



One new species and records of *Ichthydium* Ehrenberg, 1830 (Gastrotricha: Chaetonotida) from Sweden with a key to the genus

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Abstract

The freshwater gastrotrich fauna of Sweden is poorly known. Only seven species of freshwater gastrotrichs have been reported so far. This paper is the first in a series of contributions about the Swedish freshwater gastrotrich fauna. Here we describe one new species, *Ichthydium skandicum* n. sp., from Jämtland, northern Sweden. The new species falls within the boundary of the subgenus *Forficulichthys* and is morphologically closest to *Ichthydium tanytrichum* from which it can be differentiated based on the presence of four pairs of dorsal, keeled scales in the posterior trunk region. Moreover, we provide morphometric data for three additional *Ichthydium* species: *I. diacanthum*, *I. squamigerum* and *I. tanytrichum*, Italian species all of which are reported for the first time outside Italy. Considering the accompanying fauna, a total of thirteen freshwater Gastrotricha are reported for the first time from Sweden. Finally we present a dichotomous key for *Ichthydium* along with distributional data of the species considered.

Key words: Chaetonotidae, Freshwater fauna, Meiofauna, Taxonomy, Taxonomical key

Introduction

Gastrotricha are microscopic animals which inhabit both freshwater and marine environments. To date around 750 species are known. Gastrotrichs are considered cosmopolitan and have been reported, in the literature, from all continents except Antarctica (see e. g. d'Hondt, 1971; Balsamo *et al.*, 2008). Gastrotrichs are a common component of the interstitial fauna of marine sands as well as of the freshwater periphyton and epibenthos. Freshwater representatives belong, with very few exceptions, to the order Chaetonotida (Balsamo & Todaro, 2002). Characteristic for this order is the tenpin-shaped body usually with a bifurcated posterior end bearing adhesive tubes. To date Chaetonotida include 29–30 genera of which *Chaetonotus* Ehrenberg, 1830 with more than 200 nominal species is the most numerous (Todaro & Tongiorgi, 2008; Balsamo *et al.* 2009).

Only seven species of freshwater gastrotrichs have been reported for Sweden so far. Hofsten (1923) found *Chaetonotus macrochaetus* Zelinka, 1889, *C. maximus* Ehrenberg, 1838 and *Lepidodermella squamata* (Dujardin, 1841), while studying the rotifer fauna of northern Sweden. Moreover, Schwank (1990) reported *C. chuni* Voigt, 1901, *C. longispinosus* Stokes, 1887 and *C. schultzei* Metschnikoff, 1865 as present in Sweden. In addition, Fauna Europaea includes *Aspidiophorus squamulosus* (Roszczak, 1936) among the Swedish fauna. The limnic species reported from Sweden, except *A. squamulosus*, are all considered to have a cosmopolitan distribution and have been found in Central Europe, North America and/or Asia (see Schwank, 1990).

The genus *Ichthydium* Ehrenberg, 1830 contains 35 nominal species (see Balsamo *et al.* 2009) and is characterized by a loss or strong reduction of cuticular elements such as scales and spines (Schwank, 1990; Kisielewski, 1991). So far, keeled scales, spines and/or cuticular plates have been reported for *I. crassum* Daday, 1905, *I. diacanthum* Balsamo & Todaro, 1995, *I. dubium* Preobrajenskaja, 1926, *I. fossae* d'Hondt, 1972, *I. plicatum* Balsamo & Fregni, 1995, *I. squamigerum* Balsamo & Fregni, 1995 and *I. tanytrichum* Balsamo, 1982. Putative vestigial spines has also been reported for *I. sulcatum* (Stokes, 1887) by Weiss (2001). Kisielewski (1987) proposed that many *Ichthydium* species actually have very fine cuticular structures or spines. This was also acknowledged by Balsamo (1990) who used scanning electron microscopy for *Ichthydium podura* (Müller, 1773) and revealed that the apparently naked cuticle has small spine-like microsculptures not visible under a DIC-microscope.

In this paper a new species of *Ichthydium* from Sweden is described. Morphometric data are provided for three additional species within the genus found during an ongoing survey and a dichotomous key to all known species of *Ichthydium* is also presented. Records of other gastrotrich species belonging to *Chaetonotus*, *Aspidiophorus* Voigt, 1903, *Polymerurus* Remane, 1926 and *Lepidodermella* Blake, 1933, details of which will be provided in future publications, are also presented. This is the first of several contributions on the freshwater gastrotrich fauna of Sweden and a part of the Swedish Taxonomy Initiative (STI).

Material and methods

Samples were collected during spring and summer 2008 in the province of Jämtland and in the Stockholm area. Additional sampling from the Swedish west coast was done during summer 2009. Subsamples were treated with 1% MgCl₂-solution to anaesthetize the animals. Specimens were extracted with a micropipette and studied alive. Pictures and documentation were made with a Nikon Eclipse 80i DIC microscope equipped with Nikon Digital Sight DS-Fi1 digital camera. Subsequently specimens were preserved in either 95% EtOH for molecular studies or 10% borax neutralized formalin for further morphological studies or for preparation of type material. In the latter case specimens were put through a series of glycerol, ethanol and water (Solution #1: 1 glycerol: 79 distilled water: 20 EtOH (95%); solution #2: 5 glycerol: 95 EtOH (95%); solution #3: 50 glycerol: 50 EtOH (95%)). Solutions were changed when the ethanol had evaporated. Subsequently individuals were placed in a tiny drop of glycerol with formalin and sealed with asphalt varnish. The description of the species in this paper follows the convention of Hummon *et al.* (1992) where the positions of certain morphological characters are given in percentage units (U) of total body length measured from anterior to posterior.

Results

Order Chaetonotida Remane, 1925 [Rao & Clausen, 1970]

Suborder Paucitubulatina d'Hondt, 1971

Family Chaetonotidae Gosse, 1864 (*sensu* Leasi & Todaro, 2008)

Genus *Ichthydium* Ehrenberg, 1830

Ichthydium skandicum n. sp.

(Figures 1, 2; Table 1)

Type material: Holotype mounted in glycerin with 10 % borax neutralized formalin. Department of Invertebrate Zoology, Swedish Museum of Natural History, Stockholm, Sweden. Accession no. 7753.

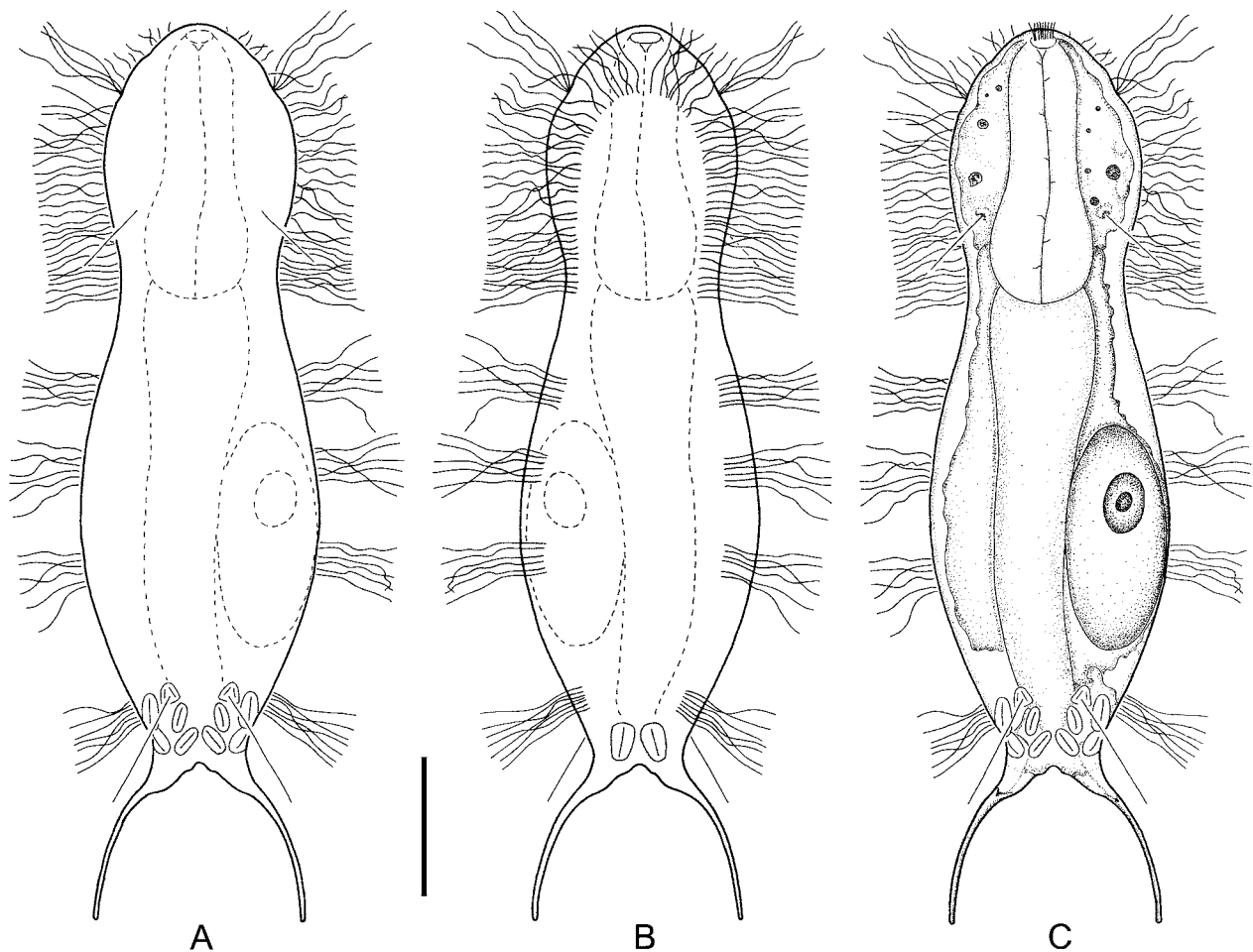


FIGURE 1. A–C) Different representations of *Ichthydium skandicum* n. sp. Schematic drawing of A) dorsal view and B) ventral view. C) Detailed drawing of dorsal view. Scale bar: 20 μ m.

