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Four new species of Chaetodermatidae (Mollusca, Caudofoveata) from bathyal bottoms of the NW Iberian Peninsula

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Abstract

Caudofoveata is a class of vermiform molluscs with bilateral symmetry and circular transverse section. There are at least 135 described species of Caudofoveata. Fourteen species have been reported from the coast of the Iberian Peninsula, four of which belong to the family Chaetodermatidae. Of these four species, three are endemic to the Mediterranean Sea and one to the NW Iberian Peninsula. The Chaetodermatidae specimens studied were collected off the NW Iberian Peninsula during several expeditions. Four new species of Caudofoveata are described from the NW Iberian Peninsula. They belong to the family Chaetodermatidae, one of them to the genus *Chaetoderma* and three to *Falcidens*. *Chaetoderma galiciense* sp. nov. has a body divided in 5 regions: anterior, neck, trunk, tail and tassel, each region is covered by typical sclerites. *Falcidens urgorrii* sp. nov. has a narrow body divided in four regions: anterior, neck, trunk and tassel, each region covered by typical sclerites, and a radula bears a pair of teeth and two pairs of lateral supports. *Falcidens garcialvarezi* sp. nov. has a body with four regions, each body region covered by characteristic sclerites. The radula bears a pair of falciform teeth, a long and narrow radular cone, a triangular central plate and a pair of lateral supports. *Falcidens valdubrensis* sp. nov. has a short body divided in four regions, each of which covered by characteristic sclerites; the radula bears two falciform teeth. The four new species described herein increase the number of known described species of Caudofoveata to 138. Thus, the Iberian Peninsula becomes one of the best known areas in the world. Also, the first species of the genus *Chaetoderma* from the Iberian Peninsula is described. This paper is registered in Zoobank under: <http://zoobank.org/urn:lsid:zoobank.org:pub:628A29EE-B45D-4D1A-8955-F84FEDAD9013>.

Keywords: Aplacophora, *Chaetoderma*, *Falcidens*, Sclerites, Taxonomy, New species

Background

Caudofoveata are vermiform molluscs with subrostral buccal shield and aculiferous mantle covered in sclerites of calcium carbonate. They are bilaterally symmetrical and circular in cross-section. Their buccal shield can be situated around, flanking or behind the mouth; their bell-shaped pallial cavity in the posterior body end and they bear a pair of ctenidia [1, 2]. Normal size in adult specimens range from 1.5 and 140 mm, although some species can be smaller or reach 400 mm [3]. The morphology of sclerites morphology is diverse, they are usually acicular

on the tassel and flat and oval, lanceolate (shaped like the head of a lance) or saggital (resembling an arrow or arrow-head) in the rest of the body. They may also bear keels, striations or grooves. The radula is biseriata, distichous, with pairs of hooked or sickle teeth located on the radular membrane [3]. The body of Caudofoveata is divided into different regions. The family Chaetodermatidae has 4–5 body regions as described above. Different terminologies and criteria are used for each of them [4–9]. In this paper, the different body regions are referred to as anterior, neck, trunk, tail and tassel, and have been delimited by external characters such as the kind of sclerites, changes in diameter or constrictions. These body regions are similar to those described in other studies based on internal anatomy [5, 9]. The correspondence of the terminology used for each body region is as follows: the anterior region

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corresponds to the region of foregut, the neck to the region of the midgut, the trunk to the region of digestive gland, the tail to the praepallial region of gonopericardial ducts and the tassel to the pallial region.

Their habitat extends through a wide bathymetric range, 50–9000 m deep. They live burrowed in soft bottoms, low hydrodynamic waters with a salinity of at least 28–30 ‰, although their abundance depends on local environmental conditions [5, 10–12]. Despite having widened the knowledge in class Caudofoveata over the last decades, there is still poor knowledge about their biogeography. Species are generally located in specific areas, although some show a wider distribution [3]. In general, the seabeds of American and European Atlantic and the American Pacific are well-documented, whereas the seabeds of the south Pacific and Antarctic are poorly documented. Chaetodermatidae are selective carnivores, their diet consists of foraminifera, worm-like animals and other unidentified animals [13]. They have separate sexes. Despite the absence of direct observations of their sexual behavior, it has been assumed that fertilization is external due to the presence of ectaquasperms [14].

Chaetodermatidae is one of the three families comprising the class Caudofoveata and is composed by three genera: *Chaetoderma*, *Falcidens* and *Furcillidens*, which are characterized by their radula type. The shape, size, ornamentation and arrangement of the sclerites, as well as their variation along the animal body, are characters of taxonomic relevance for species delimitation [5, 15].

No species of the genus *Chaetoderma* has been cited or described from waters of the Iberian Peninsula, whereas four species of the genus *Falcidens* are known, three of these four species are endemic to the Mediterranean Sea: *Falcidens gutturosus* (Kowalevsky, 1901), *Falcidens aequabilis* Salvini-Plawen, 1972 and *Falcidens strigisquamatus* (Salvini-Plawen, 1977), and one of them only known from the Atlantic peninsular coast, *Falcidens vasconiensis* Salvini-Plawen, 1996 [3, 16–24].

In this paper, four new species of Caudofoveata from the NW Atlantic coast of the Iberian Peninsula, *Chaetoderma galiciense* sp. nov., *Falcidens urgorrhii* sp. nov., *Falcidens garcialvarezi* sp. nov. and *Falcidens valdubrensis* sp. nov., are described by means of a thorough description of their body anatomy and a study of their pedal shield and radula. The typology and morphology of the sclerites using both, optical microscopy and environmental and scanning electron microscopy (ESEM).

Methods

During the oceanographic expeditions DIVA-Artabria I 2002 and 2003, A Selva 2008 and DIVA-Artabria II 2008, 15 specimens of Mollusca Caudofoveata of the family Chaetodermatidae were collected with naturalist's

rectangular dredges (NRD) and epibenthic sledges (EBS) from 400 to 2000 metres depth on soft bottoms (Table 1). Samples were preserved in ethanol 70% neutralized with sodium tetraborate 10-hydrate (borax).

Some specimens were photographed and measured in vivo and other specimens in fresh under stereoscopic microscope (Olympus SZ40). 11 specimens were prepared for their study and photographed under environmental scanning electron microscope (ESEM, Zeiss EVO LS 15). Thus, they were dehydrated through ethanol baths (70–90%-absolute) and a last bath of xylol. Subsequently, they were placed on a SEM slide with Dimethyl Hydantoin Formaldehyde (DMHF) and once the ESEM study was done, they were rehydrated in order to restore the previous conditions and to use them in future studies.

Sclerites were isolated by scraping and using sodium hypochlorite 5% on a slide for their study under optical microscope (Olympus AX70). They were then washed in distilled water, left to dry and mounted on Canada balsam with a cover slip. The preparation of sclerites for their study under ESEM was similar to that under optical microscope, but they were mounted on a SEM slide and left to dry.

The radula was studied by transparency under the optical microscope Olympus AX71 and serial histological sections were made for the study of the radula of *Falcidens garcialvarezi* sp. nov. Specimens were decalcified in an EDTA solution, embedded in paraffin, cut in 5 µm thick sections with a microtome Microm HM 340E and stained in Mallory's trichrome [25].

Results

Class **Caudofoveata** Boettger, 1956

Family **Chaetodermatidae** Ihering, 1876.

Genus ***Chaetoderma*** Lovén, 1845

***Chaetoderma galiciense* sp. nov.**

Type material—Holotype (MHN-USC 10059) 20.5 mm long specimen, preserved in ethanol 70% and deposited at the Museo de Historia Natural of the Universidade de Santiago de Compostela, number 10059 NHN-USC.

Type locality—Arousa Canyon, Galicia (NW Iberian Peninsula), oceanographic expedition DIVA-ARTABRIA II 2008, station 30-DRN-r-2008-290908 (42°30' 44"N; 9°40' 83"W), collected with a NRD dredge on muddy sand bottoms at a depth of 2000 m.

Derivatio nominis—The species is dedicated to Galicia, NW Iberian Peninsula, where the specimen was collected.

Diagnosis—Body divided in 5 regions: anterior, neck, trunk, tail and tassel. Buccal shield unknown. Typical mantle sclerites according to body region. Anterior region and neck with the same sclerite typology; two

Table 1 Specimens of *Falcidens* and *Chaetoderma* collected in the four expeditions

Species	Expedition	Station and coordinates	Depth (m)	Length (mm)	
<i>Chaetoderma galiciense</i> sp. nov.	DIVA-ARTABRIA II 2008	30-DRN-r-2008-290908 42°30, 440'N 9°40, 830'W	2000	20.5	Holotype
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2002	DRN-800-2002-110902 43°51, 265'N 8°54, 480'W	840	1	Holotype
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-600-2003-180903 43°48, 587'N 8°51, 740'W	600	1.3	Paratype 1
<i>Falcidens urgorrii</i> sp. nov.	A SELVA 08	15-2-DRN-2008-240708 43°56, 478'N 8°54, 199'W	600	1.7	Paratype 2
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-400-2003-130903 43°43, 781'N 8°46, 450'W	400	2.9	Paratype 3
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-800-2003-150903 43°51, 873'N 8°53, 683'W	800	0.8	Paratype 4
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-600-2003-180903 43°48, 587'N 8°51, 740'W	600	3.2	Paratype 5
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-800-2003-150903 43°51, 873'N 8°53, 683'W	800	3.6	Paratype 6
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-600-2003-180903 43°48, 587'N 8°51, 740'W	600	1.2	–
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-600-2003-180903 43°48, 587'N 8°51, 740'W	600	2.2	–
<i>Falcidens urgorrii</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-600-2003-180903 43°48, 587'N 8°51, 740'W	600	0.7	–
<i>Falcidens garcialvarezi</i> sp. nov.	A SELVA 08	15-2-DRN-2008-240708 43°56, 478'N 8°54, 199'W	600	5.4	Holotype
<i>Falcidens garcialvarezi</i> sp. nov.	DIVA-ARTABRIA I 2003	EBS-800-2003-150903 43°51, 873'N 8°53, 683'W	800	5.1	Paratype 1
<i>Falcidens garcialvarezi</i> sp. nov.	A SELVA 08	15-2-DRN-2008-240708 43°56, 478'N 8°54, 199'W	600	–	Paratype 2
<i>Falcidens valdubrensis</i> sp. nov.	DIVA-ARTABRIA I 2002	DRN-400-2002-130902 43°45, 892'N 8°44, 301'W	400	1.8	Holotype

types: sagittal and flat with a slight basal notch, median keel in the distal part of the blade and a longitudinal groove on each side; and lanceolate sclerites with blade and base on different planes forming an angle, with a slight notch on the base and a median keel with a groove on each side. Trunk and tail have the same types of sclerites: lanceolate, flat, with a median longitudinal keel with two lateral grooves on both sides with or without notch on the base. Two types of sclerites on the tassel: lanceolate, elongate and flat sclerites with two longitudinal grooves and soft, flat and acicular sclerites. Radula unknown.

Habitus—Animal 20.5 mm long and 0.4–1 mm wide, brownish white colour in vivo. With five body regions: anterior, neck, trunk, tail and tassel (Fig. 1a), which may be distinguished by their morphology and type of sclerites. The anterior region of the specimen is incomplete (1.6 mm long × 0.6 mm wide); buccal shield unknown. Neck short and wide (1.9 mm × 0.9 mm) delimited by two constrictions: one differentiates it from the anterior region and the other separates it from the trunk. Trunk long; it is the narrowest part of the animal

(8.4 mm × 0.4 mm). Tail approximately as long as the trunk but wider (8.1 mm × 1 mm). Tassel wider than long (0.5 mm × 0.7 mm), bell-shaped; it bears the pallial cavity with two ctenidia.

