

Revision of some spathidiid genera
(Alveolata, Ciliophora, Spathidiida)

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Berger H. (2018): urn:lsid:zoobank.org:author:DC477A8E-FC41-494C-A4A1-F23091512449: taxonomic and nomenclatural summary. – Series Monographiae Ciliophorae, Number 4: 1–52

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Edited by

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Cover: *Epispathidium papilliferum* (front; see Fig. 6.11h–j in Chapter 6); *Neospathidium longinucleatum* (back; see Fig. 12.9j–l in Chapter 12)

In memory of Wilhelm Foissner (1948–2020)

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Preface, authorship, acknowledgements, and funding

The spathidiids have been one of several favorite ciliate groups of Wilhelm Foissner. In 2001, W. Foissner started a revision of this large group of haptorids. During processing his huge archive after his sudden death in 2020, I found a well-advanced manuscript dealing with several spathidiid genera. In order to prevent this manuscript from being forgotten, I have decided to publish it in my monographic series on ciliates.

W. Foissner collected most samples, made the in vivo observations, the preparations, many morphometries, and wrote text. K. Xu made morphometries and illustrations, compiled the plates, and wrote text. I updated the text of the raw manuscript, organized the deposition of the slides in the Biology Centre of the Upper Austrian Museum in Linz, wrote the front matter, the general introduction, the material and method section including the summary of taxa (Chapter 1), the brief introduction to the spathidiids (Chapter 2), the chapter on *Neocultellothrix* Foissner nov. gen. (Chapter 13), and the back matter (index). Further, I made the layout and produced the final PDF.

The help of the following persons must be acknowledged: Sabine Agatha, Remigius Geiser, Eva Herzog, Wolf-Dietrich Krautgartner, Brigitte Moser, Birgit Peukert, Fritz Seyrl, and Andreas Zankl. Colleagues who provided samples are acknowledged in the individual species descriptions. I also want to thank Magdalini Christodoulou and Alexandra Aberham at the Biology Centre of the Upper Austrian Museum in Linz for help with the transfer of the Foissner archive from Salzburg to Linz.

Wilhelm Foissner, Kuidong Xu, and co-workers involved in this project got financial support by the Austrian Science Fund FWF (Project P15017-B06, “Monographie der Familie Spathidiidae (Ciliophora)”). I wish to thank Ilse Foissner who generously privately financed my work on this book.

Salzburg
January 2025

Helmut Berger (Publisher)
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Abstract

Foissner W., Xu K. & Berger H. (Eds) (2025): Revision of some spathidiid genera (Alveolata, Ciliophora, Spathidiida). – Ser. Monogr. Cilioph. 6: i–xv, 1–465.

This book deals with some spathidiid taxa. The following genera are treated and established, respectively: *Apospathidium* Foissner et al., 2002; *Centrospathidium* nov. gen.; *Epispathidium* Foissner, 1984; *Latispathidium* Foissner et al., 2005; *Schmidingerophrya* nov. gen.; *Semibryophyllum* nov. gen.; *Semispathidium* Foissner et al., 2002; *Supraspathidium* Foissner & Didier, 1981; *Pharyngospathidium* nov. gen. (type genus of Pharyngospathidiidae nov. fam.); *Neospathidium* nov. gen.; *Neocultellothrix* Foissner nov. gen. The latter genus “replaces” *Cultellothrix* Foissner, 2003, an unavailable genus because no holotype was fixed for the type species in the original description. In addition, 12 *Spathidium* species are reviewed, and three new species assigned to this genus are described. In total, four new subspecies, 19 new species, six new genera, and one new family are described, 13 species are transferred to other genera, and 41 known species and two subspecies are reviewed. Further, three “*Spathidium* groups” are discussed. The type slides of the new species and voucher slides of the redescribed species are documented.

Key words: Alveolata; biogeography; Ciliophora; cyst; diversity; Haptoria; monograph; morphogenesis; nomenclature; Protista; revision; soil biology; systematics; taxonomy

Chapter 10

***Semispathidium* Foissner et al., 2002 (Ciliophora, Spathidiidae), a genus whose species have a discoidal oral bulge and *Spathidium*-like oral and somatic ciliature¹**

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Abstract

Semispathidium Foissner et al., 2002 is defined by a discoidal oral bulge and a *Spathidium*-like oral and somatic ciliature. Originally the genus comprised three species while in the present revision, seven species are assigned. *Semispathidium enchelyodontides* Foissner et al., 2002 from a terrestrial habitat in Namibia is the type species. The other species are: *Semispathidium armatum* Foissner et al., 2002; *Semispathidium lagyniforme* (Kahl, 1930) Foissner et al., 2002; *Semispathidium breviararmatum* Foissner & Vdačný in Vdačný & Foissner, 2013; *Semispathidium longiararmatum* Foissner & Vdačný in Vdačný et al., 2014; *Semispathidium fraterculum* Foissner & Al-Rasheid in Foissner et al., 2010; *Semispathidium pulchrum* Foissner et al., 2010. The general appearance is reminiscent of *Enchelyodon* species which have, however, meridional somatic kineties. Likely further little-known *Spathidium* and *Enchelyodon* species belong to *Semispathidium*. A key to the species is provided. The type slides of *Semispathidium breviararmatum* and *Semispathidium longiararmatum*, which, so far, have not yet been transferred to the Biology Centre of the Upper Austrian Museum, have now been deposited in the Museum.

¹ This chapter should be referenced as follows: Foissner W., Xu K. & Berger H. (2025): *Semispathidium* Foissner et al., 2002 (Ciliophora, Spathidiidae), a genus whose species have a discoidal oral bulge and *Spathidium*-like oral and somatic ciliature. – Ser. Monogr. Cilioph. 6: 311–333.

For notes on “Material and methods”, see Chapter 1 (Berger et al. 2025a).

***Semispathidium* Foissner, Agatha & Berger, 2002**

- 2002 *Semispathidium* nov. gen. – Foissner, Agatha & Berger, Denisia 5: 327 (original description; for diagnosis see below). Type species (by original designation): *Semispathidium enchelyodontides* Foissner, Agatha & Berger, 2002.
- 2007 *Semispathidium* Foissner, Agatha et Berger, 2002 – Jankowski, Phylum Ciliophora, p. 564 (generic revision of ciliates).
- 2013 *Semispathidium* – Vďačný & Foissner, Zool. Scr. 42: 547 (note on phylogenetic relationships).
- 2014 *Semispathidium* – Vďačný, Slovák & Foissner, Eur. J. Protistol. 50: 343 (morphometric taxonomy).
- 2021 *Semispathidium* Foissner, Agatha & Berger, 2002 – Foissner, Ser. Monogr. Cilioph. 5: 57 (comparison with *Enchelariophrya* Foissner, 2016).

Nomenclature: *Semispathidium* is a composite of the Latin prefix *semi* (partially; half, according to Werner 1972, p. 74) and the genus-group name *Spathidium*, referring to the lack of a *Spathidium*-like appearance (Foissner et al. 2002). For etymology of *Spathidium* Dujardin, 1841, see Chapter 2, that is, Berger et al. (2025b). Like *Spathidium* of neuter gender (Aescht 2001, p. 300).

Diagnosis (from Foissner et al. 2002): Spathidiidae with discoidal oral bulge and *Spathidium*-like oral and somatic infraciliature.

Species originally assigned: *Semispathidium enchelyodontides* Foissner, Agatha & Berger, 2002 (type species); *Semispathidium armatum* Foissner, Agatha & Berger, 2002; *Semispathidium lagyniforme* (Kahl, 1930) Foissner, Agatha & Berger, 2002 (original combination *Spathidium lagyniforme*).

Species now assigned: *Semispathidium enchelyodontides* Foissner, Agatha & Berger, 2002 (type species); *Semispathidium armatum* Foissner, Agatha & Berger, 2002; *Semispathidium breviararmatum* Foissner & Vďačný in Vďačný & Foissner, 2013; *Semispathidium fraterculum* Foissner & Al-Rasheid in Foissner, Hess & Al-Rasheid, 2010; *Semispathidium lagyniforme* (Kahl, 1930) Foissner, Agatha & Berger, 2002 (original combination *Spathidium lagyniforme*); *Semispathidium longiararmatum* Foissner & Vďačný in Vďačný, Slovák & Foissner, 2014; *Semispathidium pulchrum* Foissner, Hess & Al-Rasheid, 2010.