Other material: Six specimens which were measured and photographed but are no longer extant. Several additional specimens in 95% Ethanol for genetic studies.

Type locality: A small pool in a bog close to highway E14 between Åre and Storlien, Jämtland, Sweden, July 2008 (63°21.248'N; 12°35.403'E).

Other localities: Rockpool on Skaftö among *Sphagnum* sp., Bohuslän, Sweden, July 2009 (58°14.837'N; 11°26.269'E); Artificial pond on Skaftö among *Sphagnum* sp., Bohuslän, Sweden, July 2009 (58°14.634'N; 11°27.220'E); Rockpool on Blåbergsholmen among *Sphagnum* sp., Bohuslän, Sweden, July 2009 (58°14.976'N; 11°26.383'E).

Etymology: The species name refers to the Scandinavian mountain range “Skanderna” where the species was first found.

Diagnosis: Mid-sized *Ichthydium* species. Head with three lobes and one pair of ciliary tufts. Furca long and tong-shaped, each branch with very short base. Two pairs of thick sensory bristles, the posterior pair anchored to bi-keeled subtriangular scales. Dorsal body surface naked except for one pair of subtriangular bi-keeled scales anchoring the posterior sensory bristles and four pairs of keeled subrectangular scales at the base of the furca. Pharynx large, 30–35 μ m in length with posterior swelling; pharyngeal-intestinal junction (PhIJ) at U28. Locomotory cilia arranged in two rows in the anterior body region divided into four pairs of tufts in the trunk region. Ventral interciliary area naked except for two subrectangular terminal scales. Specimens observed were in parthenogenetic phase.

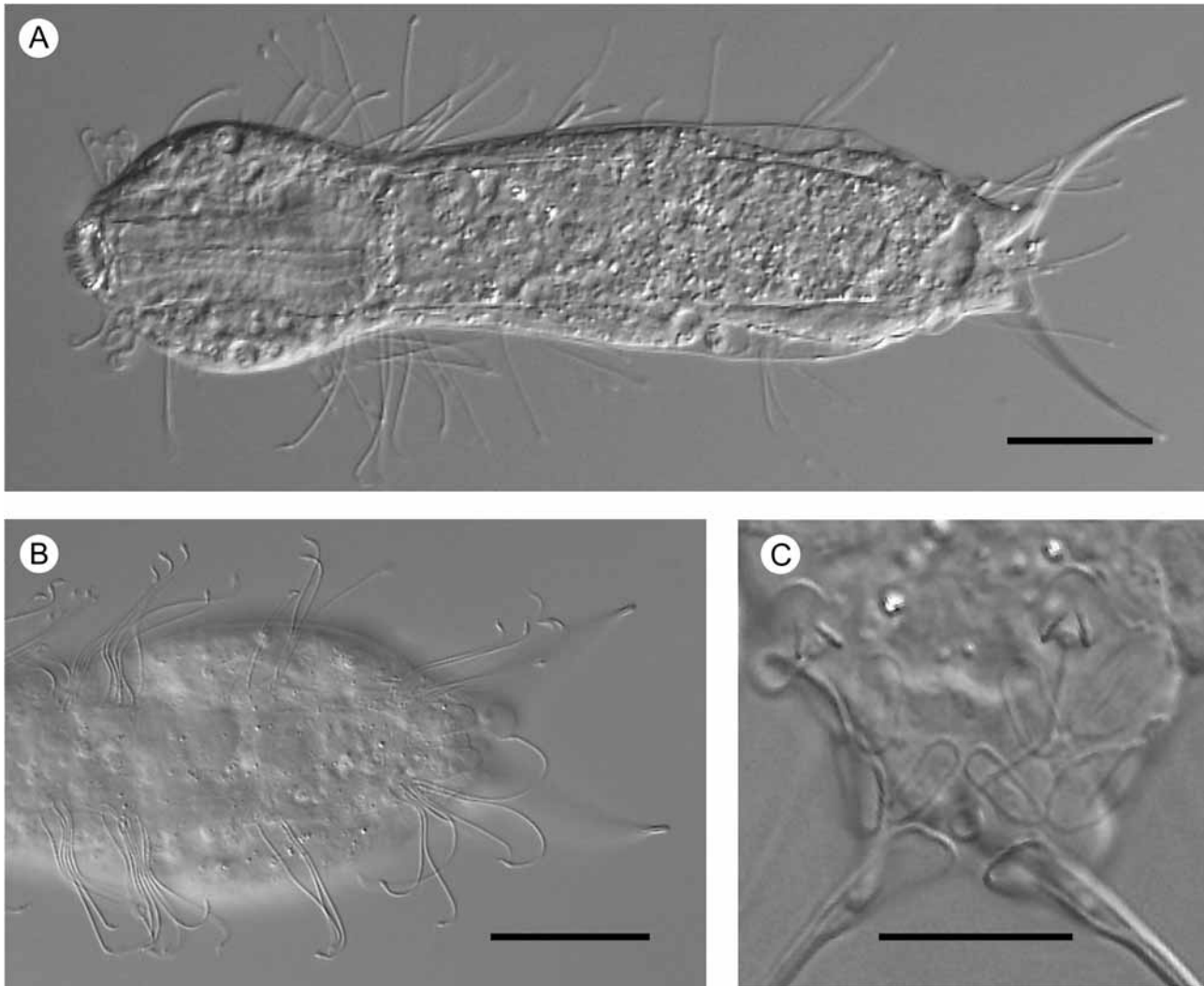


FIGURE 2. A–C) Photographs of live specimens of *Ichthydium skandicum* n. sp. A) Habitus. B) Ventral view showing distribution of ciliary tufts in the trunk region. C) Dorsal view of posterior trunk region showing distribution of scales. Scale bars: A, B 20 μm ; C, 10 μm .

Description: Mid-sized *Ichthydium* species, 132–142 μm in total body length. Three-lobed head bearing one pair of cephalic ciliary tufts at U6. The longest cilium in each tuft is 20 μm in length. No cephalic plates were detected. Width of head/neck/trunk/furcal base are as follows: 23–32/20–28/28–42/12–14 μm at U13/ U28/ U60/ U82. Furca tong-shaped, 27–30 μm in length of which the adhesive tubes contribute 20–25 μm . A pair of bi-keeled subtriangular scales anchoring the posterior sensory bristles is present at U75. Another pair of sensory bristles arises from the neck region at U20. The sensory bristles are thick, the anterior pair (ASB) measures 10–12 μm and the posterior pair (PSB) 20 μm in length. Moreover, four pairs of dorsal subelliptical, keeled scales are present at the posterior end, two pairs situated dorsolaterally at U76 (6 x 1.5 μm) and U80 (6 x 1.5 μm) respectively and two pairs dorsally at U78 (4.5–6 x 1–2 μm) and U81 (4.5–5 x 1–2 μm) respectively. Apart from these five pairs of scales the dorsal body cuticle appears naked.

Ventral ciliation consists of locomotor cilia, 20–25 μm in length, arranged in two rows. In the trunk region the two rows are divided into four pairs of tufts. The anterior-most pair of tufts is situated in the anterior trunk region. The posterior-most pair of tufts is separated by a greater distance from the others of the same row. Interciliary area naked except for two rectangular keeled terminal scales, 8–9 μm in length and 4–4.5 μm in width. Mouth subterminal, 6–7 μm in diameter. Pharynx, 30–35 μm in length, widening towards the pharyngeal intestinal junction at U28. Intestine straight, tapering towards posterior end, anus ventral at U74.

The observed specimens were in parthenogenetic phase. More or less mature eggs, situated on either side or dorsal to the intestine, were seen in all specimens.