Sclerites—Their arrangement varies along the body of the animal. Due to the poor condition of the anterior region, the arrangement of the sclerites is unknown (Fig. 1b). On the neck, they are perpendicular to the mantle surface (Fig. 1c, d) and on the trunk, tail and tassel they are lying lengthwise on the mantle (Fig. 1e–g).

The anterior region and neck present the same types of sclerites: one type (Fig. 2A) shorter (80–100 μm long × 40–50 μm wide), sagittal, flat, with a slight notch on the base, a median keel on the distal part of the blade and a longitudinal groove on both sides (Fig. 2A); the second type is longer (100–150 μm × 40–50 μm), lanceolate, with a notched base, a blade with a hollow median keel and a groove on both sides; the planes of the blade and the base form a 25°–30° angle, being the most characteristic type of sclerites of the species (Fig. 2B).

Same types of sclerites on trunk and tail; large (250–300 μm × 65–80 μm), lanceolate, flat, with a median

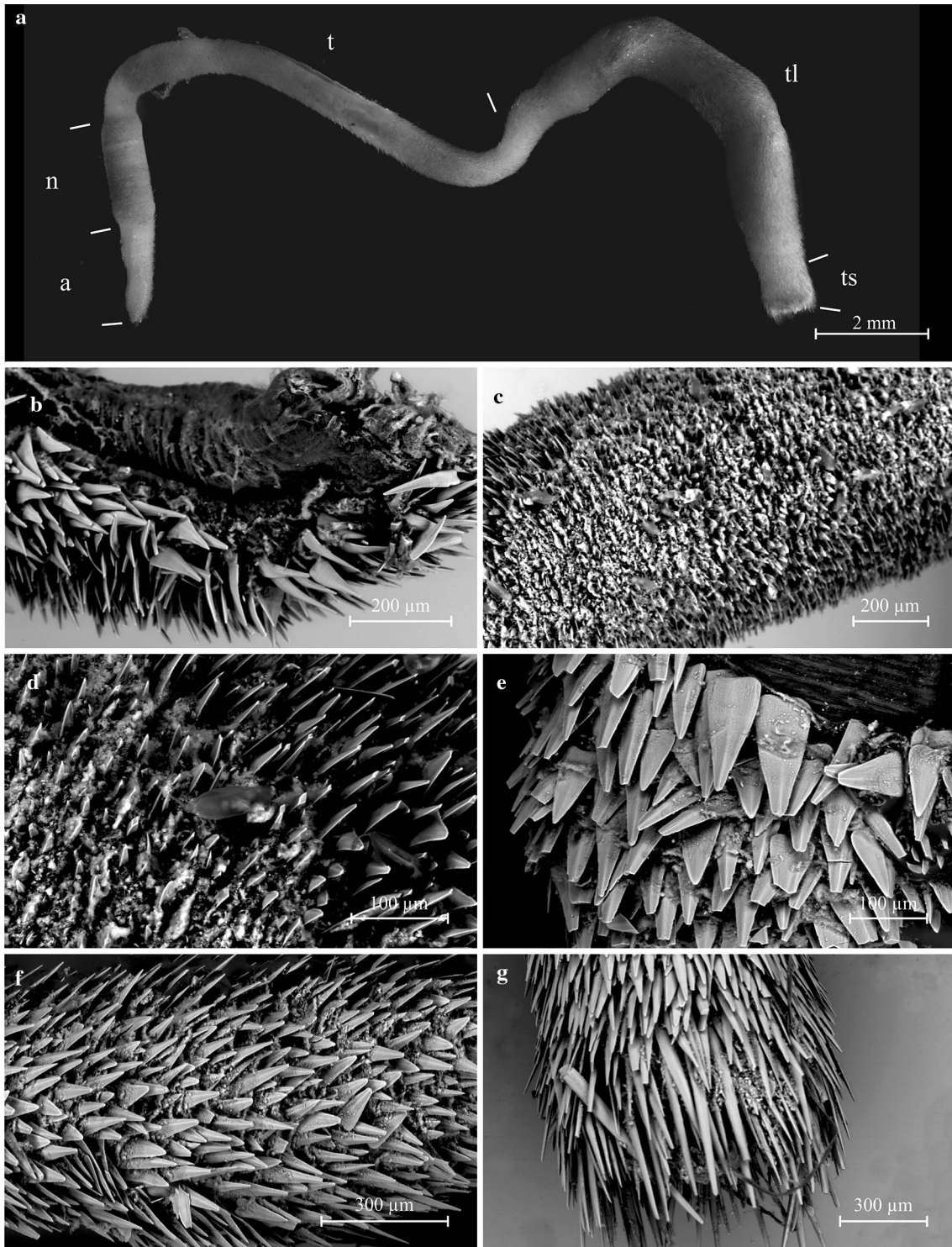


Fig. 1 *Chaetoderma galiciense* sp. nov. Holotype. **a** Habitus and body regions, **b–g** Arrangement of sclerites under SEM, **b** Anterior region; **c, d** Neck, **e** Trunk, **f** Tail, **g** Tassel (*a* anterium, *n* neck, *t* trunk, *tl* tail, *ts* tassel)

longitudinal keel with a groove on each side. Two types can be distinguished according to the base; one type presents a truncated base (Fig. 2C), whereas the second type shows a slight notch on it (Fig. 2D).

Two types of sclerites on the tassel: one smaller (150–200 $\mu\text{m} \times 25\text{--}35 \mu\text{m}$), lanceolate, elongated, flat, with two longitudinal grooves from the base to the apex of the blade (Fig. 2E); and a second type larger (400–750 $\mu\text{m} \times 30\text{--}50 \mu\text{m}$), acicular, flat and smooth (Fig. 2F, G).

Remarks—Although the radula could not be studied, the new species *Ch. galiciense* sp. nov. is classified within the genus *Chaetoderma* based on the body morphology and sclerites. The body of the new species with several regions is completely different from the body without regions of the family Limifossoridae. Moreover, it also differs from the body of the specimens belonging to the family Prochaetodermatidae with the posterior region tapered like a tail. In the family Chaetodermatidae, the posterior region of the body is tapered like a tail or has the same diameter as the rest of the body in the genus *Falcidens* [3]. However, the diameter is similar or larger in the genus *Chaetoderma* than in the new species. In addition, the sclerites of the new species with the blade and the base forming an angle are present in only four species, all of them belonging to the genus *Chaetoderma*.

Chaetoderma galiciense sp. nov. is characterized by bearing a very distinctive type of sclerites on the neck with the base and blade forming a 25°–30° angle and a keel on the distal part of the blade (Table 2). This type of sclerites is rare and is only described in four species of the genus from the Pacific Ocean: *Chaetoderma argenteum* Heath, 1911, *Chaetoderma californicum* Heath, 1911, *Chaetoderma montereyense* Heath, 1911 from waters of the North American Pacific Ocean [26] and *Chaetoderma usitatum* Scheltema, 1989 from the South coast of Australia [7].

Although the sclerites of these four species are similar to those of *Ch. galiciense* sp. nov., the latter can be easily distinguished from them (Table 2). *Ch. argenteum*, *Ch. montereyense* and *Ch. californicum* present this type of sclerites on the trunk, whereas *Ch. galiciense* sp. nov. bears them on the neck [9, 15, 27]. Also, the sclerites of *Ch. argenteum* present a marked waist unlike those of the new species and *Ch. californicum* shows median keel, usually with several ridges [15, 27].

Chaetoderma usitatum presents sclerites with the blade and base forming an angle on the trunk unlike *Ch. galiciense* sp. nov. which bears them on the neck. Besides, these have a wider base compared to the blade than those of the new species [7].

The rest of species of the genus shows no sclerites with the blade and base forming an angle, which clearly distinguishes them from *Ch. galiciense* sp. nov. *Chaetoderma nitidulum* Lovén, 1845 is the closest species of the genus, but is particularly distinct from it (Table 2). *Ch. nitidulum* shows smooth and lanceolate sclerites on the anterior region; ensiform sclerites with waist, with a base narrower than the blade on the neck; sagittal lanceolate sclerites with median keel, as well as elongated sclerites with median keel and several lateral striations on the trunk, which *Ch. galiciense* sp. nov. does not show [5, 28, 29].

Genus ***Falcidens*** Salvini-Plawen, 1968.

Falcidens urgorrii Señaris & García-Álvarez sp. nov.

Type material—Holotype (MHN-USC 10057) 1 mm long, preserved in 70% ethanol. Paratype 1 (MNCN 15.01/100) 1.3 mm long preserved in ethanol 70% and a preparation of sclerites for their study under SEM. Paratype 2 (MHN-USC 10058) 1.7 mm, preserved in 6 slides with 5 μm thick cuts of cross sections. Paratype 3 (MHN-USC 10058) 2.9 mm long, its anterior region was used for the study of sclerites and radula; its posterior region was preserved in 70% ethanol. Paratype 4 (MNCN 15.01/101) 0.8 mm long; a fragment of its posterior region (preserved in 70% ethanol) as well as a preparation of sclerites for SEM were preserved. Paratype 5 (MHN-USC 10058), 3.2 mm long; a preparation of sclerites was preserved. Paratype 6 (MHN-USC 10058), 3.6 mm long, preserved in slides with 5 μm thick cross sections. The Holotype and the rest of the types have been deposited at the Museo de Historia Natural of the Universidade de Santiago de Compostela (MHN-USC), except for Paratype 1 and Paratype 4 which have been deposited at the Museo Nacional de Ciencias Naturales of Madrid (MNCN).

Other material—Three specimens, 1.2, 2.2 and 0.7 mm, were studied. These specimens were lost but photographs under binocular stereo microscope, optical microscope and SEM have been kept.