Remarks:² The best justification for the establishment of a new genus for *Semispathidium enchelyodontides* is the fact that, based on the general appearance, nobody would assign it to *Spathidium* s. l., but likely to *Enchelyodon* Claparède & Lachmann, 1859, as we did in our notebook. However, silver impregnation reveals a basically spathidiid infraciliature, that is, somatic kineties with curved anterior end and a slightly twisted circumoral kinety. *Enchelyodon*, in contrast, has meridional kineties and a flat circumoral kinety (Fig. 10.1f, g). Actually, it is only the small, discoidal oral bulge which produces the deviating appearance. In this respect, *Semispathidium* resembles *Protospathidium* Dragesco & Dragesco-Kernéis, 1979 which, however, has the circumoral kinety fragments distinctly separated. *Apospathidium* Foissner et al., 2002 (for revision, see Chapter 4, that is, Foissner et al. 2025) has oralized somatic monokinetids, like *Kreutzophrya* Kreutz & Foissner, 2006³ which highly resembles *Semispathidium* in body shape and, especially, the oral bulge.

² Note by H. Berger: The two first paragraphs have been written by W. Foissner in the early 2000s. Since then, he and co-workers have published some important papers dealing with the genus and new species (see list of synonyms above and “Species now assigned”. Please consult these works for more information.

³ Note by H. Berger: *Kreutzophrya sphagnicola* Kreutz & Foissner, 2006 (p. 12, 149, 257) is an unavailable name because

Table 10.1 Morphometric data on *Semispathidium enchelyodontides* (upper line), *Semispathidium ar-matum* (middle line), and *Semispathidium lagyniforme* (lower line)^a

Characteristic	Mean	M	SD	SE	CV	Min	Max	n
Body, length	142.3	140.0	19.0	4.2	13.4	108.0	185.0	21
	224.1	248.5	50.8	18.0	22.7	153.0	280.0	8
	79.0	77.0	13.5	6.0	17.1	66.0	100.0	5
Body, width	22.1	21.0	4.7	1.0	21.3	16.0	33.0	21
	40.8	38.5	7.8	2.7	19.0	33.0	53.0	8
	24.0	24.0	3.6	1.6	15.0	19.0	29.0	5
Body length:width, ratio	6.7	7.4	1.6	0.4	23.8	3.5	9.6	21
	5.6	5.0	1.3	0.5	23.1	4.4	8.0	8
	3.3	3.3	0.2	0.1	7.3	2.9	3.5	5
Oral bulge, width	11.0	11.0	1.2	0.3	11.1	9.0	13.0	21
	13.3	13.5	1.9	0.7	14.4	10.0	16.0	8
	7.3	7.5	0.7	0.3	9.7	6.6	8.0	5
Oral bulge, height	4.1	4.0	0.7	0.2	17.6	3.0	6.0	21
	3.5	3.5	0.5	0.2	15.3	3.0	4.0	8
	—	—	—	—	—	—	—	—
Circumoral kinety to last dikinetid of brush row 1, distance	25.3	25.0	3.4	0.8	12.5	20.0	32.0	21
	49.0	52.5	18.1	6.4	36.9	22.0	77.0	8
	9.3	—	—	—	—	7.0	12.0	2
Dikinetids in brush row 1, number	11.4	11.0	1.7	0.4	14.8	9.0	15.0	21
	25.5	24.5	4.3	1.5	17.0	20.0	31.0	8
	—	—	—	—	—	—	—	—
Circumoral kinety to last dikinetid of brush row 2, distance	26.2	26.0	3.7	0.8	14.0	20.0	35.0	21
	58.5	65.0	17.2	6.1	29.4	28.0	75.0	8
	12.1	—	—	—	—	9.0	15.0	2
Dikinetids in brush row 2, number	16.8	17.0	2.0	0.5	12.1	14.0	21.0	21
	39.8	40.5	6.5	2.3	16.4	31.0	48.0	8
	—	—	—	—	—	—	—	—
Circumoral kinety to last dikinetid of brush row 3, distance	13.7	14.0	2.3	0.5	16.7	10.0	18.0	21
	20.0	19.5	4.0	1.4	20.0	15.0	25.0	8
	7.5	—	—	—	—	5.0	10.0	2
Dikinetids in brush row 3, number	8.8	9.0	1.2	0.3	13.7	7.0	12.0	21
	14.3	14.5	1.7	0.6	11.7	12.0	17.0	8
	—	—	—	—	—	—	—	—
Anterior body end to anteriormost macronucleus nodule, distance	41.7	43.0	13.3	2.9	31.8	13.0	63.0	21
	103.1	116.0	35.1	12.4	34.1	56.0	145.0	8
	—	—	—	—	—	—	—	—
Macronucleus figure, length	72.0	62.0	18.0	3.9	25.1	50.0	110.0	21
	44.3	46.0	10.4	3.7	23.6	25.0	58.0	8
	26.2	26.0	—	—	—	26.0	27.0	5
Macronucleus nodules, length	7.1	7.0	2.0	0.4	28.5	4.0	12.0	21
	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—
Macronucleus (nodules), width	5.2	5.0	0.8	0.2	15.9	4.0	7.0	21
	13.3	12.5	3.1	1.1	23.1	10.0	18.0	8
	7.2	6.6	0.8	0.3	10.7	6.6	8.0	5

Table 10.1 Continued

Characteristic	Mean	M	SD	SE	CV	Min	Max	n
Macronucleus nodules, number	20.7	21.0	3.4	0.8	16.6	15.0	29.0	21
	1.0	1.0	0.0	0.0	0.0	1.0	1.0	8
	1.0	1.0	0.0	0.0	0.0	1.0	1.0	5
Micronuclei, length	2.1	2.0	–	–	–	2.0	2.5	21
	4.2	4.0	–	–	–	3.5	6.0	7
	–	–	–	–	–	–	–	–
Micronuclei, width	2.0	2.0	–	–	–	1.5	2.5	21
	4.1	4.0	–	–	–	3.0	6.0	7
	–	–	–	–	–	–	–	–
Micronuclei, number	7.0	7.0	1.6	0.4	23.5	4.0	10.0	21
	1.0	1.0	0.0	0.0	0.0	1.0	1.0	7
	–	–	–	–	–	–	–	–
Somatic kineties, number	15.4	15.0	0.7	0.2	4.8	14.0	17.0	21
	21.3	21.0	1.1	0.4	5.2	20.0	23.0	7
	15.4	14.0	2.8	1.3	18.1	13.0	20.0	5
Dorsal brush rows, number	3.0	3.0	0.0	0.0	0.0	3.0	3.0	21
	3.0	3.0	0.0	0.0	0.0	3.0	3.0	8
	3.0	3.0	0.0	0.0	0.0	3.0	3.0	5
Ciliated kinetids in a ventral kinety, number	44.8	44.0	11.1	2.4	24.8	27.0	70.0	21
	91.4	90.0	17.8	6.7	19.5	73.0	120.0	7
	44.8	50.0	11.3	5.1	25.3	25.0	53.0	5

^a Data based on mounted, protargol-prepared (Foissner's method), and randomly selected specimens from non-flooded Petri dish cultures. Measurements in μm . CV – coefficient of variation in %, M – median, Max – maximum, Mean – arithmetic mean, Min – minimum, n – number of individuals investigated, SD – standard deviation, SE – standard error of arithmetic mean.

At present, seven well-defined *Semispathidium* species are known. However, there are likely many more because several *Spathidium* and *Enchelyodon* species possibly belong to *Semispathidium*, for instance, *Spathidium cylindricum* Vuxanovici, 1959 (p. 323)⁴ and *Enchelyodon vermiformis* Dragesco, 1970 (p. 7). However, a definite transfer has to await a thorough description of the ciliary pattern. Indeed, reliable genus and species identification requires protargol preparation to reveal the ∞ -shaped circumoral kinety and the curved anterior end of the ciliary rows. The separation of the species now included in *Semispathidium* is difficult in vivo and thus protargol preparations are needed.

the publication of the species name is not accompanied by the explicit fixation of a holotype (or syntypes) in the original description (for details, see ICZN 1999, Articles 16.4.1, 72.3). *Kreutzophrya sphagnicola* is the only species assigned to *Kreutzophrya* Foissner in Kreutz & Foissner, 2006 (p. 149, 257; Foissner dedicated the genus to M. Kreutz), that is, it is the type species by monotypy (ICZN 1999, Article 68.3). However, since *Kreutzophrya sphagnicola* is unavailable, the genus is (very likely) likewise an unavailable name (ICZN 1999, Article 13.3); needs detailed analysis. For a similar problem, see Chapter 13, that is, Berger et al. (2025c). The names *Kreutzophrya* and *Kreutzophrya sphagnicola* are disclaimed for nomenclatural purposes in the present work (ICZN 1999, Article 8.3).