TABLE 1. Morphometric data (μm) for *Ichthyidium skandicum* n. sp. Specimen H, 1, 2 and 3 were found in Jämtland 2008 while specimens 4, 5 and 6 were found in Bohuslän 2009. L, Length; W, Width; H, Holotype; Na, Not available.

Character	Specimen						
	H	1	2	3	4	5	6
Total body L	135	137	132	135	140	140	142
Head W	30	25	25	23	28	32	32
Neck W	25	20	22	13	22	22	28
Body W	35	33	32	28	33	30	42*
Furca Base W	13	12	12	12	13	13	14
Furca L	30	30	28	28	27	28	28
Pharynx L	34	31	30	30	32	33	35
Mouth ϕ	7	6	6	6	6	6	6
Sensory Bristle Scale L x W	4 x 4	6 x 5	Na	5 x 5	4 x 4	4 x 4	4 x 4
Anterior Sensory Bristle L	~10	Na	Na	~12	13	9	10
Posterior Sensory Bristle L	20	20	~20	~20	20	26	Na
Furca Scales Dorsolateral L x W	6 x 2	Na	Na	Na	Na	5 x 1	6 x 1.5
Furca Scales Dorsal L x W	6 x 2	Na	Na	Na	4.5 x 1	4.5 x 1	5 x 1
Ventral Cilia L	Na	~24	~25	Na	20-25	24	20-25
Ventral Terminal Scales L x W	9 x 4	Na	Na	Na	9 x 4.5	8 x 4	Na

* Specimen with large mature egg.

Taxonomic remarks: *Ichthyidium* is currently divided into three subgenera (but see Balsamo *et al.* 2009): *Euichthyidium* Schwank, 1990 predominantly species with a naked cuticle, *Forficulichthys* Schwank, 1990, characterized by species bearing tong-shaped furca with tapering tips and the monotypic *Pseudichthyidium* Rudescu, 1967 which contains *I. balatonicum* Varga, 1950, characterized by a large comb-like keel on its dorsal body surface. It should be emphasized that many species are still not affiliated to any of the three above subgenera (see Appendix 1). It should also be noted that the subgenus *Euichthyidium* is invalid; because it contains the type of the genus *Ichthyidium*, hence it must bear the same name as the genus (see ICZN Article 44.1).

Ichthyidium skandicum n. sp., by virtue of its tong-shaped furca, most closely resembles species within the subgenus *Forficulichthys*. According to Schwank (1990) the latter taxon contains four species, *I. cephalobares* Brunson, 1949, *I. forficula* Remane, 1927, *I. forcipatum* Voigt, 1901 and *I. tanytrichum*. The only species within this subgenus with both a tong-shaped furca and dorsal scales in the posterior trunk region is *I. tanytrichum*, with bi-keeled scales that carry the posterior sensory bristles in contrast to *I. skandicum* n. sp. which carries an additional four pairs of keeled dorsal scales.

Ichthyidium contains an additional four species that carry scales or spines in the posterior trunk region *I. crassum*, *I. diacanthum*, *I. dubium* and *I. squamigerum*. *I. crassum*, *I. diacanthum* and *I. dubium* have spines but apparently lack scales which together with the different shape of the furca, differentiate them from *I. skandicum* n. sp. (Daday, 1905; Schwank, 1990; Balsamo & Todaro, 1995). *I. squamigerum* has two pairs of keeled scales at the base of the furca compared to four pairs in *I. skandicum* n. sp. Moreover, at least another noticeable trait distinguishes these two species, that is the furca which is long (28–30 μm) and tong-shaped in *I. skandicum* n. sp. and short (13–18 μm) and straight in *I. squamigerum* (see Balsamo & Fregni, 1995).

Hence, *I. skandicum* n. sp. is morphologically closest to *I. tanytrichum*.

Associated gastrotrich fauna: *Chaetonotus oculifer* Kisielewski, 1981 and *Ichthyidium diacanthum*.

***Ichthydium diacanthum* Balsamo & Todaro, 1995**

(Figures 8A, B; Table 2)

Localities: Bog close to E14, Jämtland, Sweden (63°21.248'N; 12°35.403'E).

Material: 1 specimen.

Remarks: The Swedish specimen of *I. diacanthum* agrees well with the morphometric data given by Balsamo & Todaro (1995). This species is characterized by a fine pattern of cuticular microsculptures which gives the cuticle a granulated appearance. PhIJ at U29; ASB at U22; PSB at U75.

Associated gastrotrich fauna: *Chaetonotus oculifer* and *Ichthydium skandicum* n. sp.

***Ichthydium squamigerum* Balsamo & Fregni, 1995**

(Figures 8E–G; Table 3)

Localities: Trösvattnet, Västmanland, Sweden (59°33.211'N; 14°29.232'E); Lake Siljan, Dalarna, Sweden (60°53.039'N; 15°06.467'E); Stora Skuggan, Norra Djurgården, Stockholm, Sweden (59°22.068'N; 18°04.152'E).

Material: 7 specimens, 3 measured.

TABLE 2. Morphometric data (µm) for *Ichthydium diacanthum* (n=1). For comparison morphometrics from Balsamo & Todaro (1995) are included. L=Length, W=Width; Na, Not available.

Character	Specimen	
	1	Balsamo & Todaro (1995)
Total body L	125	111–143
Head W	30	33–34
Neck W	25	Na
Body W	35	Na
Furca base W	~15	Na
Furca L	18–19	15–22
Adhesive tube L	10	Na
Pharynx L	32	17–33
Mouth ø	Na	Na
Furca spine L	~10	8.9–13.5
Anterior sensory bristle L	~20	Na
Posterior sensory bristle L	~22	Na

Remarks: The specimens of *I. squamigerum* agree well with the morphometric data provided by Balsamo & Fregni (1995). The distribution and shape of the rounded keeled scales at the base of the furca as well as the subrectangular ventral terminal scales also agree with the original description. A peculiar difference between the Swedish and the Italian specimens is that the former lack the bi-keeled scales anchoring the posterior sensory bristles. The bristles originate from papillae instead of scales. Fregni *et al.* (1998) found *I. squamigerum* exclusively in freshwater sand. Six of the Swedish specimens were found at a sandy beach at lake Siljan and one specimen in a very small sandy patch at lake Trösvattnet. The findings of *I. squamigerum* in Sweden are the first records outside Italy where the species was described. PhIJ at U28; ASB at U23; PSB at U78.

Associated gastrotrich fauna: *Chaetonotus benacensis* Balsamo & Fregni, 1995, *C. hystrix* Metschnikoff, 1865, *C. mutinensis* Balsamo, 1978, *Lepidodermella squamata* and *Polymerurus rhomboides* (Stokes, 1887).

TABLE 3. Morphometric data (μm) for *Ichthyidium squamigerum* (n=3). For comparison morphometrics from Balsamo & Fregni (1995) are included. L=Length, W=Width; Na, Not available.

Character	Specimen			Balsamo & Fregni (1995)
	1	2	3	
Total body L	99	105	110	84–112
Head W	22	20	24	19–23
Neck W	18	18	20	13–20
Body W	29	28	33	20–30
Furca base W	14.5	13	13	10.0–12.4
Furca L	13	16	16	13–18
Adhesive tube L	7	10	9	10.6
Pharynx L	24	26	28	24–26
Mouth ϕ	3	4	4	Na
Furca medial scale L x W	5 x Na	5 x Na	Na	3.5–5.1 x 3.8
Furca distal scale L x W	5 x Na	5 x Na	Na	4.5 x 3.5
Longest sensory cilia L	13	14	11	10.5
Anterior sensory bristle L	7	13	12	Na
Posterior sensory bristle L	11	Na	13	Na
Ventral terminal scales L x W	Na	5 x Na	7 x 3	Na

Ichthyidium tanytrichum Balsamo, 1982

(Figures 7A, B; Table 4)

Localities: Ännsjön, Jämtland, Sweden (63°15.637'N; 12°27.090'E).

Material: 1 specimen.

Remarks: *Ichthyidium tanytrichum* is short and plump with a long tong-shaped furca. The Swedish specimen was an adult specimen of 126 μm in total body length and agrees well with descriptions provided by Balsamo (1982). The bi-keeled scales anchoring the posterior bristles as well as the large rectangular ventral terminal scales and the four pairs of long ventral ciliary tufts in the trunk region were clearly visible. Balsamo (1982) reports a total body length of only 74–76 μm for *I. tanytrichum*. In our opinion the specimens found by Balsamo (1982) were probably sub-adults based on the fact that the original drawing of this species was depicted without an egg, and most important the length of the pharynx is proportionally too long compared to total body length, a trait that is typical for sub-adult animals. PhIJ at U27; ASB at U18; PSB at U71.

Associated gastrotrich fauna: *Aspidiophorus tetrachaetus* Kisielowski, 1986, *Chaetonotus armatus* Kisielowski, 1981, *C. heideri* Brehm, 1917 and *C. polyspinosus* Greuter, 1917.