Type locality—Ferrol Canyon, Galicia (NW Iberian Peninsula). Holotype collected during the expedition DIVA-ARTABRIA I 2002 at station DRN-800-2002-110902 (43°51' 265"N; 8°54' 480"W) with a NRD on bottoms of muddy sand at a depth of 840 m. Paratype 3 was gathered during the expedition DIVA-ARTABRIA I 2003 at station EBS-400-2003-130903 (43°43' 781"N; 8°46' 450"W) with an EBS on bottoms of muddy sand at a depth of 400 m. During the same expedition, Paratypes 1, 5, and the three specimens of *other material* were collected at station EBS-600-2003-180903 (43°48' 587"N; 8°51' 740"W) with

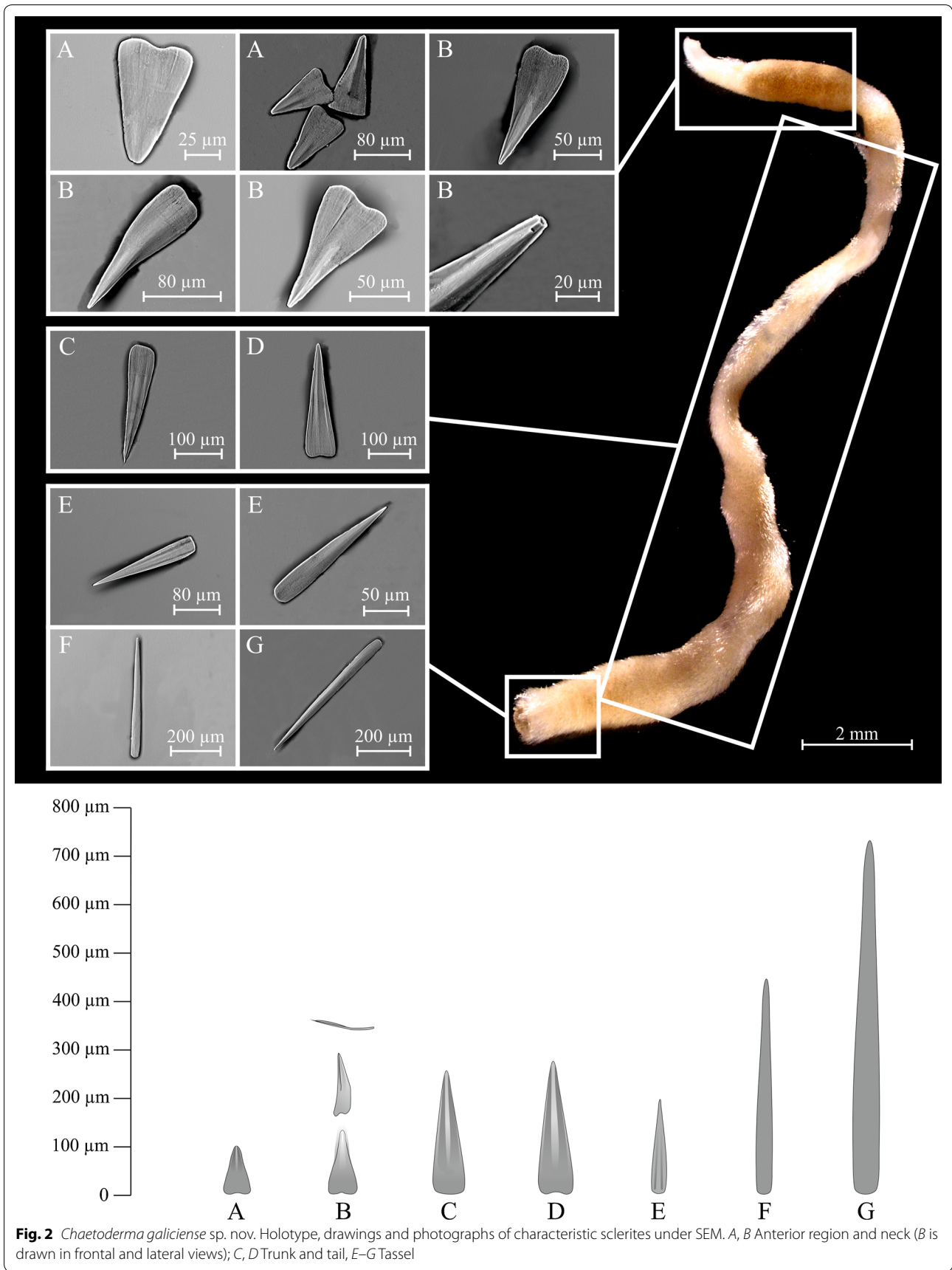


Table 2 Differences between *Chaetoderma galicense* sp. nov. and other *Chaetoderma* species from the Atlantic and Pacific

Species	References	Anterior and neck	Trunk and tail	Tassel
<i>Chaetoderma argenteum</i> Heath, 1911	[3, 26, 32]	Narrow, elongated with a clear waist	Lanceolate with median keel Lanceolate, narrow with waist and blade and base forming an angle	Only acicular
<i>Chaetoderma californicum</i> Heath, 1911	[3, 26, 32]	Sagittal, flat with median keel on the blade		Lanceolate, without median keel on the blade, waist, as well as blade and base forming an angle Lanceolate, flat, with median keel usually with several ridges on the blade and base round, truncated or with a notch
<i>Chaetoderma montereyense</i> Heath, 1911	[3, 13, 32]	Sagittal, smooth, flat with waist	Lanceolate, flat, with median keel and round or truncated base Lanceolate, smooth, with base and blade forming an angle	Acicular Lanceolate, flat with median keel on the blade.
<i>Chaetoderma nitidulum</i> Lovén, 1845	[7, 16, 18]	Lanceolate and smooth Ensiform, waist, blade wider than the base Lanceolate, waist, base with notch and median keel	Sagittal and median keel on the blade Lanceolate, elongated, median keel and several lateral striations Sagittal with notch, wings and median keel	Lanceolate, elongated and median keel Acicular and long
<i>Chaetoderma usitatatum</i> Scheltema, 1989	[27]	Sagittal, flat and smooth. Lanceolate, smooth with blade and base forming an angle and some sclerites with median keel	Lanceolate with median keel, with blade and base forming an angle Lanceolate, flat, elongated with short crests on both sides of the median keel	Acicular broad, elongated, smooth and flat. Lanceolate with median keel
<i>Chaetoderma galicense</i> sp. nov		Sagittal, flat, notched, with median keel and groove on both sides Lanceolate, notched, with median keel, groove on both sides and blade and base forming an angle	Lanceolate, flat, with median keel and groove on both sides, truncated base or with a notch	Lanceolate, elongated, flat, with two longitudinal grooves Acicular and smooth

an EBS on bottoms of muddy sand at a depth of 600 m, whereas Paratype 4 and Paratype 6 were collected at station EBS 800-2003-150903 (43°51' 873'N; 8°53' 683'W) with an EBS on bottoms of muddy sand at a depth of 800 m. In the course of the oceanographic expedition A SELVA 2008, Paratype 2 was collected at station 15-2-DRN-2008-240708 (43°56' 478'N; 8°54' 199'W) with a NRD on bottoms of muddy sand at a depth of 600 m.

Derivatio nominis—The species is dedicated to Prof. Dr. V. Urgorri, promoter of marine biology research in Galicia.

Diagnosis—Body divided in four regions: anterior, neck, trunk and tassel. Unpaired and postoral buccal shield, flanking the mouth without closing preorally. Mantle covered in typical sclerites according to the body region: on the anterior region, they are small, smooth, oval and flat; on the neck they are larger, sagittal and flat; on the trunk they are larger, lanceolate with a median keel and a groove on each side, and with three base types: round, truncated or with a central notch; on the tassel there are three types of sclerites: two lanceolate with a median groove and one acicular with the base wider, round and with a median groove. Radula with a pair of falciform teeth connected at their base by a symphysis located on the radular cone and with two pairs of curved lateral supports with round base.

Habitus—Animals 0.7–3.6 mm long and 0.2–0.5 mm wide (Table 1). White colour in ethanol 70%. With four body regions: anterior or cephalic lobe, neck, trunk and tassel (Fig. 3), which differ in the types of sclerites. Buccal shield located in the anterior region. Neck delimited by two constrictions: one separating it from the anterior region, the other from the trunk. Trunk long; tassel as terminal region, pallial cavity with ctenidia located within.

Buccal shield—Occasionally difficult to distinguish as the animal may contract during fixation. The shield occupies a postoral position, it is unpaired, oval and twice as wide as high (Fig. 4a). Its flanks are located laterally to the mouth without joining preorally; they delimit a notch, where the mouth is located, which is two-thirds as high as the shield.

Sclerites—Arranged along the animal body, lying lengthwise on the mantle (Fig. 4b), although occasionally, especially in the neck region and its surrounding areas, they may be erected at an angle of approximately 45°, which is clearer if the animal is contracted (Fig. 4c).

Each body region has a characteristic type of sclerites (Fig. 5). In the anterior region, sclerites are small (20–30 µm long × 10–15 µm wide), oval, smooth, flat, with tapering distal end of the blade (Fig. 5A–D). On the neck sclerites are larger (35–100 µm × 20–0 µm), sagittal, flat and smooth (Fig. 5E–H). Three types of large sclerites

on the trunk (50–150 µm × 20–50 µm), lanceolate, flat, with a median longitudinal keel and a groove on each side. The three types differ in the morphology of the base: round (Fig. 5I), truncated (Fig. 5J) or with a notch on the central region (Fig. 5K). Three types of sclerites on the tassel; the first type is large (50–90 µm × 10–20 µm) lanceolate, flat sclerites, with truncated base and a large central groove which takes up almost the entire surface (Fig. 5L); the second type is larger and narrower (85–125 µm × 10–25 µm), lanceolate with a slightly marked groove on the base (Fig. 5M); the last type is the largest (125–200 µm × 10–15 µm), with long acicular blade, round, wide and flat base, with a median groove that can be long and narrow (Fig. 5N) or short and wide (Fig. 5O).

Radula—It shows the typical structure of the genus and is made up of a pair of falciform teeth (52 µm long), which narrow on the base and are joined by a symphysis located on the radular cone (96 µm long), and two pairs of lateral supports of different size (52 and 27 µm long), both curved with round base (Fig. 6).

Remarks—The new species, *Falcidens urgorrii* sp. nov., is characterized by bearing sagittal sclerites, smooth and flat on the neck and three types of sclerites on the tassel, some lanceolate with a large central groove, others narrow, lanceolate, with a small groove on the base, and the last type, acicular, long, with round base, flat, wide, with a central groove.

Six species of the genus are known from the European Atlantic Ocean and differ from the new species in the type of sclerites, body and radular morphology. *Falcidens crossotus* Salvini-Plawen, 1968 and *Falcidens vasconiensis* Salvini-Plawen, 1996 present a tail-shaped body end; they also show very characteristic sclerites in the anterior region, oval with two longitudinal grooves in *F. vasconiensis* and oval with two longitudinal crests in *F. crossotus*. The latter also presents only one pair of radular supports unlike *F. urgorrii* sp. nov., whose body lacks a tail and shows smooth and flat oval sclerites in the anterior region and two pairs of radular supports (Table 3) [5, 16, 19, 24, 30, 31]. *Falcidens sterreri* (Salvini-Plawen, 1967) and *Falcidens sagittiferus* Salvini-Plawen, 1968 bear sclerites that the new species lacks. *F. sagittiferus* presents lanceolate sclerites with a median keel on the trunk and smooth acicular sclerites on the tassel, whereas *F. sterreri* shows sclerites with several crests on the trunk and acicular sclerites on the tassel; also both *F. sagittiferus* and *F. sterreri* have an only pair of radular supports unlike *F. urgorrii* sp. nov. which shows two pairs (Table 3) [5, 30–32].

Finally, two new species of the genus *Falcidens* are described herein. These two species, *Falcidens valdubrensis* sp. nov. and *Falcidens garcialvarezi* sp. nov., differ in the type of sclerites. Thus, *F. valdubrensis* sp. nov.



