reflexed testis; and d. the two opposite and reflexed ovaries. Scale bars: 15  $\mu\text{m}$  (a–c) and 60  $\mu\text{m}$  (d).

ferentiation beginning just anterior to pharyngeal base (about 80  $\mu\text{m}$  to anterior body end); and lateral differentiation beginning to disappear at anterior quarter of the tail (about 18  $\mu\text{m}$  to cloaca).

Pharynx with distinct posterior bulb (Figs 1c and 2d). Cardia small. Nerve ring located in the middle portion of pharynx. Excretory pore just anterior to pharyngeal bulb, about 61  $\mu\text{m}$  to anterior body end (Fig. 1c). Ventral gland about 48  $\mu\text{m}$  long (Fig. 1c). Three caudal glands (Fig. 1b). Tail conical, with tapering tip (Figs 1b and 2h).

Males. Single anterior testis, reflexed (Fig. 1c). Spicule and gubernaculum absent (Figs 1b and 2h). Telamon (lateral pieces of gubernaculum) falciform with distal end pointed and a large conspicuous hook in the proximal end (Figs 1b, 2h and i). Pre-cloacal supplement absent.

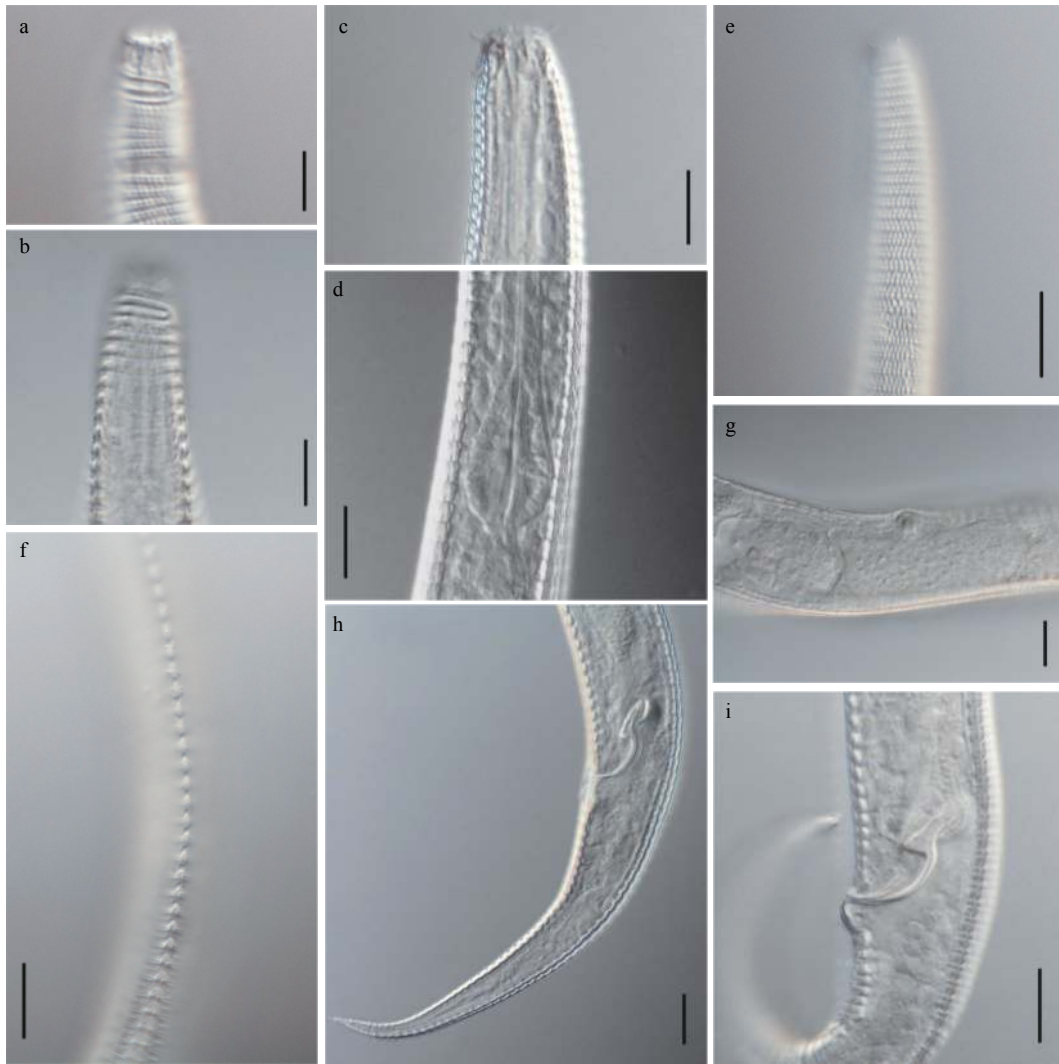
Females. Overall features similar to males. Two opposite and

reflexed ovaries, about 67  $\mu\text{m}$  long. Vulva located in the middle portion of the body (Fig. 2g). Spermatheca present (Figs 1d and 2g).

#### 4 Discussion

*Actinonema falciforme* sp. nov. is characterized by six outer labial setae and four cephalic setae in one circle, complex and heterogeneous cuticular ornamentation with lateral differentiation, large and conspicuous amphideal fovea transverse oval-shaped, a single anterior testis, two opposed reflexed ovaries, a falciform telamon (lateral pieces of gubernaculum), and the lack of spicule and gubernaculum. These main features match the generic diagnosis of *Actinonema* within the family Chromadoridae (Tchesunov, 2014).