Discussion

This study presents the first findings of *Ichthyidium* in Sweden with a description of a new species, *Ichthyidium skandicum* n. sp. Three additional taxa, *I. diacanthum*, *I. squamigerum* and *I. tanytrichum* are reported for the first time outside Italy from where they were originally described. The total number of reliable species in *Ichthyidium* has now increased to 29 (freshwater and marine). It is also the first time that *Aspidiophorus tetrachaetus*, *Chaetonotus armatus*, *C. benacensis*, *C. heideri*, *C. hystrix*, *C. mutinensis*, *C. oculifer*, *C. polyspinosus* and *Polymerurus rhomboides* are found in Sweden. This increases the total number of known freshwater gastrotrichs from the country to 20.

TABLE 4. Morphometric data (μm) for *Ichthydium tanytrichum* (n=1). For comparison morphometrics from Balsamo (1982) are included. L=Length, W=Width; Na, Not available.

Character	Specimen	
	1	Balsamo (1982)
Total body L	126	74–76
Head W	28	16–17
Neck W	26–28	13
Body W	36	20–22
Furca base W	18	Na
Furca L	30	20
Pharynx L	26–28	22–24
Mouth ϕ	8	5.5
Sensory bristle scale L x W	5 x 4	4.9 x 3.9
Anterior sensory bristle L	Na	25–26
Posterior sensory bristle L	Na	20–21
Ventral cilia L	22	27
Ventral terminal scales L x W	7 x 3	Na

There are very few known freshwater species in Sweden compared to other temperate regions. Limiting the assessment to the most studied countries, 90 species are known from Germany (Remane, 1936; Schwank, 1990), 98 species from Poland (Kisielewski, 1998), 91 species from Russia (Tretjakova, 1991) and 58 species from United Kingdom (Martin, 1990). From this it is predicted that many more species should be present in Sweden.

The genus *Ichthydium* is based on a negative character, the lack of cuticular structures, such as scales and spines. However, many species with cuticular structures (e. g. *I. crassum*, *I. dubium*, *I. plicatum*, *I. squamigerum*) have subsequently been placed within the genus. Moreover, high resolution microscopy and electron microscopy have revealed that some species have a microsculptured cuticle with very fine longitudinal reliefs and/or folds (e. g. *I. diacanthum*, *I. fossae*, *I. podura* and *I. sulcatum*). There are actually few species (e. g. *I. forficula*) that exhibit a completely naked cuticle (Kisielewski, 1987; 1991). Remane (1936) states that the absence of cuticular structures in *Ichthydium* is not ancestral. According to Kisielewski (1991) species exhibiting very fine longitudinal reliefs or keeled scales are putative descendants of *Heterolepidoderma* while species with spines are putative descendants of *Chaetonotus*.

It is obvious that *Ichthydium* is in need of a taxonomic revision. The lack of type material and the fact that some species are very rare and have only been found once or on a few occasions will certainly make this a difficult endeavour.

Key to species of *Ichthydium*

This dichotomous key to *Ichthydium* treats all the species for the genus with exception for *I. jamaicense* Schmarda, 1861, *I. malleum* Schwank, 1990, *I. macrurum* Collins, 1898, *I. monolobum* Brunson, 1950, *I. pellucidum* Preobrajenskaja, 1926 (species inquirenda), *I. stokesi* Grosso, 1973 and *I. tabulatum* Schmarda, 1861. These nominal species are of questionable status and the reason for this is outlined below. A rough geographic distribution is also given in parentheses, but it should be noted that it is preliminary as many parts of the world remain unexplored.

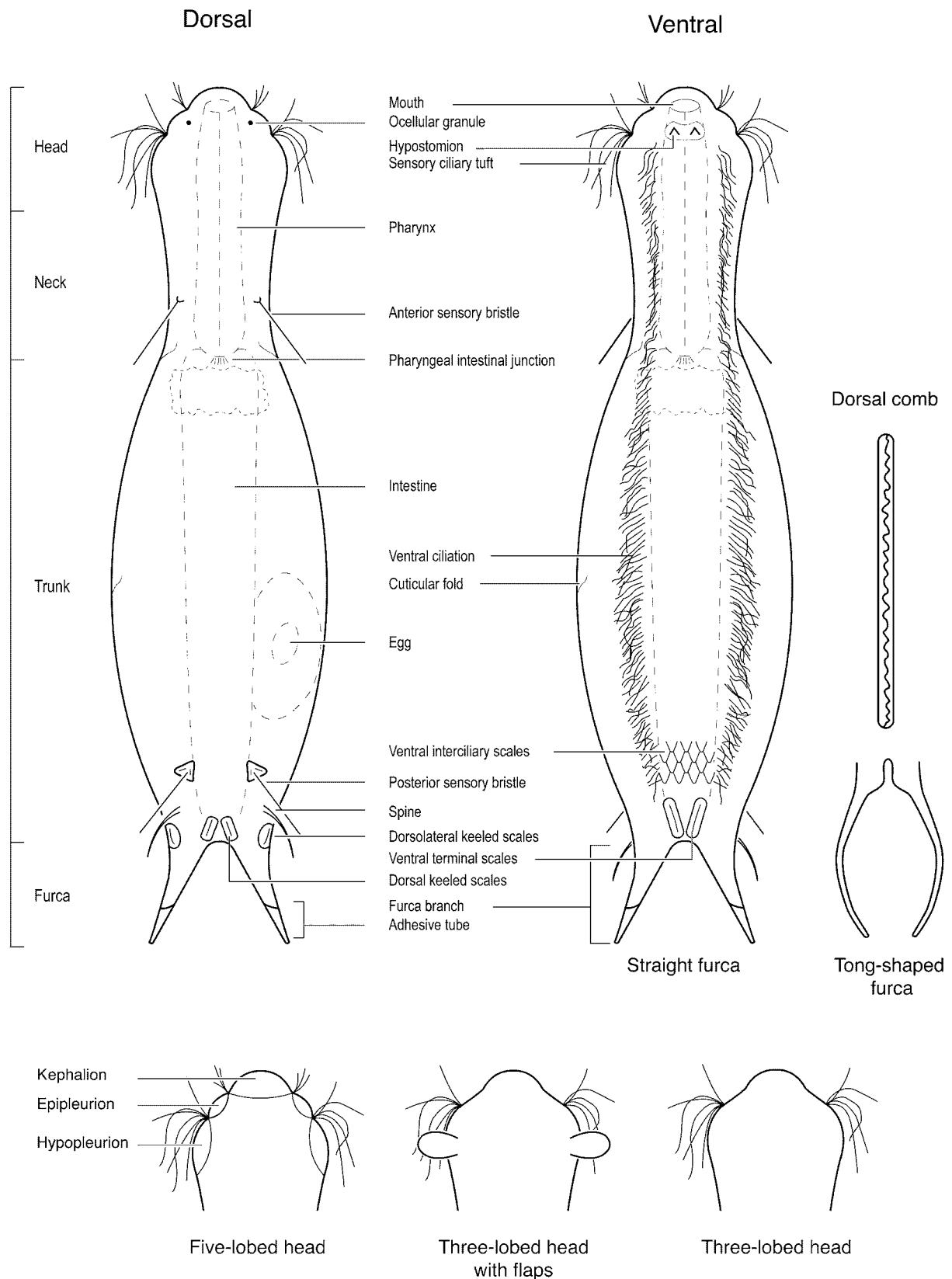


FIGURE 3. Hypothetical *Ichthyidium* species showing some diagnostic characters used in the key.

Ichthyidium jamaicense described from St. Anne area on Jamaica by Schmarda (1861) is approximately 200 µm long. According to the description it is elongate-oval in shape with an arched back and flat ventral

surface. The dorsal surface carries short bristles. The intestine is straight and ends beneath the short furca. It is most probable that *I. jamaicense* is a *Chaetonotus* with short simple spines (Murray, 1913; Schwank, 1990). Without new material more can not be said with certainty and the species is considered *species inquirenda*.

Ichthydium malleum found in Ontario, Canada is only mentioned in the identification key in Schwank (1990) and a description is lacking, hence it is *nomen nudum*.

Ichthydium macrurum found in East Africa by Collin (1898). The only information provided in the description is that the furca contributes to more than 1/3 of the total body length, consequently it is considered *species inquirenda*.

Ichthydium monolobum is here considered a synonym to *I. forficula* (see discussion in Kisielewski, 1981).

Ichthydium pellucidum described from a Russian bog by Preobrajenskaja (1926) is a rather large *Ichthydium* species (150–190 µm). The head is five-lobed (20–25 µm in width) and sharply separated from the body. A kephalion and two pairs of sensory ciliary tufts are present. The base of the furca is wide and holds short branches. The cuticle is completely naked and transparent in some places, with thirteen lateral cuticular folds. The ventral side is not described and other important diagnostic data are lacking. The figure accompanying the description lacks details and basically shows an outline of a gastrotrich. *Ichthydium pellucidum* can with certainty not be separated from *I. palustre* Kisielewski, 1981. Both species were found in *Sphagnum*, they are of approximately the same size, have similar general appearance and a cuticle with cuticular folds (Preobrajenskaja, 1926; Kisielewski, 1981). *I. pellucidum* is here considered *species inquirenda*.