Fig. 3 *Falcidens urgorii* sp. nov. **a** Habitus and body regions of Paratype 5; **b, e** Different habitus; **b** Holotype, **c** Paratype 1, **d** Paratype 2, **e** Paratype 4 (a anterior, n neck, t trunk, ts tassel)

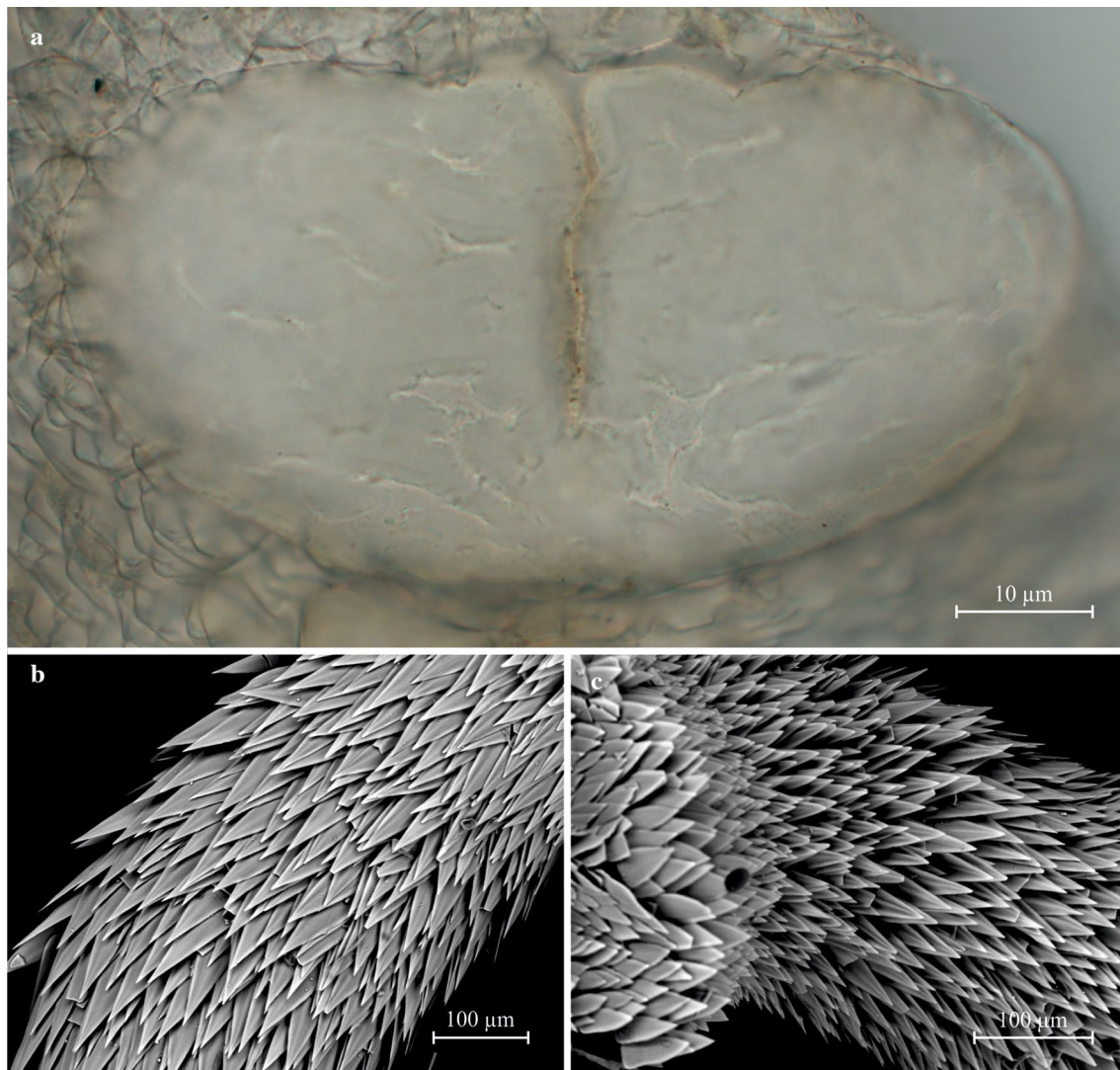
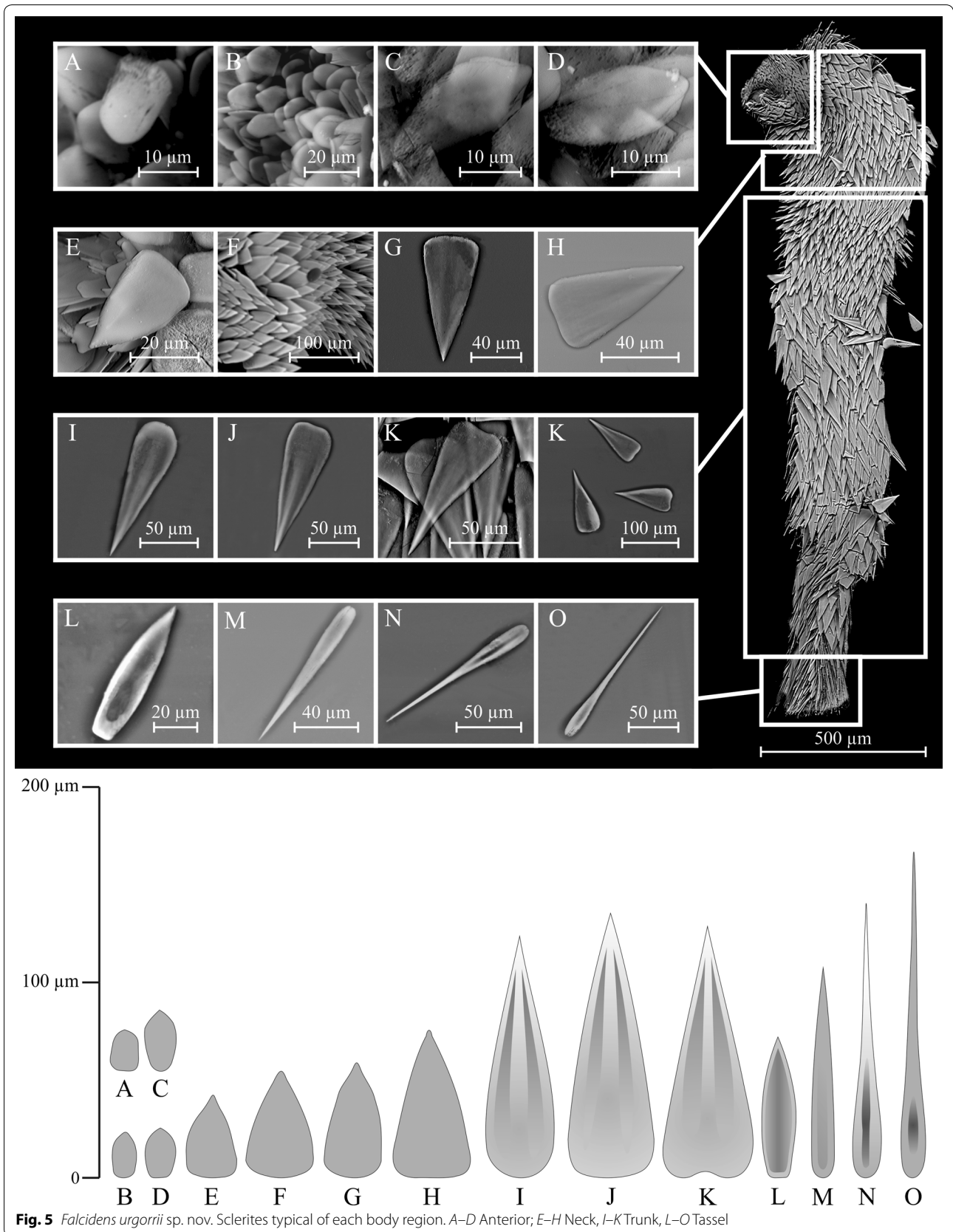


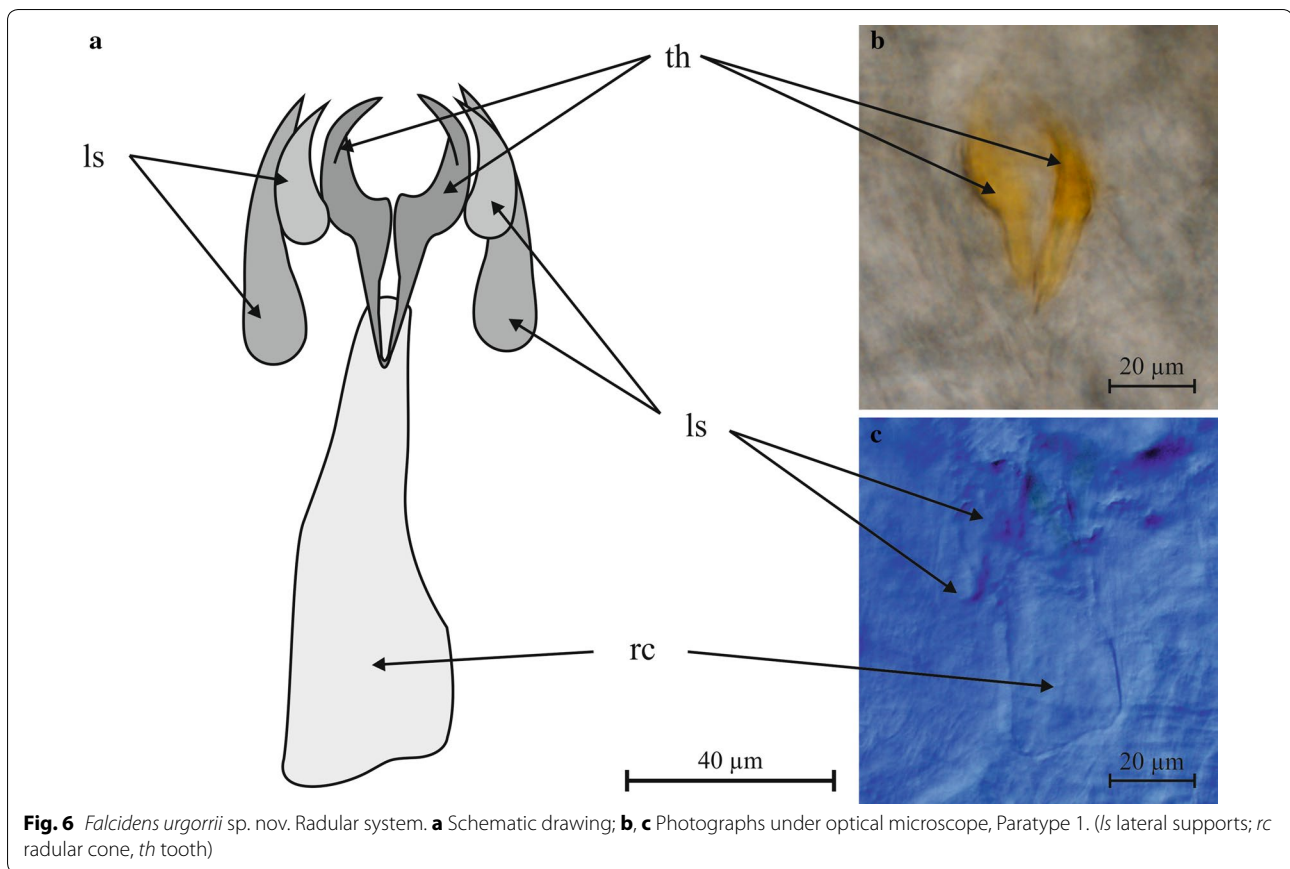
Fig. 4 *Falcidens urgorrii* sp. nov. **a** Buccal shield under optical microscope of Paratype 4; **b, c** Arrangement of sclerites of Paratype 5 under SEM; **b** Trunk; **c** Neck

presents sagittal sclerites with a keel on the neck and lanceolate sclerites with a median keel on the tassel, which differ from the sagittal smooth sclerites of the neck and the acicular and lanceolate sclerites with a groove of the tassel present in *F. urgorrii* sp. nov. Finally, *F. garcialvarezi* sp. nov. shows oval and lanceolate sclerites on the neck, but no sagittal sclerites as those of *F. urgorrii* sp. nov. Also, the radula of *F. garcialvarezi* sp. nov. shows only one pair of lateral supports and a central plate, whereas *F. urgorrii* sp. nov. presents two pairs of supports and lacks a central plate (Table 3).