Within the genus *Actinonema*, only the species *A. longicaudatum* Steiner, 1918 has only telamon and lacks spicule and guber-



**Fig. 2.** *Actinonema falciforme* sp. nov.. Male holotype (c–f, h), male (a, i) and female (b, g) paratypes. a. The amphideal fovea; b. the amphideal fovea of female paratype; c. buccal cavity and the dorsal tooth; d. pharyngeal bulb; e and f. the heterogeneous and complex cuticular ornamentation; g. vulva and the big egg; h. the falciform telamon and conical tail; and i. the falciform telamon with distal end pointed and a large conspicuous hook in the proximal end. Scale bars: 10  $\mu$ m.

naculum (Muthumbi and Vincx, 1998). The new species also possesses these peculiar features, by which the two species can be easily differentiated from the other congeners. *Actinonema falciforme* sp. nov. differs distinctly from *A. longicaudatum* by its much shorter body length (428–560  $\mu$ m vs. 840–1 251  $\mu$ m) and the peculiar falciform telamon with distal end pointed and a large conspicuous hook in the proximal end (vs. flat with a broad proximal end and a narrow distal end). In addition, *Actinonema falciforme* sp. nov. has a relatively shorter tail ( $c=5.3-7.1$  vs.  $c=3.8-4.1$ ).

Since Wieser (1954) provided a diagnostic key of *Actinonema*, six further species including the new species have been added in the genus (Boucher, 1976; Jensen, 1991; Muthumbi and Vincx, 1998; Vitello, 1970). Accordingly, we provide an updated key to nine species of the genus.

**Key to nine species of the genus *Actinonema***

- |  |   |  |
|--|---|--|
| 1. Amphids in female half the head diameter wide.....      | 2. Spicule absent.....  | 3  |
| ..... <i>A. chitwoodi</i> (Chitwood, 1951)                 | - Spicule present.....  | 5  |
| - Amphids in female wider than half the head diameter..... | 3. Gubernaculum and telamon present.....  | 4  |
| .....2   | ..... <i>A. smolae</i> Muthumbi and Vincx, 1998   |  |
|  | - Gubernaculum absent, only telamon present.....  | 4  |
|  | 4. Telamon flat with a broad anterior end and a narrow posterior end, tail very long with the ratio $c=3.8-4.1$ .....                     | ..... <i>A. longicaudatum</i> (Steiner, 1918)        |
|  | - Telamon falciform with distal end pointed and a large conspicuous hook in the proximal end, tail short with the ratio $c=5.3-7.1$ ..... | ..... <i>A. falciforme</i> sp. nov.                  |
|  | 6. Telamon absent.....  | 7  |
|  | - Telamon present.....  | 8  |
|  | 7. Spicules with weakly sclerotized proximal portion.....   | ..... <i>A. grafi</i> Jensen, 1991                   |
|  | - Spicules rod-like, without weakly sclerotized proximal portion.....   | ..... <i>A. fldata</i> Vitello, 1970                 |
|  | 8. Lateral differentiation with 'V' markings.....   | ..... <i>A. paraceltica</i> Muthumbi and Vincx, 1998 |
|  | - Lateral differentiation without 'V' markings.....   | 9  |

9. With six cones at anterior end.....  
 .....*A. pachydermatum* (Cobb, 1920)  
 - Without corns at anterior end.....  
 .....*A. celtica* Boucher, 1976

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#### References

- Boucher G. 1976. Nématodes des sables fins infralittoraux de la Pierre Noire (Manche Occidentale): II. Chromadorida. Bulletin du Muséum National d'Histoire Naturelle, 245(352): 26–30
- Coomans A. 1979. Addendum I. A proposal for a more precise terminology of the body regions in the nematode. Annales de la Societe Royale Zoologique de Belgique, 108: 155–117
- Decraemer W, Smol N. 2006. The chromadorida, desmodorida and desmoscolecida. In: Eyuaem A, Andrassy I, Traunspurger W, eds. Freshwater Nematodes: Taxonomy and Ecology. Wallingford, UK: CABI Publishing, 497–573
- Jensen P. 1991. Nine new and less known nematode species from the deep-sea benthos of the Norwegian Sea. Hydrobiologia, 222(1): 57–76, doi: [10.1007/BF00017500](https://doi.org/10.1007/BF00017500)
- Lorenzen S. 1994. The Phylogenetic Systematics of Freelifving Nematodes. London: Ray Society, 383
- Muthumbi A W, Vincx M. 1998. Chromadoridae (Chromadorida: Nematoda) from the Indian Ocean: Difficulties in morphological identification of *Actinonema* Cobb, 1920 and *Rhyps* Cobb, 1920. Hydrobiologia, 364(2): 155–167
- Platt H M, Warwick R M. 1983. Free-living marine nematodes: I. British enoplids: pictorial key to world genera and notes for the identification of British species. In: Barnes R S K, Crothers J H, eds. Synopses of the British Fauna (New Series), no. 28. Cambridge: Cambridge University Press, 169–171
- Platt H M, Zhang Z N. 1982. New species of marine nematodes from Loch Ewe, Scotland. Bulletin of the British Museum (Natural History), 42: 227–246
- Tchesunov A. 2014. Order Chromadorida Chitwood, 1933. In: Schmidt-Rhaesa A, ed. Handbook of Zoology. Gastrotricha, Cycloneuralia, Gnathifera. Volume 2: Nematoda. Berlin, Boston: De Gruyter, 373–398
- Vitiello P. 1970. Nématodes libres marins des vases profondes du Golfe du Lion: II. Chromadorida. Tethys, 2: 449–500
- Wieser W. 1954. Reports of the Lund University Chile Expedition 1948–49. 17. Free-living marine nematodes II. Chromadoroidae. Lunds Universitets Årsskrift, Ny Foljd, Avdelningen 2, 50(16): 1–148