⁴ Note by H. Berger: *Spathidium cylindricum* Vuxanovici, 1959 (p. 323, Plansa VII, Fig. 44) is a junior primary homonym of *Spathidium cylindricum* Kahl, 1930 (p. 156, Fig. 22₁₈). Vuxanovici (1962, p. 561, footnote) introduced the replacement name *Spathidium longicolum* Vuxanovici, 1962 for *Spathidium cylindricum* Vuxanovici, 1959.

Key to species

- 1 About 20 macronuclear nodules *Semispathidium enchelyodontides* (p. 315)
 - Macronucleus not as above 2
- 2 Macronucleus long ellipsoidal 4
 - Macronucleus nodulated and tortuous 3
- 3 A ventral kinety with 32 ciliated kinetids on average
 - *Semispathidium pulchrum* (p. 330)
 - A ventral kinety with 68 ciliated kinetids on average
 - *Semispathidium fraterculum* (p. 329)
- 4 (2) Body length on average in vivo <200 μm *Semispathidium lagyniforme* (p. 322)
 - Body length on average in vivo >200 μm 5
- 5 Somatic kineties, 21 on average *Semispathidium armatum* (p. 320)
 - Somatic kineties, 30–34 on average 6
- 6 Number of dikinetids in dorsal brush row 1, on average 37 (range 24–52)
 - *Semispathidium longiarmatum* (p. 326)
 - Number of dikinetids in dorsal brush row 1, on average 73 (52–102)
 - *Semispathidium breviarmatum* (p. 325)

Semispathidium enchelyodontides Foissner, Agatha & Berger, 2002

(Fig. 10.1a–e, h–n, 10.2a–d, Table 10.1)

2002 *Semispathidium enchelyodontides* nov. spec. – Foissner, Agatha & Berger, Denisia 5: 327, Fig. 74a–l, 328i, Table 61 (Fig. 10.1a–e, h–n, 10.2c; original description, type species of *Semispathidium*; the holotype slide [accession number 2002/351] and five paratype slides [2002/342, 2002/343, 2002/358, 2002/360, 2002/375] have been deposited in the Biology Centre of the Upper Austrian Museum in Linz [LI]; Foissner et al. 2002, p. 42, Aescht 2008, p. 153).

Nomenclature: The species-group name *enchelyodontides* is a composite of the genus-group name *Enchelyodon* and the Greek suffix *-ides* (look like, similarity, especially as concerns shape; Werner 1972, p. 47). The name refers to the similarity with species of the genus *Enchelyodon* (Foissner et al. 2002).

Diagnosis (from Foissner et al. 2002, slightly modified): Body size about $160 \times 23 \mu\text{m}$ in vivo; body cylindroidal to indistinctly obclavate. On average 21 macronuclear nodules. Two size-types of rod-shaped extrusomes: type I about $30 \mu\text{m}$ long, forms conspicuous bundle attached to center of oral bulge; type II about $3 \mu\text{m}$ long, forms a ring in margin of oral bulge. On average 15 ciliary rows, three of them anteriorly differentiated to moderately distinct dorsal brush.

Remarks: This is a conspicuous ciliate with several distinct features, such as the long, slender body; the nodular macronucleus; and the $30 \mu\text{m}$ long extrusomes. Thus, it is easily identified and distinguished from *Semispathidium armatum* and *Semispathidium lagyniforme*, which have an ellipsoidal macronucleus. On the other hand, similar features are found in several *Enchelyodon* and *Enchelys* Müller, 1773 species, for instance, *Enchelyodon terrenus* Foissner, 1984 (body 200–300 μm long, extrusomes acicular and only $14 \mu\text{m}$ long, 100–300 macronuclear nodules; Fig. 10.1f, g) and *Enchelys terricola* Foissner, 1987 (body slenderly

bursiform, extrusomes only 5 μm long). Thus, reliable identification requires protargol impregnation to reveal the ∞ -shaped circumoral kinety and the curved anterior end of the ciliary rows.

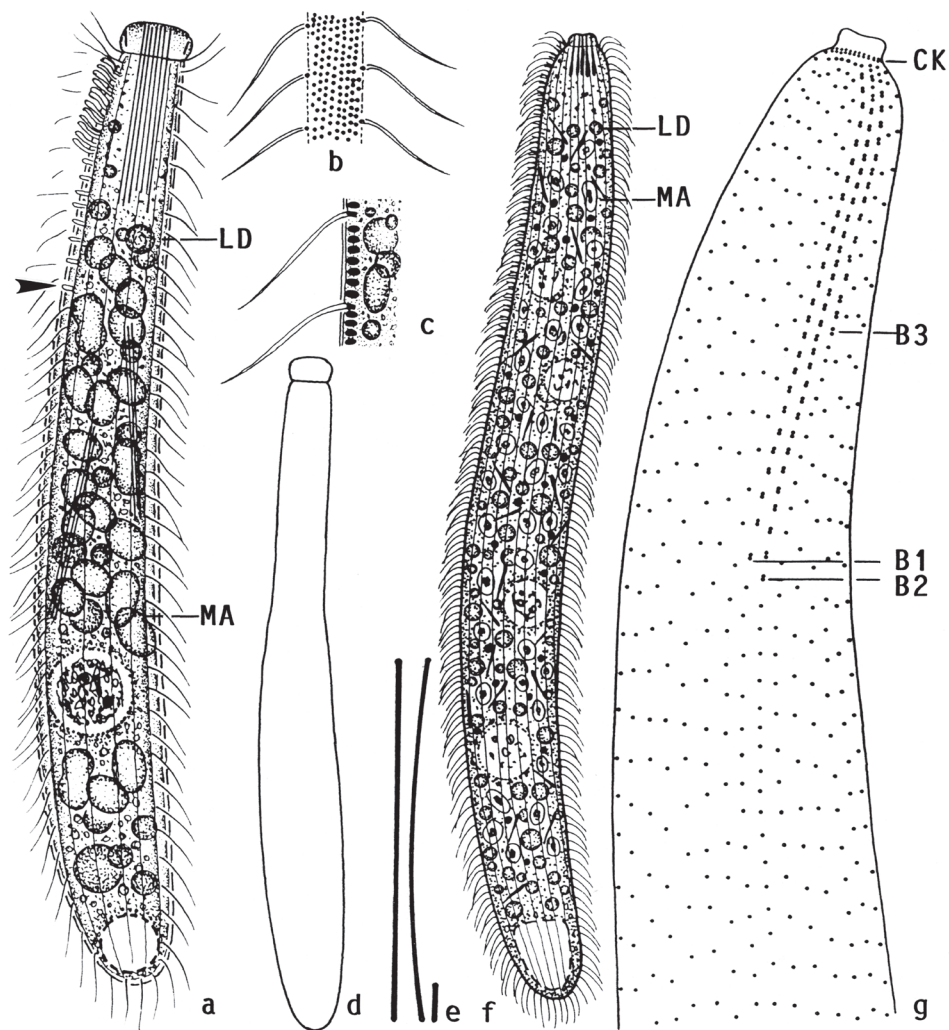


Fig. 10.1a–e *Semispathidium enchelyodontides* Foissner et al., 2002 (from Foissner et al. 2002. From life). **a**: Right side view of a representative specimen packed with macronuclear nodules and lipid droplets, length 160 μm . Arrowhead marks end of monokinetid bristle tail of brush row 3. **b**, **c**: Surface view and optical section showing cortical granules about $0.8 \times 0.4 \mu\text{m}$ in size. **d**: Slender, obclavate shape variant. **e**: Extrusomes, length 30 μm and 3 μm ; drawn to scale.

Fig. 10.1f, g *Enchelyodon terrenus* Foissner, 1984 (from Foissner 1984. **f**, from life; **g**, protargol preparation). This species highly resembles *Semispathidium* species. However, it has shorter, acicular extrusomes, a “flat” (not ∞ -shaped) circumoral kinety, and the ciliary rows are not curved anteriorly, as in *Semispathidium*, but straight. **f**: Right side view of a representative specimen packed with macronuclear nodules and lipid droplets, length 200–300 μm . **g**: Ciliary pattern in dorsal anterior body portion, length 80 μm .

B1–3 – dorsal brush rows, CK – circumoral kinety, LD – lipid droplets, MA – macronuclear nodule.