Two species are described from the Mediterranean Sea, *Falcidens aequabilis* Salvini-Plawen, 1972 and *Falcidens guttuosus* (Kowalevsky, 1901), which

present a tail-shaped posterior region of the body and smooth acicular sclerites on the tassel unlike *F. urgorrii* sp. nov., which lacks a tail and shows three different types of sclerites on the tassel. Also, *F. aequabilis* shows sagittal sclerites with a notch on the base and several crests on the trunk as well as a single pair of radular supports on the radula. *F. guttuosus* presents sagittal sclerites with a notch on the base and median keel with lateral crests on the neck and lanceolate sclerites with a notch on the base, waist, median keel and several lateral crests on the trunk, which differ from *F. urgorrii* sp. nov. in the smooth sagittal sclerites of the neck and the lanceolate sclerites with median keel of the trunk (Table 3) [21, 23].





Third species from the Mediterranean Sea, *Falcidens strigisquamatus* (Salvini-Plawen, 1977), shows sagittal sclerites with many striations on the neck and lanceolate sclerites with several crests on the trunk unlike the smooth sagittal sclerites of the neck and the lanceolate sclerites with median keel and lateral grooves of *F. urgorrii* sp. nov. (Table 3) [17, 22]. In addition, *F. strigisquamatus* bears a pair of radular supports, while *F. urgorrii* sp. nov. has two pairs [17].

Falcidens garcialvarezi Señaris & Urganri sp. nov.

Type material—Holotype (MHN-USC 10060), 5.4 mm long; 6 slides with the anterior region cut in 5 μm cross sections have been preserved as well as 6 preparations of sclerites (2 on a slide in Canada balsam for the optical microscope and 4 preparations on slides for the SEM). Also, the posterior region was preserved in 70% ethanol. Paratype 1 (MNCN 15.01/102), 5.1 mm long; was preserved in 70% ethanol. Paratype 2 (MHN-USC 10061), damaged, was preserved in 70% ethanol. Holotype and Paratype 2 are deposited at the Museo de Historia Natural of the Universidade de Santiago de Compostela (MHN-USC) and Paratype 1 at the Museo Nacional de Ciencias Naturales of Madrid (MNCN).

Type locality—Ferrol Canyon, Galicia (NW Spain). Oceanographic expedition A SELVA 2008, station 15-2-DRN-2008-240708 (43°56' 478"N; 8°54' 199"W), collected with a NRD on muddy bottoms with corals at a depth of 600 m, Holotype and Paratype 2. Oceanographic expedition DIVA-ARTABRIA I 2003 station EBS-800-2003-150903 (43°51' 873"N; 8°53' 683"W), with an EBS on bottoms of white mud with stones at a depth of 800 m, Paratype 1.

Derivatio nominis—The species is dedicated to Dr. O. García-Álvarez, researcher in the field of Solenogastres and Caudofoveata in Spain.

Diagnosis—Body with four regions: anterior, neck, trunk and tassel. Unpaired and postoral buccal shield flanking the mouth without joining preorally. Mantle covered in sclerites characteristic of each body region. In the anterior region, sclerites are oval, flat and smooth. On the neck, they are lanceolate, with a well-marked waist, a median keel, a slight groove on each side, base with wings and a notch. In the anterior region and on the neck, it also shows oval sclerites with a median keel. On the trunk, sclerites are larger, lanceolate with a median keel and a groove on each side; base with or without a notch. Four types of sclerites on the tassel: some lanceolate with

Table 3 Differences between the new species of *Falcidens* and the known Mediterranean and Atlantic species

Species	References	No. of body regions	Anterior	Neck	Trunk/Tail	Tassel	Radula
<i>Falcidens aequabilis</i> (Salvini-Plawen, 1972)	[19]	5	Lanceolate and elongated	Lanceolate, waist and median keel	Sagittal, base with notch and median keel Sagittal, base with notch and several crests	Acicular	One pair of supports
<i>Falcidens crossotus</i> (Salvini-Plawen, 1968)	[18, 20, 21]	5	Oval with two crests.	Sagittal, median keel and several lateral	Lanceolate and elongated with medial keel	Acicular. Lanceolate with median groove	One pair of supports
<i>Falcidens gutturosus</i> (Kowalevsky, 1901)	[6, 17, 19]	5	Lanceolate	Sagittal, with notch, median keel and lateral crests	Lanceolate, notched, waist, median keel and several crests	Acicular	Two pairs of supports
<i>Falcidens sagittiferus</i> (Salvini-Plawen, 1968)	[18, 20, 21]	4	Oval	Lanceolate with waist, only median keel and base with notch	Lanceolate with median keel	Acicular	One pair of supports
<i>Falcidens sterreri</i> (Salvini-Plawen, 1967)	[18, 22]	4	Lanceolate	Lanceolate, notched and median keel	Lanceolate with several crests	Acicular	One pair of supports
<i>Falcidens strigisquamatus</i> (Salvini-Plawen, 1977)	[8, 17]	4	Sagittal	Sagittal with many striations	Lanceolate with several crests	Lanceolate with median groove	One pair of supports
<i>Falcidens vasconiensis</i> (Salvini-Plawen, 1996)	[10, 12, 34, 35]	5	Oval with two grooves	Sagittal, with median keel and several lateral crests	Lanceolate, waist, median keel and lateral keels	Acicular smooth or with one or two grooves	Two pairs of supports
<i>Falcidens valdubrensis</i> sp. nov.		4	Oval	Sagittal with median keel. Sagittal, median keel and two lateral grooves. Sagittal with small median keel	Lanceolate, waist and median keel. Lanceolate, wide and median keel. Lanceolate, median keel and lateral grooves, round and truncated base	Lanceolate with median keel. Lanceolate, elongated blade, median keel and lateral grooves	Unknown
<i>Falcidens garciaivarezi</i> sp. nov.		4	Oval Oval, median keel	Oval, median keel. Lanceolate, waist, median keel and lateral grooves, base with notch and wings	Lanceolate, median keel, lateral grooves and base with and without notch	Lanceolate with median groove. Spatulate, truncated base, narrower than blade, with median groove. Acicular, one or two grooves	One pair of supports and central plate
<i>Falcidens urgorrii</i> sp. nov.		4	Oval	Sagittal	Lanceolate, median keel, two lateral grooves and three types of bases	Lanceolate with median groove on the base. Lanceolate with median groove. Acicular, wide base with medial groove	Two pairs of supports

a round base and a large groove, others spatulate with a truncated base and two types of acicular sclerites with a flat, wide and round base, one with one groove and the other with two. Radula with a pair of falciform teeth joined in their base by a symphysis, long and narrow radular cone, with a triangular central plate and a pair of lateral supports.

Habitus—Animals 5.1–5.4 mm long with a diameter of 0.4–0.8 mm (Table 1). White colour after fixation in alcohol. Four body regions: anterior, neck, trunk and tassel (Fig. 7), the posterior region may narrow and appear as an incipient tail. Buccal shield located in the anterior region. Neck delimited by two constrictions: one separating it from the cephalic lobe and the other differentiating it from the trunk. Long trunk; pallial cavity located in the tassel with two ctenidia.

Buccal shield—Unpaired, rounded contours, slightly wider than long (Fig. 8a). The shield surrounds the mouth without joining it preorally and delimits the notch that takes up three quarters of the shield's height where the mouth is located.

Sclerites—On the neck and anterior region of the trunk, sclerites are arranged vertically to the mantle (Fig. 8b), whereas in the rest of the body they are lying on the mantle and parallel to the longitudinal axis (Fig. 8c). The sclerites of the anterior region are small (15–30 μm long), oval, flat and smooth (Fig. 9A, B). The most characteristic sclerites of this species are located on the neck, they are larger (50–100 μm long), lanceolate, with a well-marked waist, a blunt blade apex, a median keel and a slight groove on both sides; the base shows slight wings and a notch (Fig. 9D). Oval, elongated sclerites (30–50 μm long) with a median keel on the central area occur between the anterior region and the neck and on the anterior region of the neck (Fig. 9C); less abundant than the characteristic lanceolate type. On the trunk sclerites are larger, lanceolate, with a median keel and a groove on each side. Four types: two types are shorter (100–150 μm long) with the base wider than the blade, some of them with a rounded base (Fig. 9E) and others showing a notch (Fig. 9F); the other two types are longer (150–250 μm long), with elongated blade and a base as wide as the blade; one shows a rounded base (Fig. 9G) and in others the base presents a notch (Fig. 9H). Four types of sclerites on the tassel: lanceolate (30–50 μm long) with a rounded base and a large median groove (Fig. 9I); spatulate (50–100 μm long), with a median groove and a truncated base narrower than the blade (Fig. 9J); the other two types are acicular (150–300 μm long), with flat, wide and rounded base, one with a large central groove on the base (Fig. 9K) and the other with two grooves (Fig. 9L).

Radula—Radular system (Fig. 10) made up of a pair of falciform teeth (20 μm long) joined by a symphysis located on a radular membrane turned into a very

long and narrow bar (38 μm long \times 3 μm wide). It also shows a central triangular plate between the teeth (5 μm long \times 9 μm wide), and a pair of lateral supports (24 μm long \times 8 μm wide).

Remarks—This new species *Falcidens garcialvarezi* sp. nov. has three types of characteristic sclerites. Two types are on the neck; some are oval, with median keel; they are also present in the anterior region; others are lanceolate, with waist, narrow blade, median keel, lateral grooves, base with wings and a notch. The third type is on the tassel; they are long, with round base and two longitudinal grooves; the blade is acicular.

F. garcialvarezi sp. nov. differs from the other species of the genus in its body and radular morphology and the typology of its sclerites (Table 3). When comparing this species with the closest biogeographically, it can be highlighted as regards the three species of the Mediterranean Sea, that two of them, *Falcidens aequabilis* Salvini-Plawen, 1972 and *Falcidens guttuosus* (Kowalevsky, 1901), have a tapering posterior body in the shape of a tail and lack a central plate on the radula. Also, *F. aequabilis* presents on the trunk sagittal elongated sclerites with a notch on the base and a median keel, and on the tail sagittal sclerites showing a base with a notch and several crests on the blade. Moreover, *F. guttuosus* presents on the neck sagittal sclerites with a median keel and two lateral crests; on the tail, notched lanceolate sclerites with waist, median keel and several lateral crests, and on the radula, two pairs of lateral supports [21, 23]. These characteristics differ from *F. garcialvarezi* sp. nov. in the lanceolate sclerites of the neck, the lanceolate sclerites with median keel and lateral grooves of the trunk as well as in the single pair of lateral radular supports. The third Mediterranean species *Falcidens strigisquamatus* (Salvini-Plawen, 1977) bears sagittal sclerites with many striations on the neck unlike the oval and lanceolate sclerites of *F. garcialvarezi* sp. nov. [17, 22].