Ichthydium stokesi described from Argentina is here considered a synonym of *Heterolepidoderma gracile* Remane, 1927 (see discussion in Kisielewski, 1991).

Ichthydium tabulatum was described by Schmarda (1861) from Cali, Colombia. It is approximately 200 µm long with dorsal hexagonal “Zellen” (scales) that carries bristles. The trunk is wider than the head and the furca is short. Two pairs of sensory ciliary tufts are present on the head. The intestine is cylindrical with two rods resembling rudimentary jaws. It is probable that *I. tabulatum* is a *Chaetonotus* with simple spines (Schwank, 1990). *I. tabulatum* is here considered *species inquirenda*.

Appendix 1 gives a list of the nominal species in *Ichthydium* as well as their synonyms. Figure 3 gives an overview of the morphology of *Ichthydium* and should serve as a complement to the key.

Identification key

- | | | |
|---|---|--|
| 1 | Marine or brackish water | 2 |
| - | Freshwater | 3 |
| 2 | Total body length less than 120 µm. Head rounded, hypostomion present as two short wedge-like bars posterior to the mouth. Adhesive tubes more or less ½ of total furca length..... | <i>I. cyclocephalum</i> (Adriatic Sea) (Figures 7G, H) |
| - | Total body length more than 120 µm. Head weakly five-lobed | <i>I. tergestinum</i> (Adriatic Sea) (Figure 8H) |
| 3 | Cuticle naked or with very fine ornamentation | 11 |
| - | Cuticle with scales, including scales anchoring posterior sensory bristles and ventral scales, or spines | 4 |
| 4 | Cuticle with spines that lack scales. If ventral terminal scales are present spines are simple, hair-like and distributed in two ventrolateral rows | 5 |
| - | Cuticle with dorsal and/or ventral scales. Spines absent | 8 |
| 5 | Base of furca with one pair of parafurcal spines, if absent, two ventrolateral rows of hair-like spines present | 6 |
| - | Base of furca with more than one pair of spines | 7 |
| 6 | Base of furca without spines. Two ventrolateral rows of hair-like spines present. Ocellular granules present on head. Pharynx with anterior and posterior swelling | <i>I. chaetiferum</i> (Brazil) (Figure 7F) |
| - | Base of furca with one pair of simple parafurcal spines. Cuticle granulated | <i>I. diacanthum</i> (Italy, Sweden) (Figures 8A, B) |
| 7 | Base of furca wide, with one pair of dorsal simple spines and one pair of ventral simple spines between furca branches | <i>I. dubium</i> (Russia, Romania) (Figure 4I) |
| - | Furca extremely short, forming two knobs. Base of furca with seven simple spines | <i>I. crassum</i> (Paraguay) (Figures 4G, H) |

8	Furca tong-shaped. Ventral ciliation of trunk region divided into four pairs of long tufts	9
-	Furca straight. Base of furca with transverse trapezoidal cuticular folds or with two pairs of keeled rounded scales and one pair of bi-keeled scales anchoring posterior sensory bristles	10
9	Base of furca with only one pair of bi-keeled scales anchoring posterior sensory bristles. Ventral terminal scales large and rectangular	<i>I. tanytrichum</i> (Italy, Sweden) (Figures 7A, B)
-	Base of furca with four pairs of keeled scales and one pair of bi-keeled scales anchoring posterior sensory bristles. Pharynx with posterior swelling	<i>I. skandicum</i> n. sp. (Sweden) (Figures 1, 2, 7C, D)
10	Dorsal scales absent. Base of furca with transverse trapezoidal cuticular fold. Ventral interciliary area with scales	<i>I. plicatum</i> (Italy) (Figures 8C, D)
-	Base of furca with two pairs of rounded keeled scales and one pair of bi-keeled scales anchoring posterior sensory bristles (bi-keeled scales absent in the Swedish specimens). Pharynx with weak anterior and posterior swellings. Ventral ciliation in two parallel rows	<i>I. squamigerum</i> (Italy, Sweden) (Figures 8E–G)
11	Body slender and elongated. Head five-lobed or weakly five-lobed. Furca long and tong-shaped, adhesive tubes contributing to most of its length. At least posterior sensory bristles present, on papillae	12
-	These characters not combined	13
12	Sensory bristles thick, emerging from papillae. Posterior pleura large. Base of furca ends as square, well delimited from furca branches. Inner part of adhesive tubes with a hook-like structure	<i>I. forcipatum</i> (Switzerland, Germany, Hungary, Romania, Russia: Moscow area, United Kingdom, Italy) (Figure 6F)
-	Sensory bristles thin, at least posterior sensory bristles present and emerging from papillae. Adhesive tubes without hook-like structure, $\frac{3}{4}$ of total furca length, and thin tapering into a fine point	<i>I. forficula</i> (cosmopolitan) (Figures 6G, H)
13	Dorsal body surface with large firm wavy comb-like ridge. Furca with prolonged distal tips	<i>I. balatonicum</i> (Hungary, Romania) (Figure 7E)
-	Dorsal body surface without comb-like structure. Furca not as above	14
14	Base of furca wide. Kephalion very large covering most of head or rectangular and drawn out anteriorly	15
-	Base of furca not wide. Kephalion of normal size and shape not covering most of head	17
15	Kephalion rectangular and drawn out anteriorly, adhesive tubes with bifurcated tips resembling hooves.	<i>I. bifurcatum</i> (Russia: Moscow area, Poland, Great Britain) (Figures 4C–E)
-	Kephalion covering most of head, adhesive tubes not bifurcated.	16
16	Kephalion hood-like extending laterally beyond head, posterior part with incision. Head five-lobed. Furca short.....	<i>I. galeatum</i> (Bulgaria, Romania) (Figures 4K, L)
-	Kephalion rounded without incision of posterior part. Head single-lobed	<i>I. rostrum</i> (Poland) (Figure 6C)
17	Head with dorsal flaps	18
-	Head without dorsal flaps	20
18	Head with one pair of dorsal flaps and one pair of sensory ciliary tufts	<i>I. auritum</i> (USA: Michigan, India) (Figure 4A)
-	Head with two pairs of dorsal flaps and at least one pair of sensory ciliary tufts	19
19	Neck not differentiated from head. Adhesive tubes $\frac{3}{4}$ of total furca length	<i>I. macrocapitatum</i> (Japan) (Figure 5B, C)
-	Neck differentiated from head by constriction. Adhesive tubes $\frac{1}{3}$ of total furca length with pointed tips	<i>I. macropharyngistum</i> (USA: Michigan) (Figure 5D)
20	Head single-lobed, rectangular or oval. Furca very small, $\frac{1}{25}$ of total body length or tong-shaped	21
-	Head three- or five-lobed. Furca longer than $\frac{1}{25}$ of total body length, not tong-shaped	22
21	Head rectangular, wider than trunk. Pharynx broad, almost as wide as trunk. One pair of short sensory ciliary tufts. Furca tong-shaped	<i>I. cephalobares</i> (USA: Michigan) (Figure 6E)
-	Head oval, wider than rest of body. Pharynx with thick middle part. Furca small, $\frac{1}{25}$ of total body length	<i>I. brachykolon</i> (USA: Michigan) (Figure 4F)
22	Head three lobed cuticular covering with very fine ridges or intestine divided into two parts	23
-	These characters not combined	24
23	Head large, rounded to weakly three-lobed; body plump. Cuticular covering with very fine ridges.....	<i>I. podura</i> (cosmopolitan) (Figures 6A, B)
-	Head distinctly three-lobed; body elongated and slender. Intestine divided into two parts	<i>I. bifasciale</i> (Germany) (Figure 4B)
24	Body surface with cuticular folds, transverse dorsal ridges and/or very fine longitudinal reliefs	25
-	Body surface completely smooth	27
25	Body surface with transverse dorsal ridges or very fine longitudinal reliefs	26
-	Body surface with cuticular folds. One pair of very long cilia in posterior sensory ciliary tufts. Pharynx with anterior and posterior swelling	<i>I. palustre</i> (Poland) (Figure 5G)

- 26 Dorsal body surface with approx. 40 transverse ridges. Body outline accordion-like. Anterior bristles present, posterior bristles might be absent. Anterior lobe of head distinctly separated from the other lobes *I. sulcatum* (Germany, Poland, Romania, Canada: Ontario, USA: Indiana, Michigan, New Jersey) (Figure 6D)
- Dorsal body surface with very fine longitudinal reliefs. Lateral body surface finely waved. Furca well delimited from trunk by arching of posterior trunk region *I. fossae* (France, Italy) (Figure 4J)
- 27 Long and slender species, at least 128 μm in total body length 28
- Small species, $\sim 70 \mu\text{m}$ in total body length. Ventral surface covered by short thick cilia. Pharynx cone-shaped *I. minimum* (USA: Michigan, India) (Figure 5F)
- 28 Total body length 225–258 μm . Japanese specimens at least 128–142 μm . Head wider than trunk. Both anterior and posterior sensory bristles present *I. maximum* (Poland, Romania, Switzerland, Russia, Great Britain, Japan) (Figure 5E)
- Total body length 170 μm . Base of furca branches slightly enlarged. Anterior sensory bristles absent *I. leptum* (USA: Michigan) (Figure 5A)