Description (from Foissner et al. 2002, slightly modified): Body size 120–210 × 20–35 µm in vivo, usually near 160 × 23 µm; length:width ratio highly variable, viz., 3.5–9.6:1,

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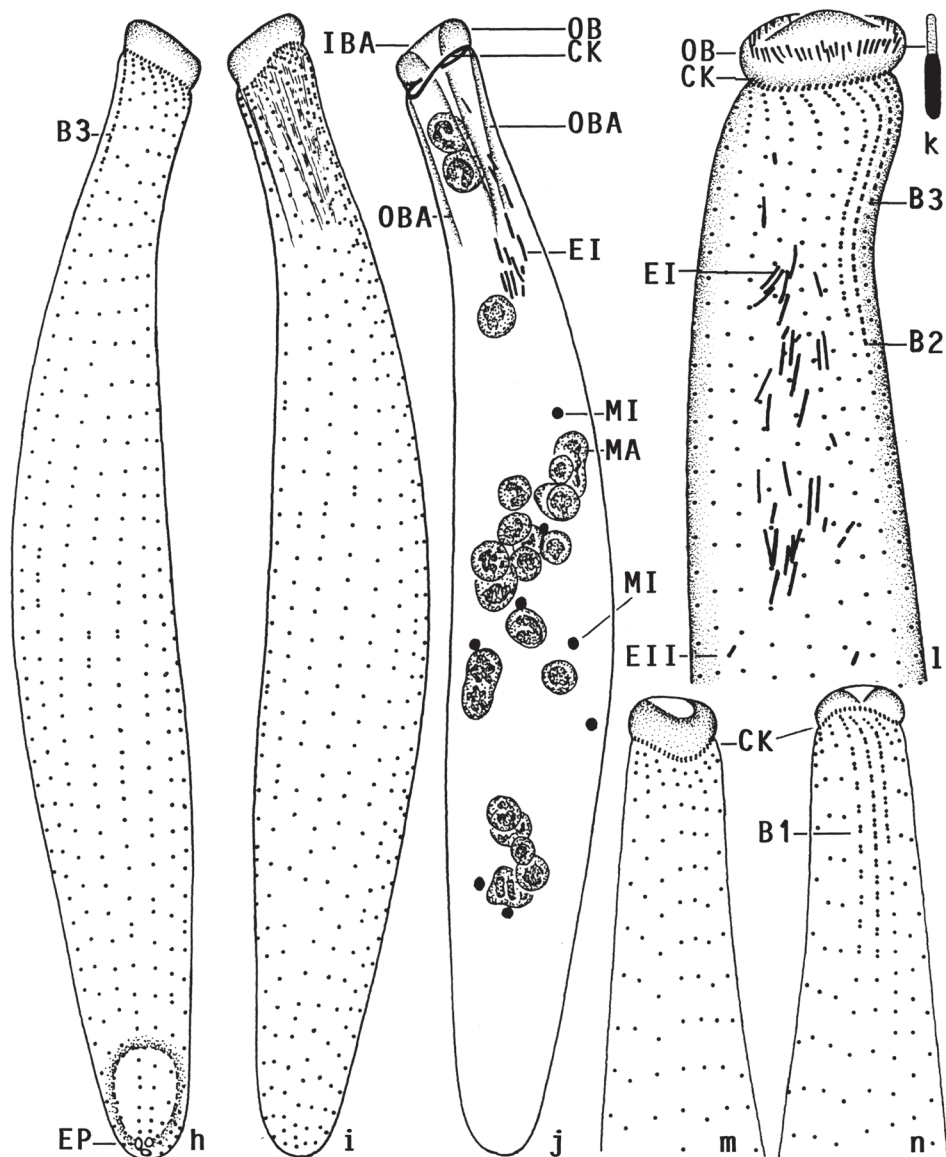


Fig. 10.1h–n *Semispathidium encbelyodontides* Foissner et al., 2002 (from Foissner et al. 2002. Protargol preparation). Somatic and oral ciliary pattern after protargol impregnation. **h–j**: Ciliary pattern of right and left side and nuclear apparatus of holotype specimen, length 160 µm. **k, l**: Oral bulge extrusome and dorso-leftlateral view of ciliary pattern, bulge width 14 µm. Note the curved and polymerized anterior portion of ciliary rows. **m, n**: Ciliary pattern of anterior body portion in ventral and dorsal view, length 46 µm. Note twisted circumoral kinety. B1–3 – dorsal brush rows 1–3, CK – circumoral kinety, EI, II – type I and type II extrusomes, EP – excretory pores of contractile vacuole, IBA – inner oral basket, MA – macronuclear nodules, MI – micronuclei, OB – oral bulge, OBA – outer oral basket.

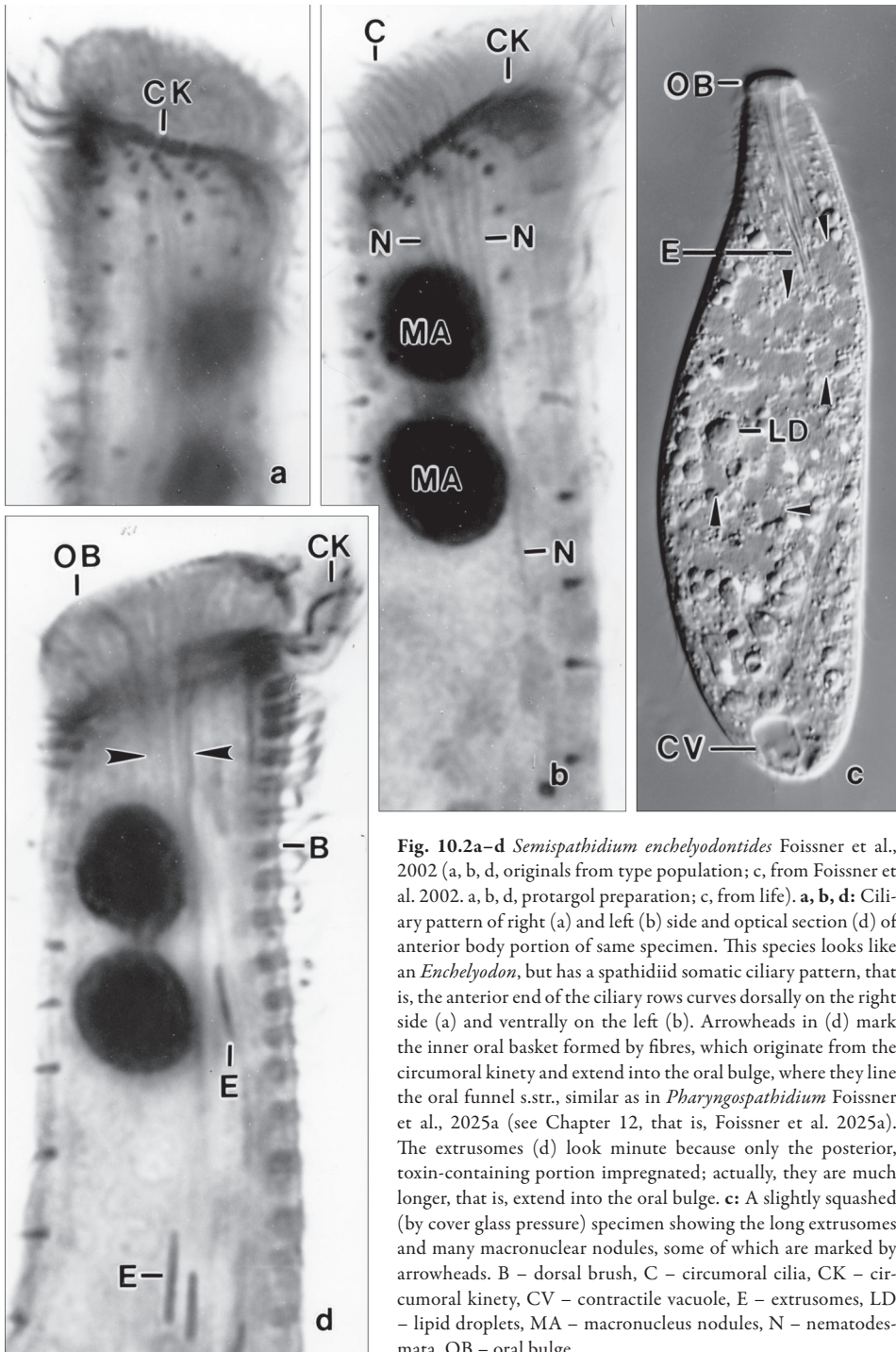


Fig. 10.2a–d *Semispathidium enchelyodontides* Foissner et al., 2002 (a, b, d, originals from type population; c, from Foissner et al. 2002. a, b, d, protargol preparation; c, from life). **a, b, d:** Ciliary pattern of right (a) and left (b) side and optical section (d) of anterior body portion of same specimen. This species looks like an *Enchelyodon*, but has a spathidiid somatic ciliary pattern, that is, the anterior end of the ciliary rows curves dorsally on the right side (a) and ventrally on the left (b). Arrowheads in (d) mark the inner oral basket formed by fibres, which originate from the circumoral kinety and extend into the oral bulge, where they line the oral funnel s.str., similar as in *Pharyngospathidium* Foissner et al., 2025a (see Chapter 12, that is, Foissner et al. 2025a). The extrusomes (d) look minute because only the posterior, toxin-containing portion impregnated; actually, they are much longer, that is, extend into the oral bulge. **c:** A slightly squashed (by cover glass pressure) specimen showing the long extrusomes and many macronuclear nodules, some of which are marked by arrowheads. B – dorsal brush, C – circumoral cilia, CK – circumoral kinety, CV – contractile vacuole, E – extrusomes, LD – lipid droplets, MA – macronucleus nodules, N – nematodesmata, OB – oral bulge.