Of the six species of the genus known from the European Atlantic Ocean, three do not occur off the coast of the Iberian Peninsula and are easily distinguishable from *F. garcialvarezi* sp. nov. (Table 3). *Falcidens crosotus* Salvini-Plawen, 1968 shows a tail-shaped posterior region, oval sclerites with two longitudinal crests on the anterior region and sagittal sclerites with median keel and several lateral crests on the neck [5, 31]. *Falcidens sterreri* (Salvini-Plawen, 1967) presents lanceolate sclerites on the anterior region, lanceolate sclerites with several longitudinal crests on the trunk and acicular sclerites only on the tassel [5, 31, 32]. As for *Falcidens sagittiferus* Salvini-Plawen, 1968, it presents lanceolate sclerites with waist, a single median keel and base with notch on the neck, lanceolate sclerites with a single median keel on the trunk and acicular sclerites only on the tassel [5,



Fig. 7 *Falcidens garcialvarezi* sp. nov. **a** Habitus and body regions of holotype, **b** Habitus of paratype 1 (a anterior, n neck, t trunk, ts tassel)

30]. These features contrast with those of *F. garcialvarezi* sp. nov.: body without tail-shaped posterior region, oval smooth sclerites or with a longitudinal keel on the anterior region; lanceolate sclerites, with waist, median keel, base with a notch and wings on the neck; lanceolate sclerites with median keel, lateral grooves and base with

or without notch on the trunk; lanceolate sclerites with median groove, spatulate sclerites and acicular sclerites with one or two grooves on the tassel. It should also be pointed out that none of these three species present an accessory triangular plate on the radula as that of *F. garcialvarezi* sp. nov. [5, 30–32].

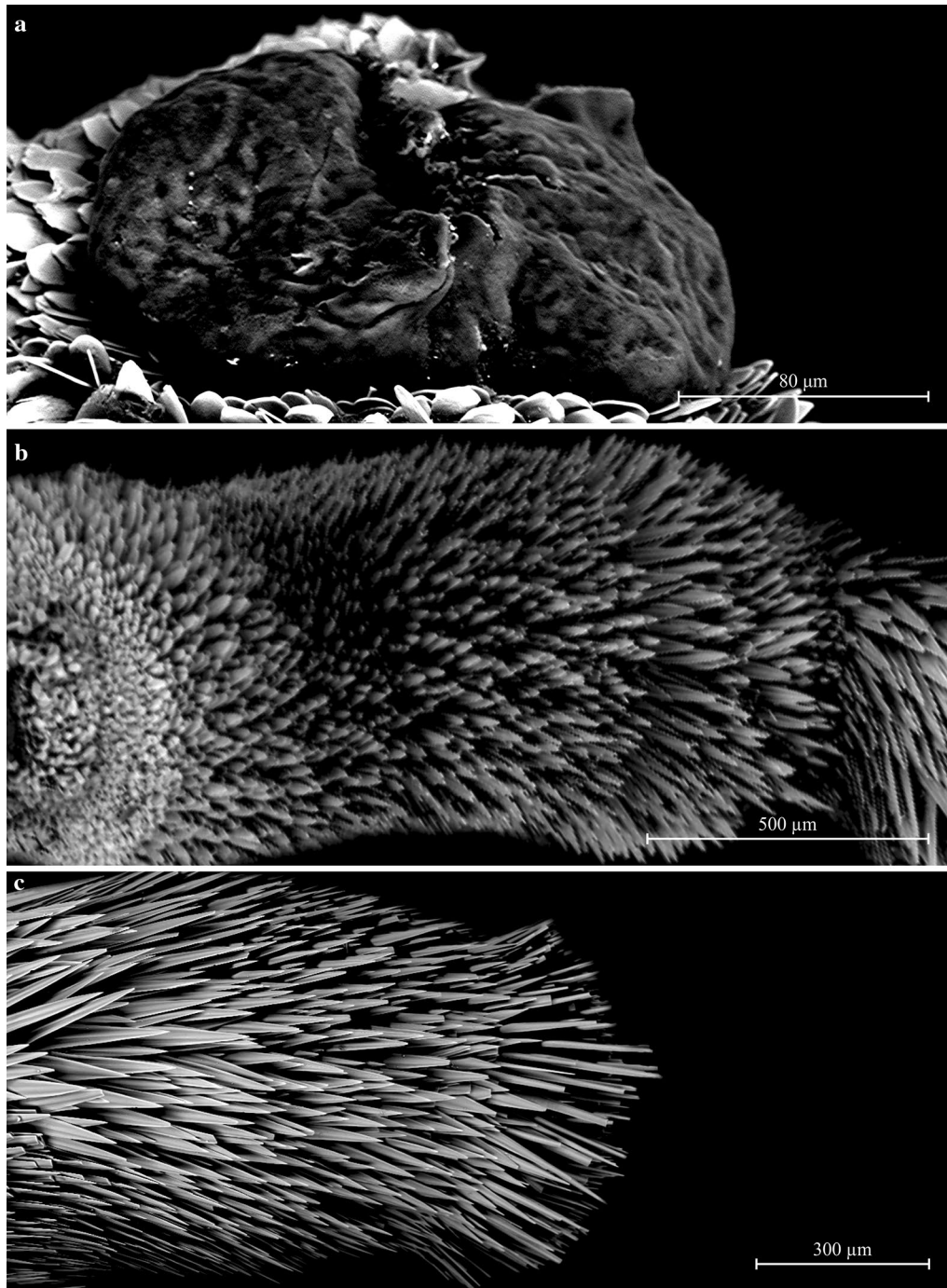


Fig. 8 *Falcidens garcialvarezi* sp. nov. Holotype. **a** Buccal shield; **b, c** Arrangement of sclerites; **b** Sclerites forming an angle to the longitudinal axis on the ventral region of the neck; **c** Sclerites parallel to the mantle on the posterior region

The other three European Atlantic Ocean species occur off the Iberian Peninsula and show characters, which differ from those of *F. garcialvarezi* sp. nov. (Table 3). *Falcidens vasconiensis* Salvini-Plawen, 1996 shows a tail-shaped posterior region, oval sclerites with

two longitudinal grooves on the anterior region, lanceolate sclerites with waist, median keel and several lateral keels on the trunk and tail as well as two pairs of lateral supports; it lacks a triangular plate on the radula. These features differ from the body of *F. garcialvarezi* sp. nov.

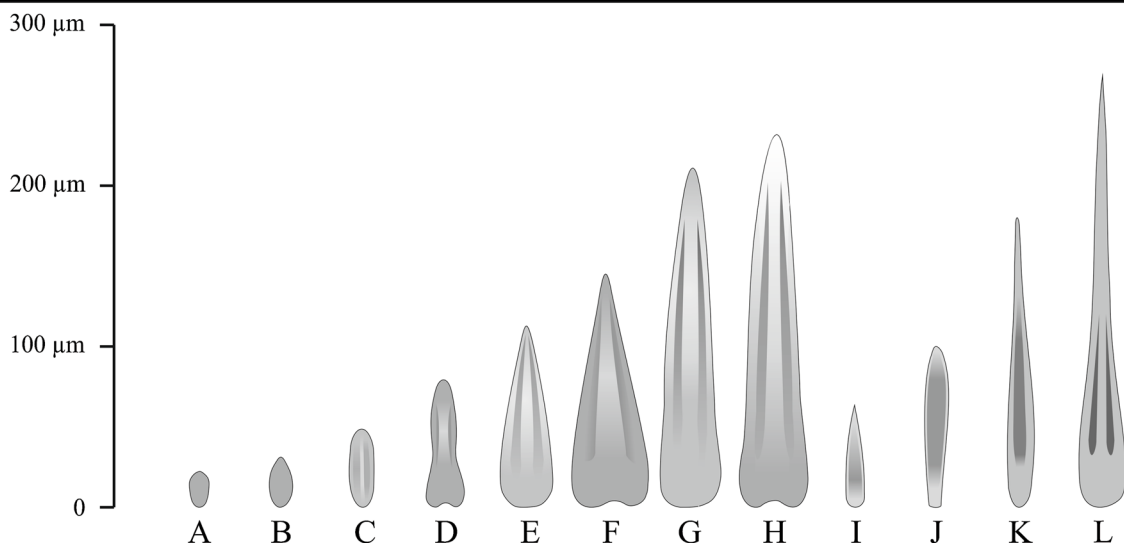
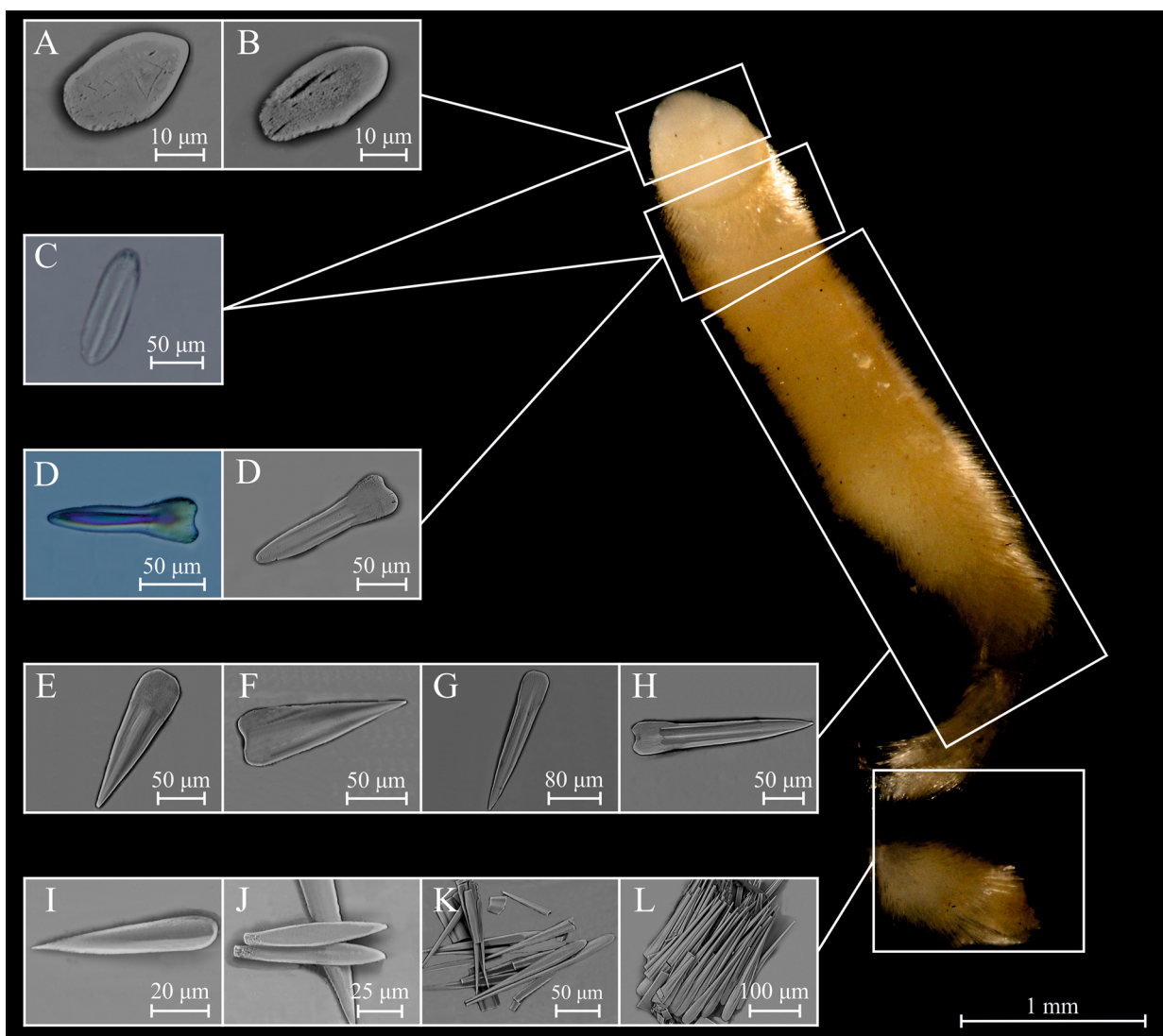
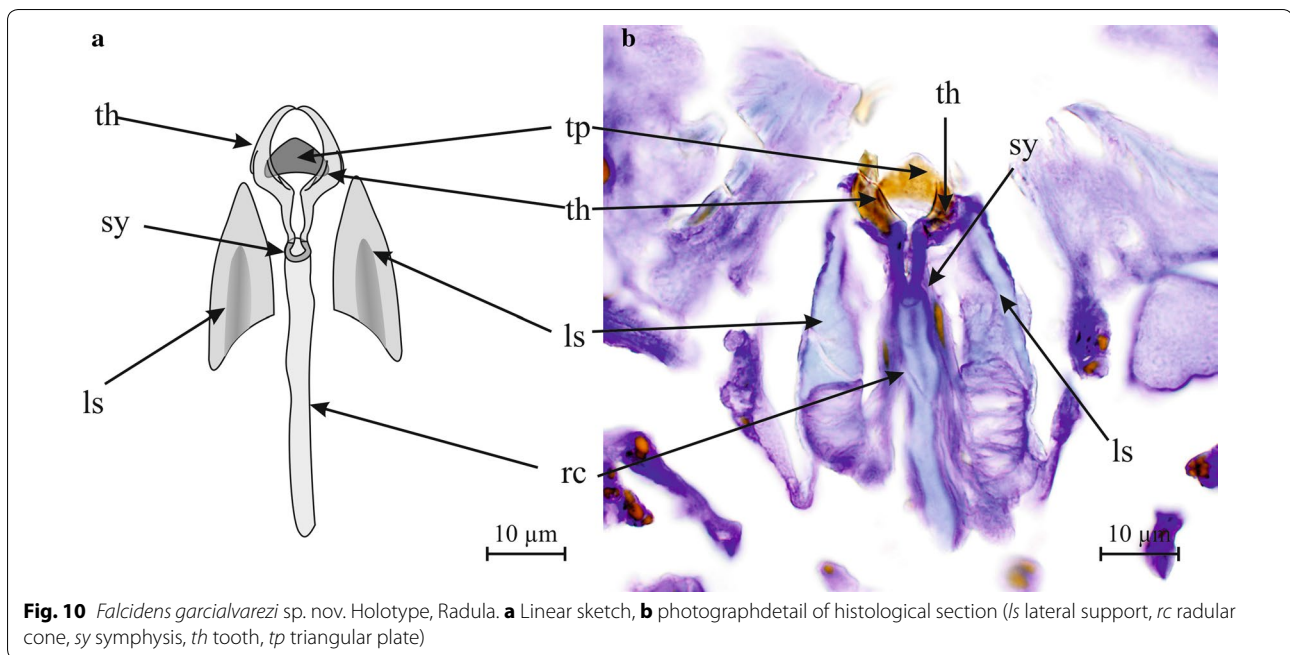