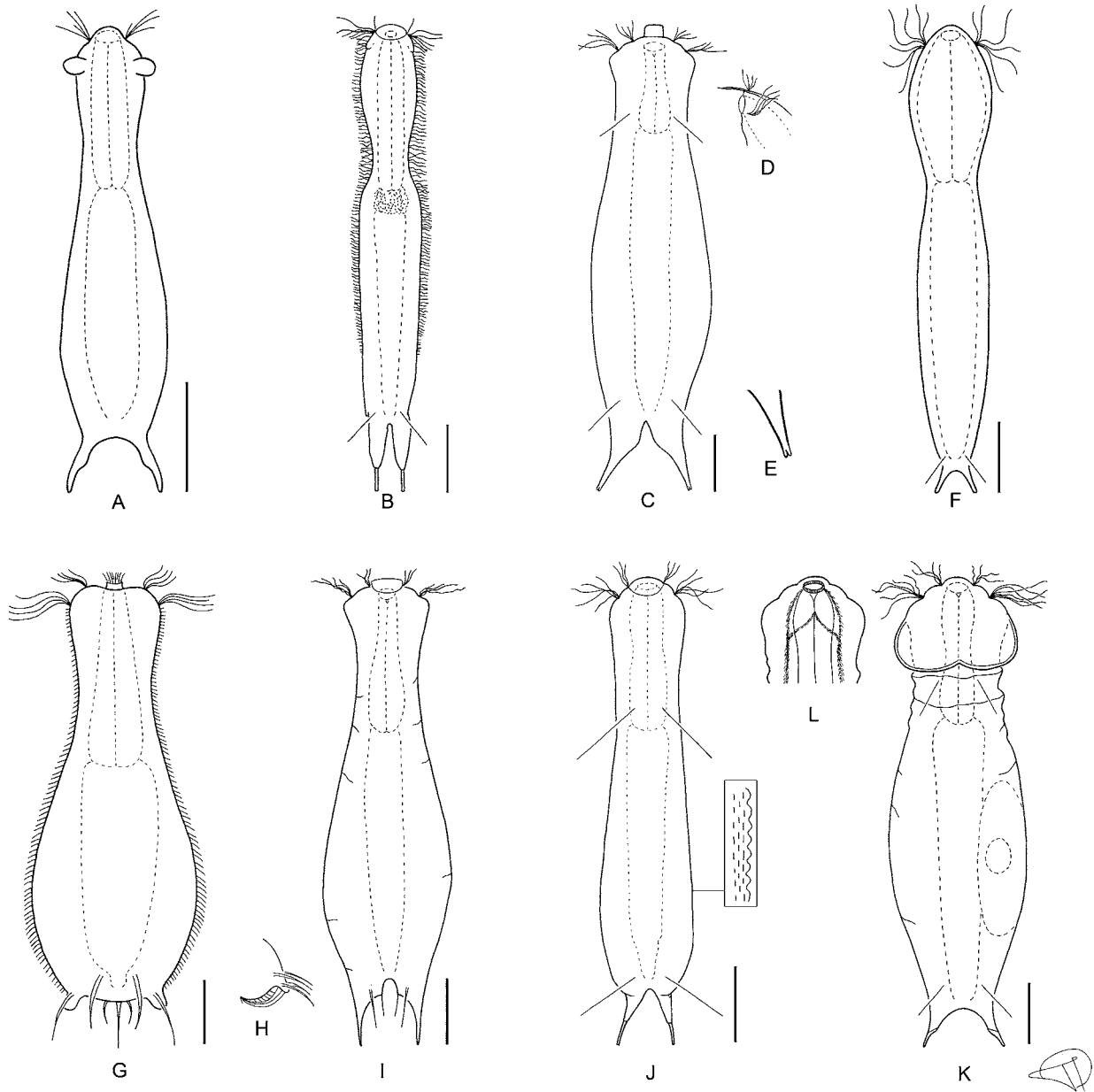


FIGURE 4. A–L) Subgenus *Ichthyidium sensu stricto*. A) *Ichthyidium auritum* dorsal view. B) *I. bifasciale* dorsal view. C) *I. bifurcatum* dorsal view. D) *I. bifurcatum* lateral view of head. E) *I. bifurcatum* enlargement of adhesive tube. F) *I. brachykolon* dorsal view. G) *I. crassum* dorsal view and H) lateral view of posterior end. I) *I. dubium* dorsal view. J) *I. fossae* dorsal view. K) *I. galeatum* dorsal view and L) ventral view of head showing arrangement of ciliation. A, modified from Brunson (1950); B–E, I–L, modified from Schwank (1990); F, modified from Brunson (1949); G, H, modified from Daday (1905). Scale bars: 20 μm .

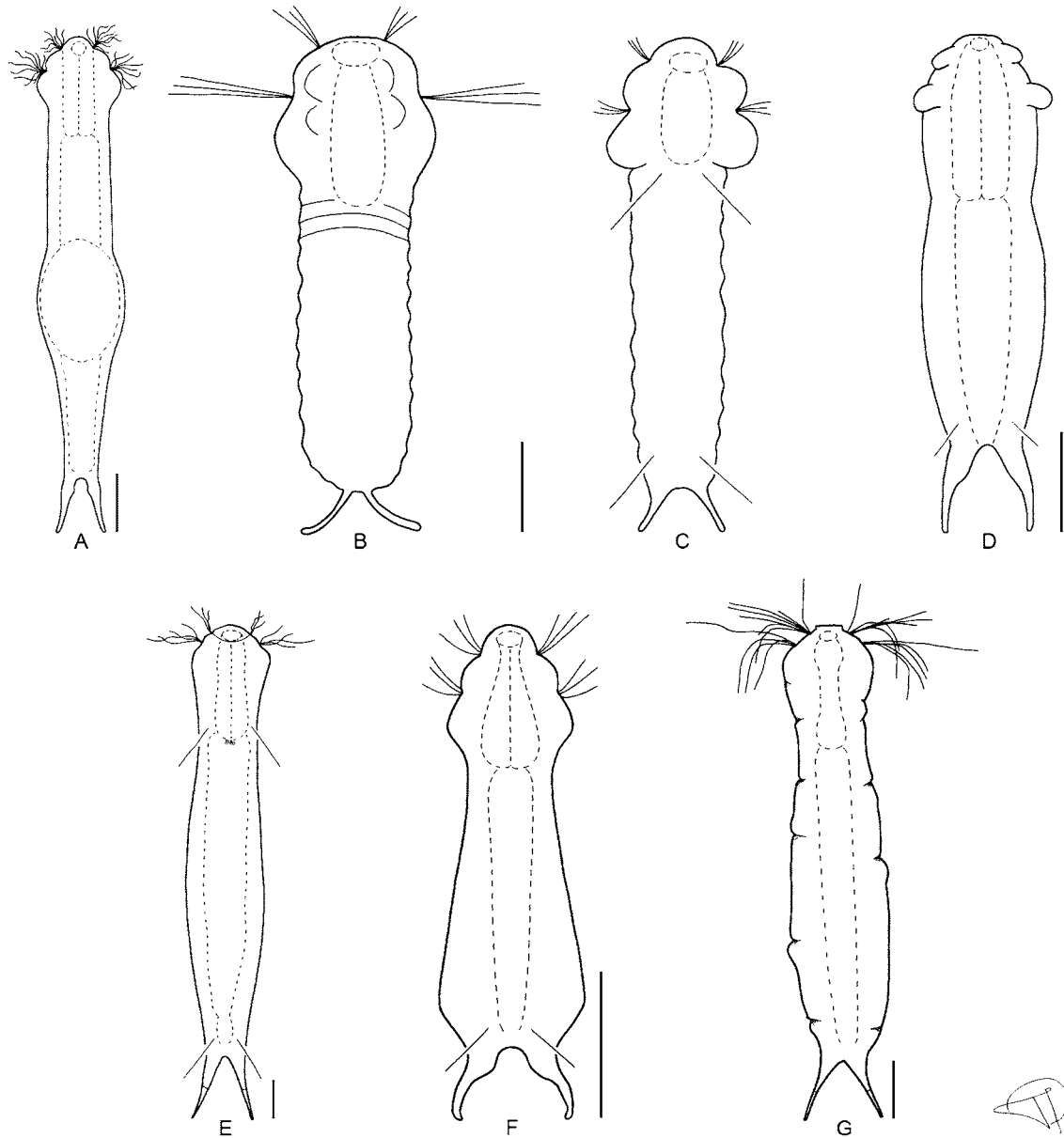


FIGURE 5. A–G) Subgenus *Ichthyidium sensu stricto* continued. A) *Ichthyidium leptum* dorsal view. B–C) *I. macrocapitatum* dorsal view of the two different forms. D) *I. macropharyngistum* dorsal view. E) *I. maximum* dorsal view. F) *I. minimum* dorsal view. G) *I. palustre* dorsal view. A, modified from Brunson (1947); B, C, modified from Suzuki (1971); D, modified from Brunson (1949); E, G, modified from Schwank (1990); F, modified from Brunson (1950). Scale bars: 20 μm (~20 μm for B, C).