on average about 7:1 in protargol preparations. Body shape inconspicuous, that is, cylindrical to slightly obclavate or fusiform, anterior end somewhat inclined ventrally, posterior rounded; usually slightly curved when swimming; not flattened and acontractile (Fig. 10.1a, d, h, 10.2i; Table 10.1). Nuclear apparatus in central quarters of cell, consists of an average of 21 scattered macronuclear nodules and seven globular micronuclei. Individual nodules globular to ellipsoidal, frequently more or less distinctly dumbbell-shaped, about $8 \times 6 \mu\text{m}$ in vivo and in protargol preparations, usually contain a large, lobate nucleolus; rarely, several nodules form a somewhat moniliform pattern. Contractile vacuole in rear end, several excretory pores in posterior pole area. Two size-types of rod-shaped extrusomes (Fig. 10.1a, e, j–l, 10.2i): type I in vivo approximately $30 \mu\text{m}$ long, fine and flexible, forms conspicuous bundle attached to central area of oral bulge and several smaller cytoplasmic bundles, posterior $3\text{--}5 \mu\text{m}$ impregnate heavily with protargol; type II extrusomes about $3 \mu\text{m}$ long, rod-like to indistinctly flask-shaped, form a ring in margin of oral bulge, numerous and scattered in cytoplasm, posterior half occasionally heavily impregnates with protargol. Cortex very flexible, contains dense rows of refractive granules about $0.8 \times 0.4 \mu\text{m}$ in size. Cytoplasm colourless, in well-fed specimens packed with globular and irregular fat inclusions $1\text{--}10 \mu\text{m}$ across. Feeds on heterotrophic flagellates and middle-sized ciliates, such as *Gonostomum strenuum*, which are ingested whole producing up to $50 \times 25 \mu\text{m}$ -sized food vacuoles. Swims rather rapidly by rotation about main body axis.

Cilia about $8 \mu\text{m}$ long in vivo, widely spaced ($4 \mu\text{m}$), especially in neck region, arranged in an average of 15 equidistant, bipolar rows anteriorly densely ciliated and curved dorsally on right side of cell, while ventrally on left, as in *Spathidium* (Foissner 1984). Three dorsal rows anteriorly differentiated to moderately conspicuous dorsal brush with up to $4 \mu\text{m}$ long, distally slightly inflated bristles. Brush rows 1 and 2 of almost same length, but composed of 11, respectively, 17 dikinetids; row 3 shorter than rows 1 and 2, composed of an average of nine dikinetids and an about $40 \mu\text{m}$ long, monokinetidal tail of $1.0\text{--}1.5 \mu\text{m}$ long bristles (Fig. 10.1a, h, i, l–n, 10.2i; Table 10.1).

Oral bulge discoidal, conspicuous because occupying anterior end of cell and about $13 \times 5 \mu\text{m}$ in size, surface slightly convex; margin contains type II extrusomes, as described above, producing a nice, crown-like pattern when impregnated with protargol (Fig. 10.1l); bulge center slightly to distinctly opened, forming a long, obconical inner oral basket lined by fibres originating from circumoral dikinetids (Fig. 10.1j). Circumoral kinety at base of oral bulge, ∞ -shaped, that is, slightly twisted relative to transverse axis of cell (Fig. 10.1j), composed of comparatively widely spaced dikinetids associated with fibres extending anteriorly, as described above, and fine nematodesmata forming an about $30 \mu\text{m}$ long, outer oral basket only occasionally impregnated with the protargol method used (Fig. 10.1a, d, j, l, m, 10.2i; Table 10.1).

Occurrence and ecology: To date, *Semispathidium enchelyodontides* was found only at the type locality, that is, in mud and soil from road puddles in the Bambatsi Guest Farm ($20^{\circ}10'S$ $15^{\circ}25'E$), Namibia (Foissner et al. 2002). The slender body shape indicates that *Semispathidium enchelyodontides* is a true soil inhabitant. It was moderately abundant in the non-flooded Petri dish culture.

***Semispathidium armatum* Foissner, Agatha & Berger, 2002**

(Fig. 10.3a–j, Table 10.1)

2002 *Semispathidium armatum* nov. spec. – Foissner, Agatha & Berger, *Denisia* 5: 331, Fig. 75a–j, Table 61 (Fig. 10.3a–j; the holotype slide [accession number 2002/362] and two paratype slides [2002/340, 2002/341] have been deposited in the Biology Centre of the Upper Austrian Museum in Linz [LI]; Foissner et al. 2002, p. 42, Aeschl 2008, p. 144).

Nomenclature: The species-group name *armatus*, *-a*, *-um* (Latin adjective [m, f, n]; armed, defended; Hentschel & Wagner 1996, p. 103) refers to the conspicuous extrusomes (Foissner et al. 2002).

Diagnosis (from Foissner et al. 2002, slightly modified): Body size about $270 \times 40 \mu\text{m}$ in vivo. Body shape cylindroidal to indistinctly fusiform. Macronucleus ellipsoidal to elongate ellipsoidal. Oral extrusomes obclavate with rod-shaped anterior process, total size about $10 \times 1 \mu\text{m}$. On average 21 ciliary rows, three of them anteriorly differentiated to moderately distinct dorsal brush with row 2 about twice as long as conspicuously shortened row 3.

Remarks: This conspicuous ciliate is easily identified and distinguished from the two congeners originally assigned, viz., *Semispathidium enchelyodontides* and *Semispathidium lagyniforme*, by the large size, the reniform macronucleus, and the obclavate extrusomes. On the other hand, similar features are found in several *Enchelyodon* and *Enchelys* species, for instance, *Enchelyodon terrenus* Foissner, 1984 (many macronuclear nodules; Fig. 10.1f, g). Thus, reliable identification requires protargol impregnation to reveal the curved anterior end of the ciliary rows.

Enchelyodon vermiformis, discovered by Dragesco (1970) in an ephemeral puddle in Cameroun, likely belongs to *Semispathidium* and is very similar to *Semispathidium armatum*, differing mainly by the $50 \mu\text{m}$ long, rod-shaped extrusomes. Unfortunately, the ciliary pattern is not known, and thus it cannot be combined with *Semispathidium*.

Description (from Foissner et al. 2002, slightly modified): Body size conspicuous, that is, $180\text{--}320 \times 30\text{--}50 \mu\text{m}$ in vivo, usually near $270 \times 40 \mu\text{m}$; length:width ratio 4.4–8.1, on average 5.6:1 in protargol preparations. Body shape inconspicuous, that is, slightly fusiform in vivo and distinctly so in preparations, anterior end slanted ventrally, posterior rounded; not flattened and acontractile (Fig. 10.3a, e; Table 10.1). Macronucleus in or near mid-body, rod-shaped to slightly reniform, ellipsoidal (2:1) to distinctly oblong (5:1); nucleolus reticulate. Micronucleus attached to macronucleus at varying position, about $5 \mu\text{m}$ across in vivo. Contractile vacuole in rear body end, an average of six excretory pores in posterior pole area. Extrusomes scattered in cytoplasm and attached to oral bulge forming a ring-like array; conspicuous because $8\text{--}12 \times 0.8\text{--}1.0 \mu\text{m}$ in size and obclavate with an about $5 \mu\text{m}$ long rod projecting anteriorly; mature organelles occasionally impregnate brownish with protargol, while a certain cytoplasmic developmental stage stains black (Fig. 10.3a–d). Cortex very flexible, contains rather dense rows of colourless granules. Cytoplasm packed with fat globules up to $5 \mu\text{m}$ across in well-nourished specimens; likely feeds on protists. Swims moderately fast by rotation about main body axis.