Fig. 9 *Falcidens garcialvarezi* sp. nov. Photograph under SEM and optical microscope; drawings of the sclerites characteristic of each body region. A, B Anterior, C Anterior and Neck, D Neck, E–H Trunk; I–L Tassel



without tail with oval smooth sclerites and oval sclerites with median keel on the anterior region and lanceolate sclerites with median keel and lateral grooves on the trunk. [16, 19, 24, 33].

Falcidens urgorrhii sp. nov. presents sagittal sclerites on the neck, lanceolate sclerites with three types of bases on the trunk and sclerites with acicular blade and round base with a groove on the tassel which *F. garcialvarezi* sp. nov. lacks. Finally, *Falcidens valdubrensis* sp. nov., described below, shows sagittal sclerites on the neck and lanceolate sclerites with waist and median keel on the trunk, which differ from the lanceolate sclerites of the neck and the lanceolate sclerites with median keel and lateral grooves of the trunk shown by *F. garcialvarezi* sp. nov.

***Falcidens valdubrensis* sp. nov.**

Type material—Holotype (MHN-USC 10056) 1.8 mm long, of which only three preparations of sclerites are preserved on slides for optical microscope and one preparation for SEM and deposited at the Museo de Historia Natural of the Universidade de Santiago de Compostela (MHN-USC).

Type locality—Ferrol Canyon; Galicia (NW Iberian Peninsula). Oceanographic expedition DIVA-ARTABRIA I 2002, station DRN-400-2002-130902 (43°45' 892'N; 8°44' 301'W) with EBS on muddy sand bottoms at a depth of 400 m.

Derivatio nominis—The specific epithet is dedicated to the region Val do Dubra, where the first author of this paper comes from.

Diagnosis—Body divided in four regions: anterior, neck, trunk and tassel. Mantle covered in characteristic sclerites according to body region. On the anterior region, they are oval, flat and smooth. Three types of sagittal sclerites on the neck: some with median keel on the blade; others with round base and a blade with median keel with a groove on each side; and a third type of wide sclerites with truncated base and a blade with median keel. Four types of sclerites on the trunk: a first type of narrow lanceolate sclerites with a clear waist and a blade with median keel; a second type of wide lanceolate sclerites with a clear waist and a base as long as the blade, which shows a slight median keel; the other two types are lanceolate, they show a slight median keel and a groove on each side and a base, which is round in one type and truncated in the other. Tassel with two types of sclerites: the first type is lanceolate, with a round base and a blade with a narrow median keel; and a second type of lanceolate sclerites with round base and a very elongated blade with a median keel and a longitudinal groove on each side. Radula with two falciform teeth.

Habitus—Animal 1.8 mm long; twice as wide in the anterior region (0.30 mm) as in the posterior region (0.16 mm), fixed in ethanol 70%; white and transparent. Four body regions: anterior, neck, trunk and tassel (Fig. 11a), which differ in the types of sclerites. Neck delimited by two constrictions: the first separates it from the anterior region; the second differentiates it from the trunk. Long trunk continuing in the tassel, where

the pallial cavity is located with two ctenidia. No buccal shield could be observed due to body contraction.

Sclerites—Sclerites are arranged along the animal body lying parallel to the longitudinal axis on the mantle (Fig. 11b–e). Small on the anterior region (10–20 μm long \times 10–15 μm wide), oval, smooth and flat (Fig. 12A, B). On the neck, it presents three types of larger and sagittal sclerites (30–60 μm \times 20–40 μm); the first type are smooth and flat with a median keel on the distal region of the blade (Fig. 12C); the second type has a round base and a median keel with a groove on each side of the median keel (Fig. 12D); the third type are wide sclerites with truncated base and a slight keel on the distal region of the blade (Fig. 12E). Four types of sclerites on the trunk: the first type are lanceolate, narrow (70–80 μm \times 20–30 μm), with a well-marked waist, a truncated base and an elongated blade, narrower than the base, with a median keel (Fig. 12F); the second type are lanceolate, wide (70–80 μm \times 30–40 μm), with a slight waist in the median region of the sclerite, a median keel on the distal region of the blade, a truncated base and a blade shorter than the base (Fig. 12G). The other two types of the trunk are similar, larger (80–90 μm \times 30–40 μm), lanceolate, with median keel and a longitudinal groove on each side of the median keel. However, one shows a truncated base (Fig. 12H), whereas the second presents a round one (Fig. 12I). The tassel bears two types of sclerites: a smaller type (75–50 μm \times 20–25 μm) of lanceolate elongated sclerites with rounded base and a tapering blade with a narrow median keel (Fig. 12J), and a second type of larger sclerites (100–150 μm \times 25–30 μm) similar but with a much more elongated blade, narrow with a wider median keel and a longitudinal groove on each side (Fig. 12K).

Radula—Only two 20–25 μm long falciform teeth could be observed by transparency. Radular supports and cone unknown.

Remarks—*Falcidens valdubrensis* sp. nov. is characterized by three types of sclerites. The first type is located on the trunk; lanceolate, narrow, with a well-marked waist, a narrow blade with a median keel and a truncated base. The other two types appear on the tassel; they are lanceolate, with a round base and an elongated and narrow blade; one of these types shows only a median keel, whereas the other also presents two lateral grooves.

Six other species of the genus can be found in the North Atlantic Ocean, also easily distinguishable from *F. valdubrensis* sp. nov. Three of them are not present off the NW Iberian Peninsula. *Falcidens crossotus* Salvini-Plawen, 1968 has a tail-shaped posterior body end and oval sclerites with two longitudinal crests on the anterior region [5, 31] which differentiate it from *F. valdubrensis* sp. nov. as the latter lacks a tail and is provided with smooth oval sclerites on the anterior region. Equally, *Falcidens sterreri*

(Salvini-Plawen, 1967) and *Falcidens sagittiferus* Salvini-Plawen, 1968 bear only acicular sclerites on the tassel, whereas *F. valdubrensis* sp. nov. shows solely lanceolate sclerites on this region. Also, *F. valdubrensis* sp. nov. presents sagittal sclerites with a median keel on the neck that are absent in the other three species [5, 30–32]. The other three species of the genus are present in the same geographical area as *F. valdubrensis* sp. nov. Of these three, *Falcidens vasconiensis* Salvini-Plawen, 1996, bears a tail-shaped posterior end, oval sclerites with two longitudinal grooves on the anterior part and lanceolate sclerites with a median keel and several lateral crests on the trunk [16, 19, 24, 33], whereas *F. valdubrensis* sp. nov. lacks a tail and bears smooth oval sclerites on the anterior region and lanceolate sclerites with median keel but without lateral crests on the trunk. Also, *Falcidens garcialvarezi* sp. nov. bears on the neck oval sclerites with median keel and lateral grooves on the one hand, and on the other hand, notched lanceolate sclerites with well-marked waist, median keel and lateral grooves. On the trunk, sclerites are elongated and lanceolate with median keel, lateral grooves and round base with or without notch; the tassel shows four types of sclerites, two acicular, one lanceolate and one spatulate. In contrast, *F. valdubrensis* sp. nov. presents sagittal sclerites with median keel on the neck, four types of lanceolate sclerites on the trunk and a tassel with lanceolate sclerites only. Finally, *Falcidens urgorrii* sp. nov. bears smooth and sagittal sclerites on the neck and three types of sclerites on the tassel; two lanceolate with a median keel and one with acicular blade and wide base and a median groove that *F. valdubrensis* sp. nov. lacks.