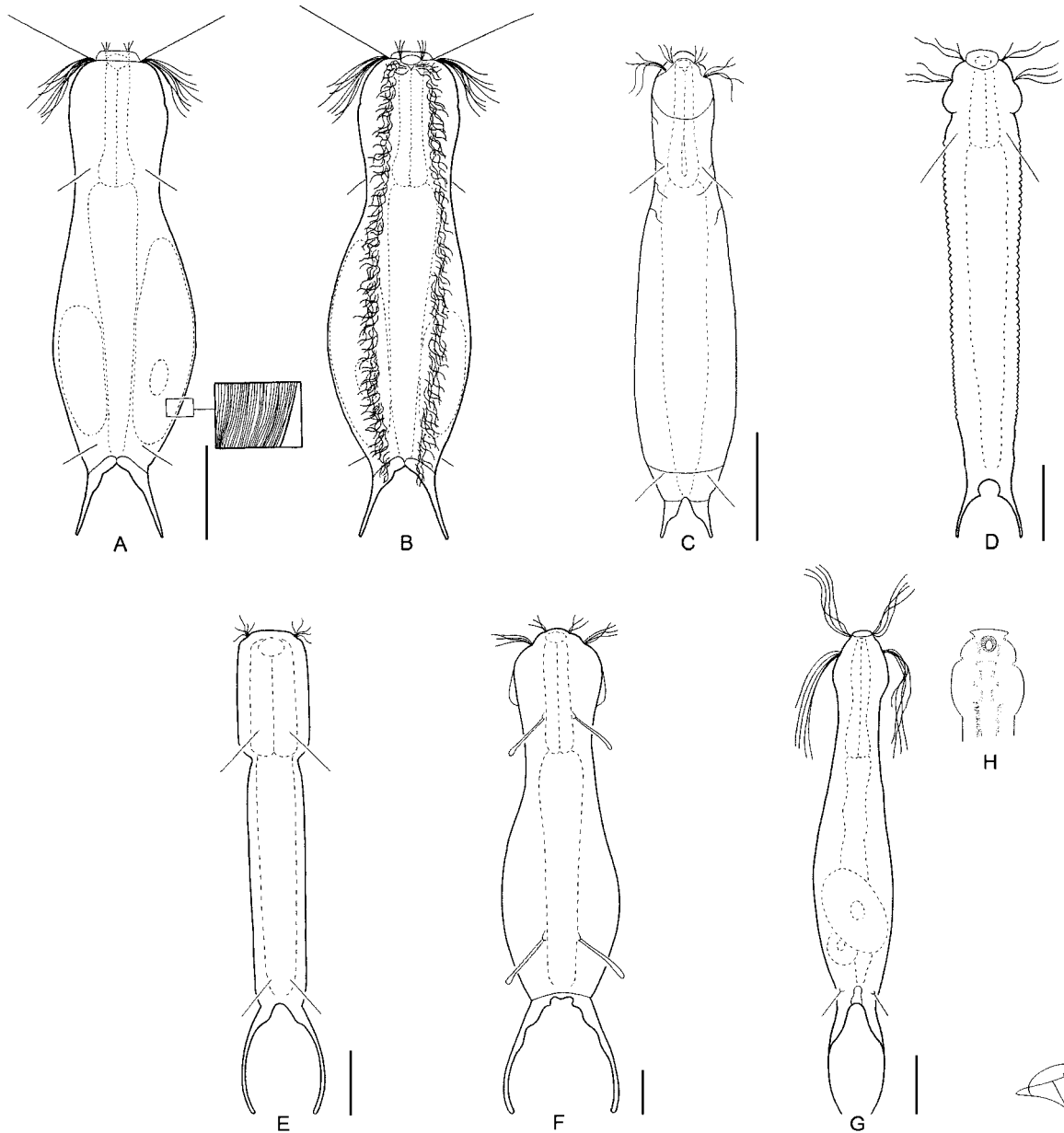


FIGURE 6. A–D) Subgenus *Ichthyidium* *sensu stricto* continued; E–H) Subgenus *Forficulichthys*. A) *Ichthyidium podura* dorsal and B) ventral view. C) *I. rostrum* dorsal view. D) *I. sulcatum* dorsal view. E) *I. cephalobares* dorsal view. F) *I. forcipatum* dorsal view. G) *I. forcicula* dorsal view and H) ventral view of head showing arrangement of ciliation. A, B, F, modified from Balsamo (1983); C, D, G, H, modified from Schwank (1990); E, modified from Brunson (1949). Scale bars: 20 μ m.

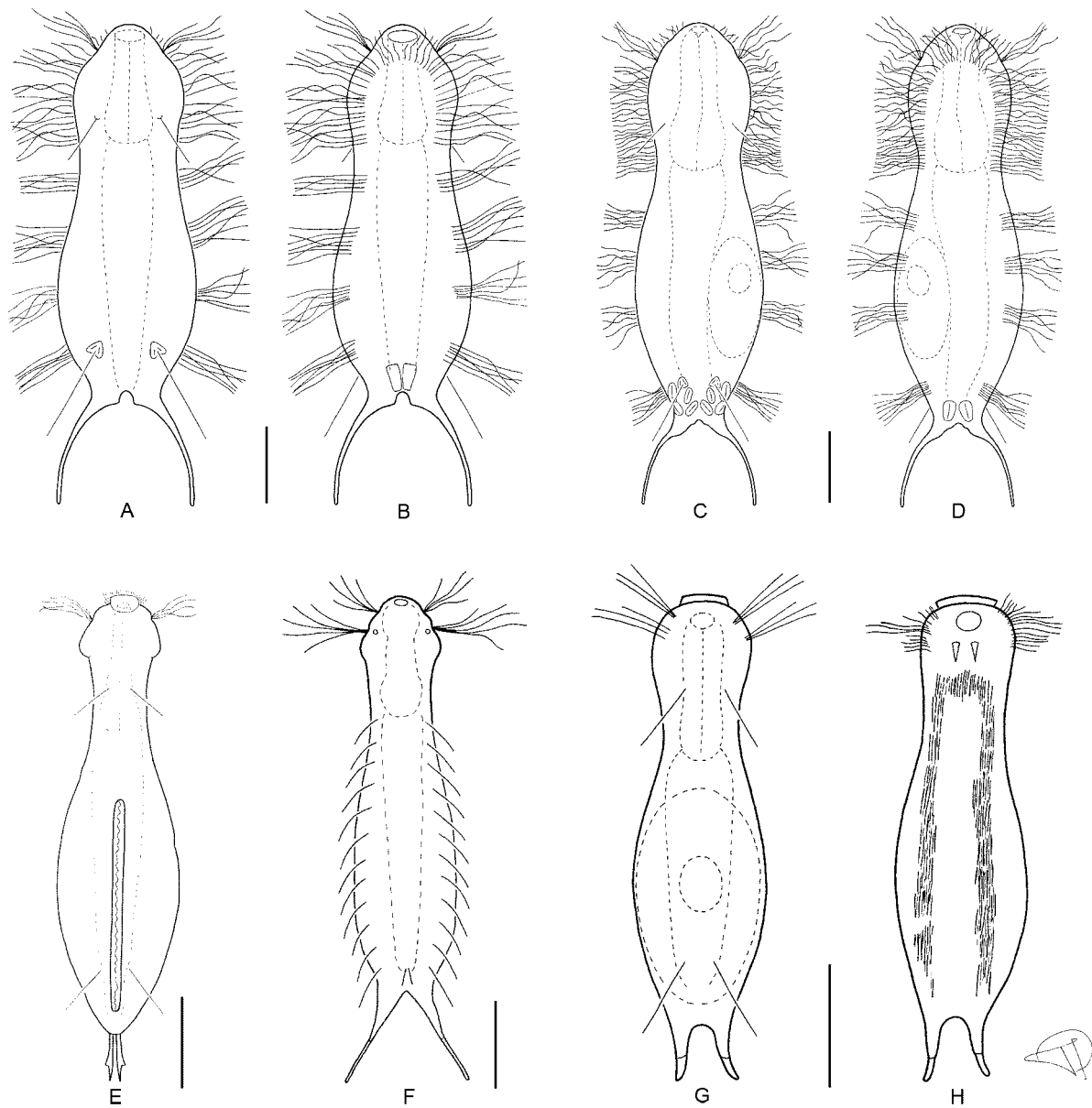


FIGURE 7. A–D) Subgenus *Forficulichthys* continued; E) Subgenus *Pseudichthydium*; F–H) *Incertae sedis*. A) *Ichthydium tanytrichum* dorsal and B) ventral view. C) *I. skandicum* n. sp. dorsal and D) ventral view. E) *I. balatonicum* dorsal view. F) *I. chaetiferum* ventral view. G) *I. cyclocephalum* dorsal and H) ventral view. A–D, original; E, modified from Schwank (1990); F, modified from Kisielewski (1991); G, H, modified from Grünspan (1908). Scale bars: 20 μ m.