Cilia about $12 \mu\text{m}$ long in vivo, rather loosely spaced in neck region, arranged in an average of 21 equidistant, bipolar rows anteriorly densely ciliated and curved dorsally on right side of cell, while ventrally on left, as in *Spathidium*. Three dorsal rows anteriorly

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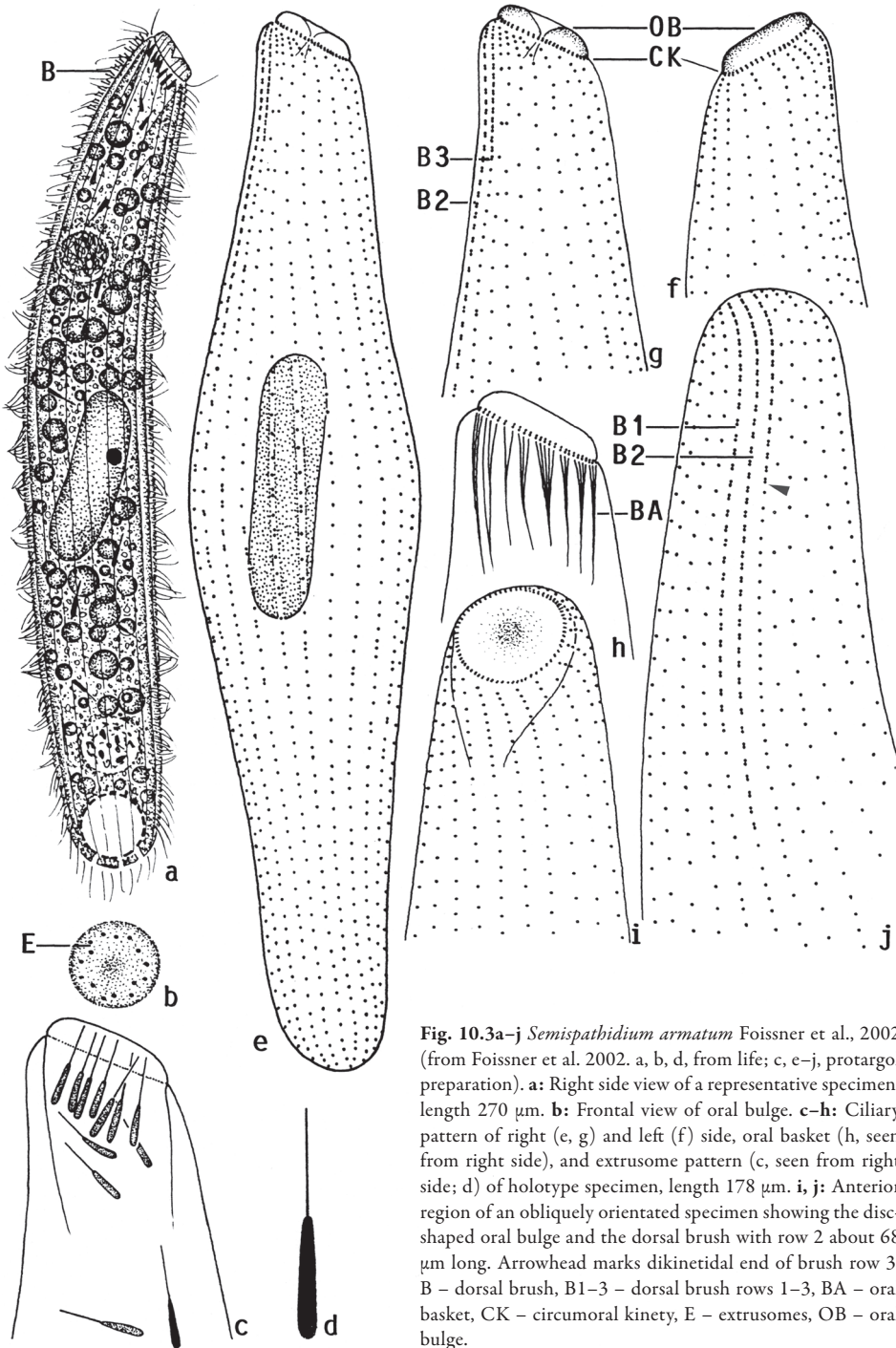


Fig. 10.3a-j *Semispathidium armatum* Foissner et al., 2002 (from Foissner et al. 2002. **a**, **b**, **d**, from life; **c**, **e-j**, protargol preparation). **a**: Right side view of a representative specimen, length 270 µm. **b**: Frontal view of oral bulge. **c-h**: Ciliary pattern of right (**e**, **g**) and left (**f**) side, oral basket (**h**, seen from right side), and extrusome pattern (**c**, seen from right side; **d**) of holotype specimen, length 178 µm. **i**, **j**: Anterior region of an obliquely orientated specimen showing the disc-shaped oral bulge and the dorsal brush with row 2 about 68 µm long. Arrowhead marks dikinetidal end of brush row 3. B – dorsal brush, B1–3 – dorsal brush rows 1–3, BA – oral basket, CK – circumoral kinety, E – extrusomes, OB – oral bulge.

differentiated to rather conspicuous dorsal brush with up to 6 μm long bristles, anterior bristle of pairs shortened. Brush row 1 slightly shorter than row 2, composed of an average of 25 dikinetids; row 2 twice as long as row 3, composed of 40 dikinetids on average; row 3 distinctly shortened, consisting of only 14 dikinetids on average, but has a monokinetidal tail of 3 μm long bristles extending to at least mid-body (Fig. 10.3a, e–g, i, j; Table 10.1).

Oral bulge discoidal, moderately conspicuous occupying most of anterior end of cell, about 15 μm across and 4–5 μm high. Bulge center slightly depressed and lined by an “ χ -shaped” fibrillar core (inner oral basket) extending up to 10 μm into the cell (Fig. 10.3e, g). Circumoral kinety at base of oral bulge, flat as in *Enchelyodon*, composed of narrowly spaced dikinetids associated with fine nematodesmata forming small bundles, which produce a rather inconspicuous, cylindrical to conical, about 25 μm long oral basket impregnating with protargol (Fig. 10.3a, f–h; Table 10.1).

Occurrence and ecology: To date, *Semispathidium armatum* was found only at the type locality, where it was very rare in the non-flooded Petri dish culture. The type locality is mud and soil from road puddles in the Bambatsi Guest Farm (20°10'S 15°25'E), Namibia (Foissner et al. 2002). The slender shape indicates that *Semispathidium armatum* is a true soil inhabitant. Interestingly, *Semispathidium armatum* occurred at the same site and habitat as *Semispathidium enchelyodontides*.

Semispathidium lagyniforme (Kahl, 1930)

Foissner, Agatha & Berger, 2002

(Fig. 10.4a–g, Table 10.1)

1930 *Spathidium lagyniforme* spec. n. – Kahl, Tierwelt Dtl. 18: 155, Fig. 22 17 (Fig. 10.4a; original description; no type material available).

1943 *Spathidium lagyniforme* Kahl – Kahl, Infusorien, p. 25, Tafel V, Fig. 33 (Fig. 1a; review).

1984 *Spathidium lagyniforme* Kahl, 1930 – Foissner, Stapfia 12: 74, Abb. 37a–f, Tabelle 17 (Fig. 10.4b–g; description of Austrian population based on life observations and protargol-prepared specimens).⁵

2002 *Semispathidium lagyniforme* (Kahl, 1930) nov. comb. – Foissner, Agatha & Berger, Denisia 5: 327 (combination with *Semispathidium*).

2008 *lagyniforme Spathidium* Kahl, 1930 – Aescht, Denisia 23: 162 (note on neotypification by Foissner 1984, see footnote below).

Nomenclature: No derivation of the name is given in the original description or a later work. The species-group name *lagyniform-is*, *-is*, *-e* is, very likely, a composite of the Greek noun *lagynos* (flagon, flask, bottle; Brown 1954, p. 159), the thematic vowel *-i-*, and *-form-is*, *-is*, *-e* (Latin adjective [m, f, n]; -shaped; see Hentschel & Wagner 1996, p. 274 at *glómeriformis*), likely meaning a flask-shaped *Spathidium*.