The new species can be easily distinguished from the rest of the genus by its body morphology and its particular typology of sclerites (Table 3). Considering the closest species biogeographically, *F. valdubrensis* sp. nov. differs from the three species cited from the Mediterranean Sea. *Falcidens gutturosus* (Kowalevsky, 1901) present the posterior body end tapering in the shape of a tail [21–23]. Regarding the type of sclerites, *F. gutturosus* bears long sagittal sclerites with notched base, median keel and two lateral crests on the neck; lanceolate sclerites with notched base, waist, median keel and several lateral crests on the trunk and acicular sclerites on the tassel. *Falcidens aequabilis* Salvini-Plawen, 1972 shows sagittal elongated sclerites with notched base and median keel on the trunk and sagittal sclerites with notched base and several crests on the tail; the tassel shows only acicular sclerites [21, 23]. In contrast, *F. valdubrensis* sp. nov. bears sagittal sclerites with median keel and lateral grooves on the neck; lanceolate sclerites with a base without notch on the trunk and lanceolate sclerites with median keel on the tassel. As regards the third species

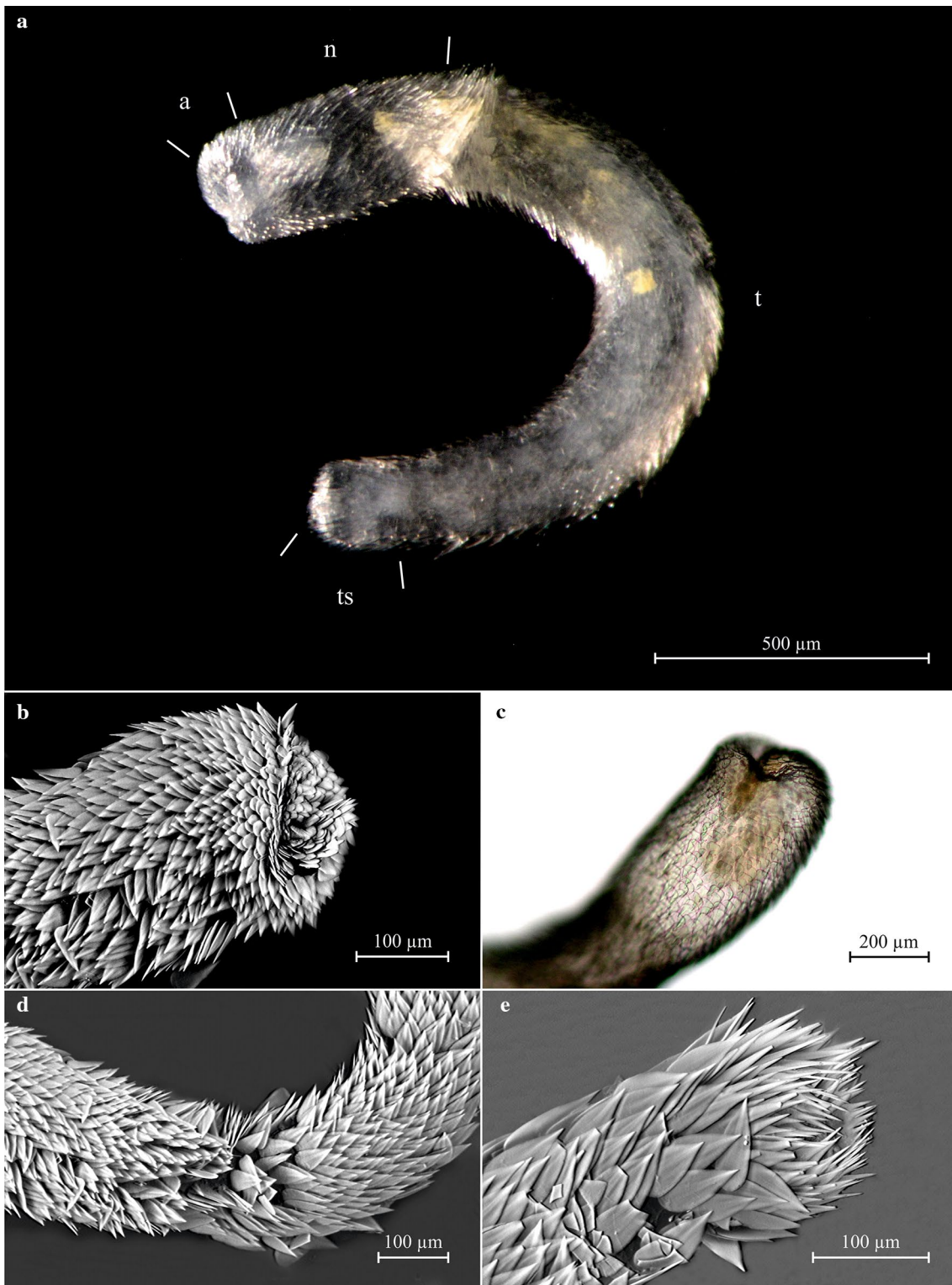
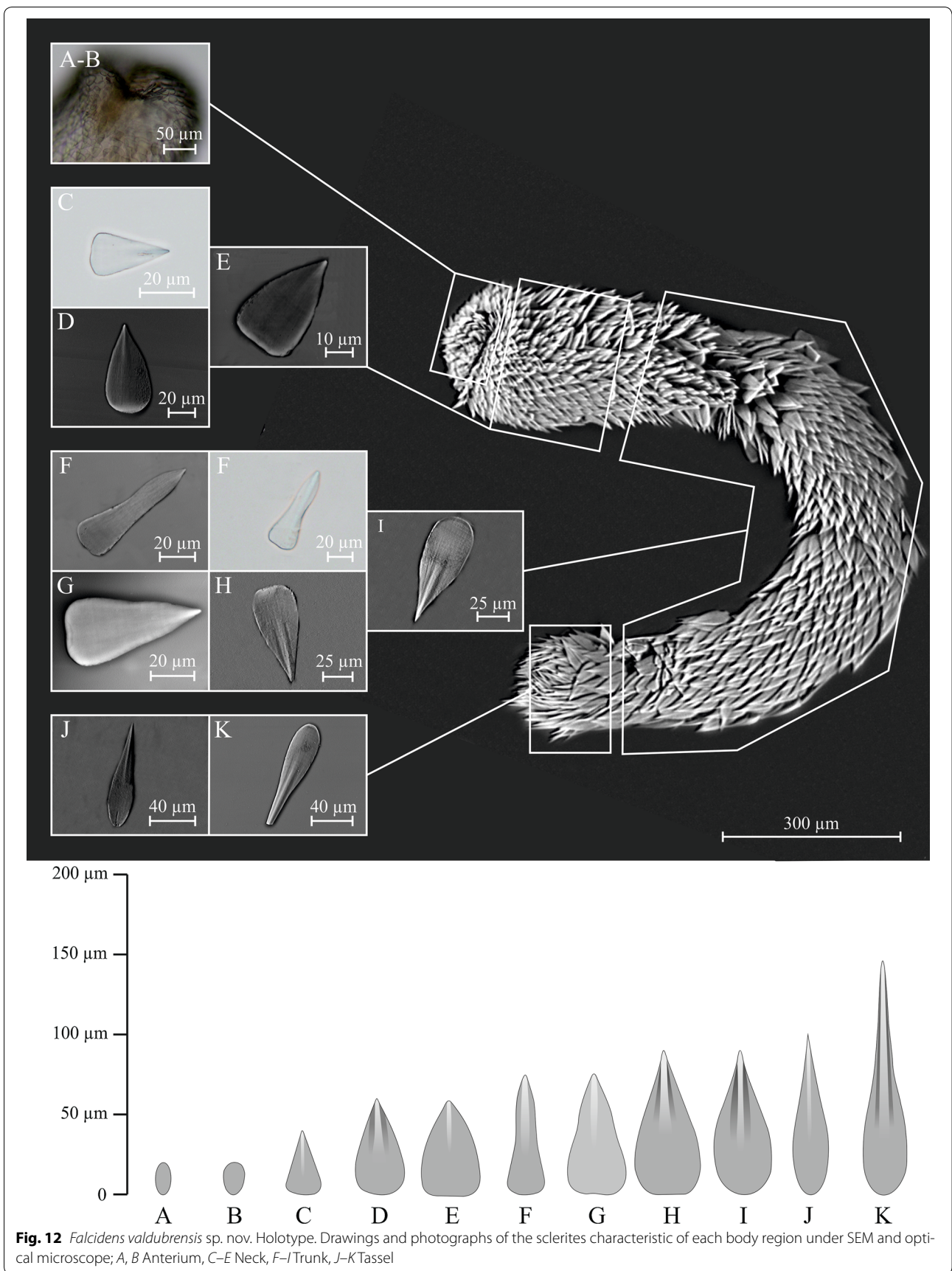


Fig. 11 *Falcidens valdubrensis* sp. nov., Holotype. **a** Habitus; **b–e** Arrangement of sclerites under optical microscope and SEM; **b, c** Anterior and body region; **d** Trunk, **e** Tassel (*a* anterior, *n* neck, *t* trunk, *ts* tassel)



cited from the Mediterranean, *Falcidens strigisquamatus* (Salvini-Plawen, 1977), its trunk shows lanceolate sclerites with several crests that are absent in *F. valdubrensis* sp. nov. [17, 22].

Discussion

The body morphology of Chaetodermatidae has been described in several papers [4–9]. However, there is no consensus regarding the terminology and definition of body regions, which make it difficult to compare different species. Consequently, in the present study, the body regionalization is based on external characters which facilitates the visualization and use in all species.

The data available on the biology and biodiversity of Caudofoveata are still very scarce, which is reflected when describing new species from the European Atlantic coast, one of the areas where these molluscs are best known. Although Caudofoveata can be found in all oceans and most seas, their biogeography has been very little studied and their knowledge is reduced to those areas that were or are still object of systematic research studies.

With the present paper, the number of described species of Caudofoveata stands at 139, 15 of which belong to the family Limifossoridae (5 to the genus *Limifossor*, 1 to *Metachaetoderma*, 6 to *Scutopus* and 3 to *Psilodens*), 39 species to the family Prochaetodermatidae (with only one genus *Prochaetoderma*) and 85 to the family Chaetodermatidae (49 to the genus *Chaetoderma*, 35 to *Falcidens* and 1 to *Furcillidens*).

The new species were collected in soft bottoms, similar in their composition and bathymetry to the most of Caudofoveata habitats [5]. In *Falcidens garcialvarezi* sp. nov., *Falcidens urgorrhii* sp. nov. and *Falcidens valdubrensis* sp. nov. the radula has one pair of sickle shaped teeth, which could act as grasping pincers in a selective carnivorous diet [13, 34, 35].

Concerning to the class Caudofoveata, and considering the description of 4 new species in this study, the European Atlantic area becomes a well-documented area with a total of 25 described species, followed by the North American Atlantic and the Pacific areas with 22 species each one. As for the Iberian Peninsula, the number of known species is now 18; 3 belong to the family Limifossoridae: *Scutopus ventrolineatus* Salvini-Plawen, 1968; *Scutopus robustus* Salvini-Plawen, 1970 and *Psilodens tenuis* Salvini-Plawen, 1977, 7 to Prochaetodermatidae: *Prochaetoderma alleni*, (Scheltema and Ivanov, 2000); *Prochaetoderma boucheti* Scheltema and Ivanov, 2000; *Prochaetoderma clenchi* (Scheltema, 1985); *Prochaetoderma gladiatum* Salvini-Plawen, 1992; *Prochaetoderma iberogallicum* Salvini-Plawen, 1999; *Prochaetoderma turnerae* (Scheltema, 1985), *Prochaetoderma yonguei* Scheltema, 1985, 8 to

Chaetodermatidae: *Chaetoderma galiciense* sp. nov.; *Falcidens aequabilis* Salvini-Plawen, 1972; *Falcidens gutturosus* (Kowalevsky, 1901); *Falcidens garcialvarezi* sp. nov.; *Falcidens strigisquamatus* (Salvini-Plawen, 1977); *Falcidens urgorrhii* sp. nov.; *Falcidens valdubrensis* sp. nov. and *Falcidens vasconiensis* Salvini-Plawen, 1996. Thus, the coast of the NW Iberian Peninsula is with 6 species one of the most researched areas of the Iberian Peninsula.

Authors' contributions

MPS carried out the study and photographed the specimens, participated in data collection and drafted the manuscript. OGA carried out the data collection, helped to study the specimens and to draft the manuscript. VU conceived the study, participated in its design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and material

The data supporting the conclusions of this article are available in the main paper.

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