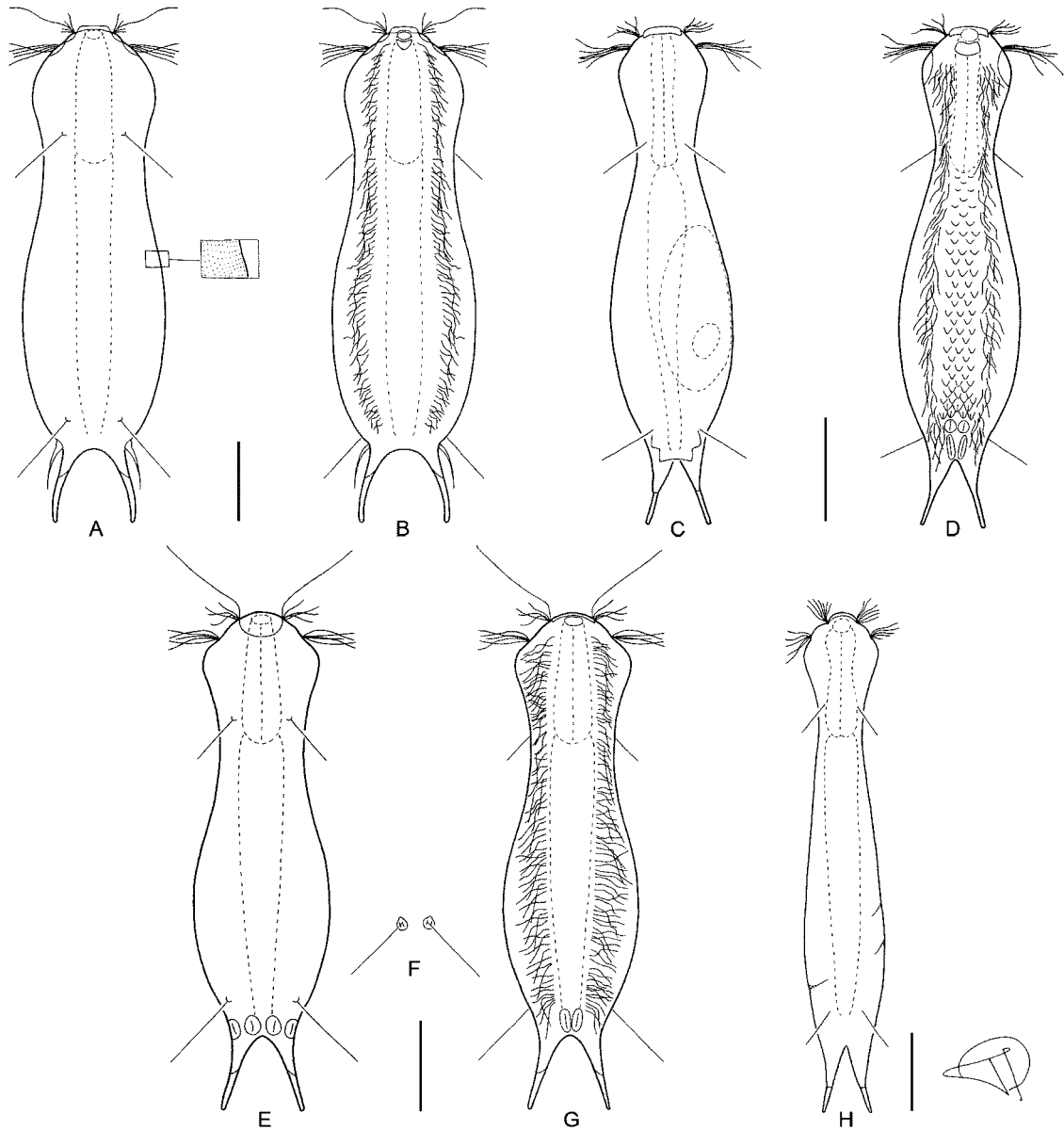


FIGURE 8. A–H) *Incertae sedis* continued. A) *Ichthydium diacanthum* dorsal and B) ventral view. C) *I. plicatum* dorsal and D) ventral view. E) *I. squamigerum* dorsal view and F) bi-keeled scales anchoring posterior sensory bristles. G) *I. squamigerum* ventral view. H) *I. tergestinum* dorsal view. A, B, original; C, D, modified from Balsamo & Fregni (1995); F, after Balsamo & Fregni (1995); E, G, original; H, modified from Grünspan (1908). Scale bars: 20 μ m.

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Appendix 1 – Taxonomic list of *Ichthydium*

Genus *Ichthydium* Ehrenberg, 1830

1. Type species: *Ichthydium (I.) podura* (Müller, 1773)

= *Cercaria podura* Müller, 1773

= *Furcocerca podura* Lamarck, 1815

= *Enchelys podura* Nitsch, 1817

= *Furcocerca triloba* Bory de St. Vincent, 1824

= *Diurella podura* Ehrenberg, 1831

= *Chaetonotus podura* Stokes, 1887

Type subgenus *Ichthydium* Ehrenberg, 1830 = [*Euichthydium* Schwank, 1990] syn. nov.

Type species: *Ichthydium (I.) podura* (Müller, 1773)

2. *Ichthydium (I.) auritum* Brunson, 1950

3. *Ichthydium (I.) bifasciale* Schwank, 1990

4. *Ichthydium (I.) bifurcatum* Preobrajenskaja, 1926

5. *Ichthydium (I.) brachykolon* Brunson, 1949

6. *Ichthydium (I.) crassum* Daday, 1905

7. *Ichthydium (I.) dubium* Preobrajenskaja, 1926

8. *Ichthydium (I.) fossae* d'Hondt, 1972

9. *Ichthydium (I.) galeatum* Konsuloff, 1921

10. *Ichthydium (I.) leptum* Brunson, 1949¹

1. Possible junior synonym of *I. maximum* according to Schwank (1990)

11. *Ichthydium (I.) macrocapitatum* Sudzuki, 1971
12. *Ichthydium (I.) macropharyngistum* Brunson, 1949
13. *Ichthydium (I.) maximum* Greuter, 1917
14. *Ichthydium (I.) minimum* Brunson, 1950
15. *Ichthydium (I.) palustre* Kisielewski, 1981²
16. *Ichthydium (I.) rostrum* Roszczak, 1969
17. *Ichthydium (I.) sulcatum* (Stokes, 1887)
= *Chaetonotus sulcatus* Stokes, 1887

Subgenus *Forficulichthys* Schwank, 1990

18. Type species: *Ichthydium (F.) forficula* Remane, 1927
= *Ichthydium (F.) monolobum* Brunson, 1950
19. *Ichthydium (F.) cephalobares* Brunson, 1949
20. *Ichthydium (F.) forcipatum* Voigt, 1901
= *Brunellia forcipatum* Mola, 1932
21. *Ichthydium (F.) skandicum* n. sp.
22. *Ichthydium (F.) tanytrichum* Balsamo, 1982

Subgenus *Pseudichthydium* Rudescu, 1967

23. Type species: *Ichthydium (P.) balatonicum* Varga, 1950

Unknown subgeneric division

24. *Ichthydium chaetiferum* Kisielewski, 1991
25. *Ichthydium cyclocephalum* Grünspan, 1908³ (marine)
26. *Ichthydium diacanthum* Balsamo & Todaro, 1995
27. *Ichthydium plicatum* Balsamo & Fregni, 1995

2. Possible junior synonym of *I. pellucidum* according to Schwank (1990)
3. Possible junior synonym of *I. podura*.

28. *Ichthydium squamigerum* Balsamo & Fregni, 1995

29. *Ichthydium tergestinum* Grünspan, 1908 (marine)

Nomen nudum and species inquirenda

Ichthydium jamaicense Schmarda, 1861 (*species inquirenda*)⁴

Ichthydium macrurum Collin, 1898 (*species inquirenda*)⁵

Ichthydium (I.) malleum Schwank, 1990 (*nomen nudum*)

Ichthydium (I.) pellucidum Preobrajenskaja, 1926 (*species inquirenda*)

Ichthydium tabulatum Schmarda, 1861 (*species inquirenda*)⁶

4. Probably a *Chaetonotus* according to Schwank (1990).

5. *Polymerurus* according to Remane, 1936.

6. Probably a *Chaetonotus* according to Schwank (1990).