⁵ Note by H. Berger: According to Aescht (2003, p. 389; 2008, p. 162), a neotype slide (accession number 1984/54) has been deposited in the Biology Centre of the Upper Austrian Museum in Linz (LI) by Foissner (1984). However, Foissner (1984, p. 8) made only a brief comment on the deposition of type material; from redescribed species he deposited at least one slide (“Von den übrigen Arten ist ebenfalls mindestens je 1 Präparat dort hinterlegt”) in the museum, that is, he made no comment on the type (voucher or neotype) of the slide. According to Aescht (2008, p. 162), the slide deposited in the museum (accession number 1984/54) is incorrectly labelled as “paratype” (a paratype is each specimen of a type series other than the holotype; ICZN 1999, p. 120). For that reason, and more important, since he did not provide the qualifying conditions necessary for a neotypification (ICZN 1999, Article 75.3), the slide deposited by Foissner (1984) was not a neotype, but a voucher slide.

continued on p. 324

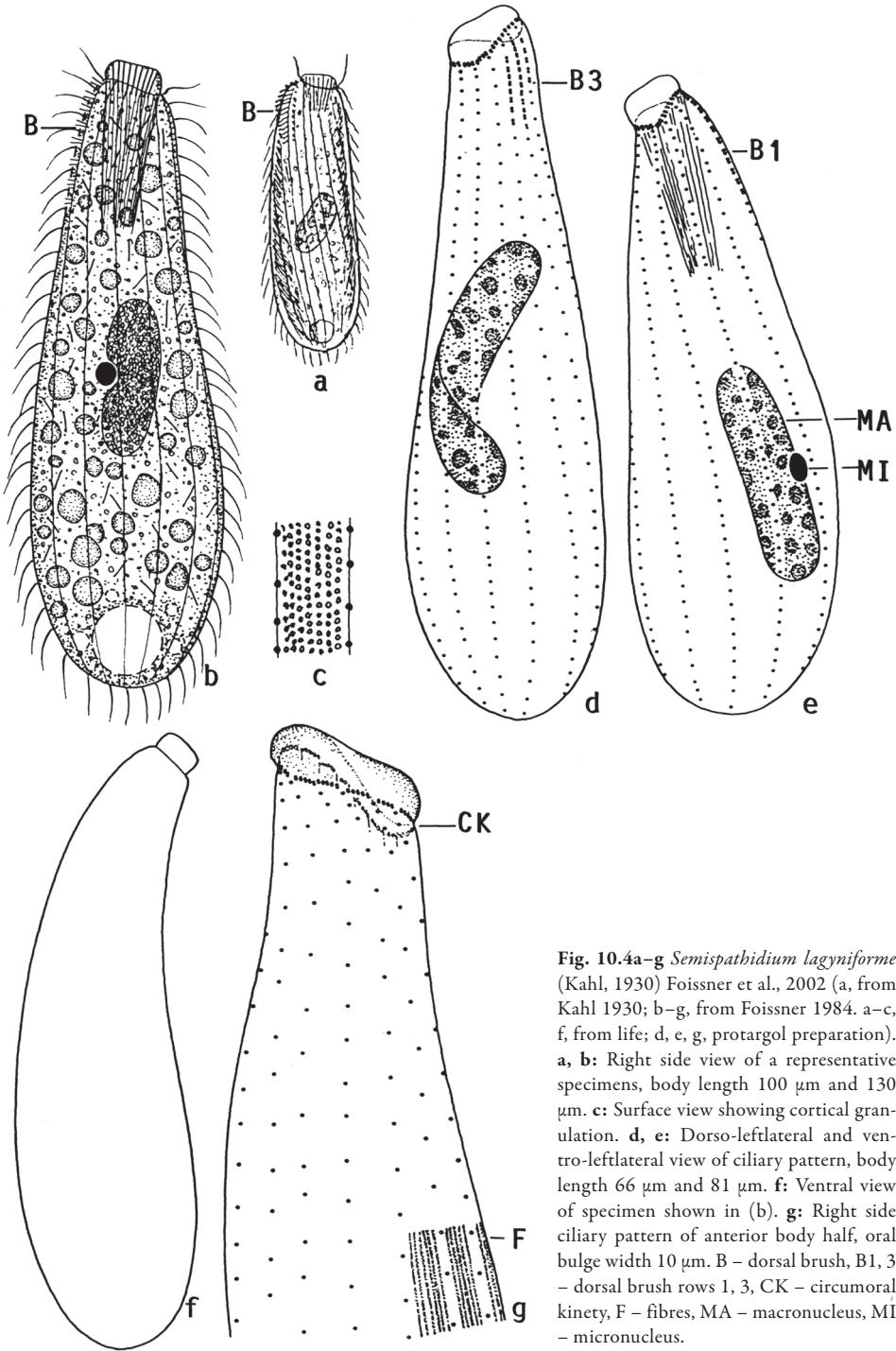


Fig. 10.4a–g *Semispathidium lagyniforme* (Kahl, 1930) Foissner et al., 2002 (a, from Kahl 1930; b–g, from Foissner 1984. a–c, f, from life; d, e, g, protargol preparation). **a, b**: Right side view of a representative specimens, body length 100 µm and 130 µm. **c**: Surface view showing cortical granulation. **d, e**: Dorso-leftlateral and ventro-leftlateral view of ciliary pattern, body length 66 µm and 81 µm. **f**: Ventral view of specimen shown in (b). **g**: Right side ciliary pattern of anterior body half, oral bulge width 10 µm. B – dorsal brush, B1, 3 – dorsal brush rows 1, 3, CK – circumoral kinety, F – fibres, MA – macronucleus, MI – micronucleus.

Improved diagnosis (based on Kahl 1930 and Foissner 1984): Body size about 100–120 × 30–40 µm in vivo. Body ellipsoidal to indistinctly pyriform. Macronucleus ellipsoidal to elongate ellipsoidal. Oral extrusomes rod-shaped, about 5 µm long. On average 15 ciliary rows, three of them anteriorly differentiated to inconspicuous dorsal brush with row 2 about twice as long as row 3.

Remarks: *Semispathidium lagyniforme* has few distinct features and is thus easily confused with quite a lot of haptorid gymnostomes, especially with species of the genera *Enchelys* Müller, 1773 (oral bulge flatter and thus hardly visible in vivo, no circumoral kinety) and *Enchelyodon* Claparède & Lachmann, 1859 (circumoral kinety not twisted, ciliary rows not curved anteriorly). Thus, reliable identification requires protargol preparation. The specimens studied by Foissner (1984) match the original description very well and confirm Kahl's (1930) remark in the key "that this species is not a typical *Spathidium*". We do not fix the Austrian population described by Foissner (1984) as neotype material, mainly because no gene sequence data are available, a prerequisite for a modern description. The neotype should preferably come from the Hamburg region (Germany; see, however, occurrence and ecology) or at least from Europe and has to agree with the descriptions by Kahl (1930) and Foissner (1984).

Description: Body size 100–120 (length; Kahl 1930) to 100–160 × 35–50 µm (Foissner 1984), usually about 100–120 × 30–40 µm in vivo; length:width ratio near 3:1. Body shape inconspicuous, viz., ellipsoidal to indistinctly pyriform or bursiform with button-like anterior (oral) end and widely rounded posterior one; slightly flattened and curved laterally; very flexible, but acontractile (Fig. 10.4a, b, d–f; Table 10.1). Nuclear apparatus in middle body third. Macronucleus bluntly to elongate ellipsoidal, in vivo up to 50 × 10 µm; nucleoli inconspicuous. Micronucleus in deep indentation of macronucleus, about 5 µm across in vivo. Contractile vacuole in rear body end. Extrusomes studded in oral bulge and scattered in cytoplasm, rod-shaped to slightly fusiform, about 5 µm long. Cortex flexible, contains approximately 10 rows of minute, colourless granules and six fibres between two kineties each (Fig. 10.4c, g). Cytoplasm packed with globular and irregular lipid droplets up to 8 µm across. Swims moderately fast by rotation about main body axis.

Cilia about 7 µm long in vivo, ordinarily spaced, arranged in an average of 15 equidistant, meridional (Foissner 1984) or slightly spiral (Kahl 1930) rows anteriorly rather distinctly curved dorsally on right side of cell, while ventrally on left. Three dorsal rows anteriorly differentiated to short, inconspicuous dorsal brush with bristles merely up to 2 µm long; row 3 distinctly shortened (Fig. 10.4a, b, d, e, g; Table 10.1).

Oral bulge button-like projecting and somewhat twisted along main body axis, distinctly narrower than widest trunk region and broadly elliptical in transverse view, slightly obliquely truncate anteriorly. Circumoral kinety at base of oral bulge, conspicuously ∞-shaped, that is, twisted relative to transverse axis of cell, composed of narrowly spaced dikinetids forming more or less distinct kinetofragments; dikinetids associated with fine nematodesmata forming inconspicuous oral basket recognizable only in protargol preparations (Fig. 10.4a, b, d–g; Table 10.1).

Occurrence and ecology: Kahl (1930) discovered *Semispathidium lagyniforme* in shallow road drains very likely in the surroundings of Hamburg, Germany⁶. Foissner (1984, p.

⁶ Note by H. Berger: Kahl (1930) usually did not mention the sample site. But since he lived and worked in Hamburg, we must assume that most material is from this region. However, strictly speaking, the type locality is not known.

6, 7, site “FO15”) found *Semispathidium lagyniforme* in arable field soil near the village of Bierbaum am Kleebüchel (48°23'N 15°57'E) in Lower Austria (for detailed description of this sample site, see “Profil 3: Feld A (FA)” in Foissner et al. 1985, p. 83, 87). Record not substantiated by morphological data: slightly polluted upper region of the river Stirone in northern Italy (Madoni & Ghetti 1981, their Table III). The species was rare at all locations mentioned, and obviously occurs both in limnetic and terrestrial environments.

***Semispathidium breviararmatum* Foissner &
Vdačný in Vdačný & Foissner, 2013**
(Fig. 10.5a–d)

2013 *Semispathidium breviararmatum* Foissner & Vdačný sp. n. – Vdačný & Foissner, Zool. Scr. 42: 535, Fig. 1A–N, 2A–D, 3A–L, 4A–I, 5A–F, 6A–G, Table 3 (original description; for type material, see nomenclature).

Nomenclature: For detailed derivation of the species-group name, see Vdačný & Foissner (2013, p. 537). It refers to the short extrusomes.

According to Vdačný & Foissner (2013, p. 535), the slide containing the holotype specimen and one paratype slide have been deposited in the Biology Centre of the Upper Austrian Museum in Linz (LI). However, due to various circumstances the slides have not been deposited in the museum in Linz (see Aeschl 2013, 2018, who do not mention these slides). According to ICZN (1999, Article 16.4), the name bearing types of species and subspecies described after 1999 have to be fixed explicitly in the original description. In addition, the work must contain a statement where the type material, will be (or is) deposited (ICZN 1999, Articles 16.4.2, 72.3). Since Vdačný & Foissner (2013, p. 535) fixed a specimen as holotype (their Fig. 1D, E) and since they mentioned the collection (Biology Centre of the Upper Austrian Museum in Linz) the description is valid. The type slides (the slide containing the holotype [Fig. 10.5a, b; accession number 2024/194] and one paratype slide [Fig. 10.5c, d; 2024/195]) have been deposited in the Biology Centre of the Upper Austrian Museum in Linz (LI), together with the slides of the other species treated in the present book.

Diagnosis (from Vdačný & Foissner 2013, p. 535, slightly modified): Body size about $300 \times 50 \mu\text{m}$ in vivo. Body shape narrowly to very narrowly cylindrical with distinctly oblique oral bulge. Macronucleus narrowly to very narrowly ellipsoidal; one micronucleus. Oral bulge extrusomes narrowly to very narrowly ovate, about $5\text{--}7 \times 1.0\text{--}1.3 \mu\text{m}$ in size, arranged in two indistinct rings. On average 34 ciliary rows, three of them anteriorly differentiated into a distinctly heterostichad dorsal brush with longest row 2 occupying an average of 36% of body length.

Remarks: For comparison with congeners see original description (p. 545) and key above.

Description: For brief characterization, see diagnosis above; for detailed description, see Vdačný & Foissner (2013, p. 537, type population from South Africa; p. 543, population from Botswana).

Resting cyst: The resting cysts of the type population are about $66 \mu\text{m}$ in diameter and lack an escape apparatus. They display a conspicuous wall with a rugose surface (for details, see Vdačný & Foissner 2013, p. 544).

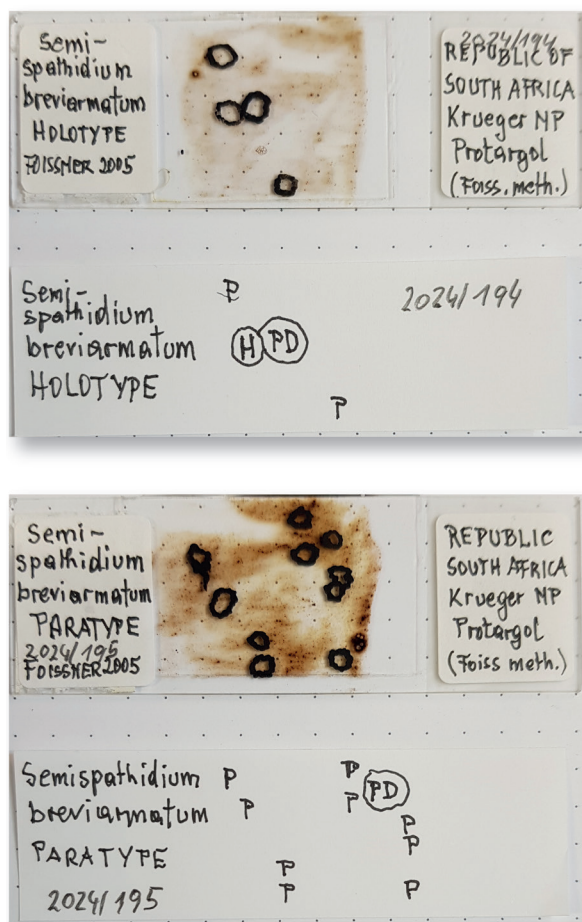


Fig. 10.5a–d *Semispathidium breviararmatum* Foissner & Vdačný in Vdačný & Foissner, 2013 (originals. Protargol slides). **a, b:** Slide (a) and protocol (b) containing holotype (H), paratypes (P), and paratypes drawn (PD). Accession number (LI): 2024/194. **c, d:** Slide (c) and protocol (d) containing a paratype drawn (PD) and paratypes (P). Accession number (LI): 2024/195.

544) found *Semispathidium breviararmatum* also in a soil sample from the green riverbed of the Thamalakene River near the town of Maun, Botswana.

Semispathidium longiarmatum Foissner & Vdačný in Vdačný, Slovák & Foissner, 2014 (Fig. 10.6a–d)

2014 *Semispathidium longiarmatum* Foissner & Vdačný nov. spec. – Vdačný, Slovák & Foissner, Eur. J. Protistol. 50: 331, Fig. 1A–P, 2A–H, 3A–E, 4A–D, 5A–D, Table 1 (original description; the slide containing the holotype specimen [accession number 2013/50] and three paratype slides [2013/51–53] have been

Molecular phylogeny:

Vdačný & Foissner (2013) deposited the 18S rRNA gene and the ITS1-5.8S rRNA-ITS2 region nucleotide sequences, both obtained from specimens of the type population, in GenBank under the accession number JF263450 (the number “JF263449” in their Fig. 8 is incorrect) and JX070873. In the 18S rRNA phylogeny it clusters with *Enchelys polynucleata* DQ411861 + *Protopathidium muscicola* JF263449. For further details, see Vdačný et al. (2011, 2012; as “*Semispathidium* sp.”).

Occurrence and ecology:

Semispathidium breviararmatum was discovered in a soil sample from the floodplain of the Matjulu River in the surroundings of the Berg-en-dal Lodge (about 25°20'S 31°28'E), South Africa (Vdačný & Foissner 2013, p. 544). The Matjulu River is a small tributary to the large Crocodile River at the southern border of the Krüger National Park. Vdačný & Foissner (2013, p.

deposited in the Biology Centre of the Upper Austrian Museum in Linz [LI] according to Vdačný et al. 2014, p. 331; however, slides not mentioned in Aescht 2018; for details, see nomenclature).

Nomenclature: For detailed derivation of the species-group name, see Vdačný et al. (2014, p. 331). It refers to the comparatively long extrusomes, a main feature of this species.

According to Vdačný et al. (2014, p. 331), the slide containing the holotype specimen (accession number 2023/50) and three paratype slides (2023/51, 52, 53) have been deposited in the Biology Centre of the Upper Austrian Museum in Linz (LI). However, due to various circumstances the slides have not been deposited in the museum in Linz (see Aescht 2018 who does not mention these slides). According to ICZN (1999, Article 16.4), the name bearing types of species and subspecies described after 1999 have to be fixed explicitly. In addition, the work must contain a statement where the type material, will be (or is) deposited (ICZN 1999, Articles 16.4.2, 72.3). Since Vdačný et al. (2014, p. 535, their Fig. 1B, C) fixed a specimen as holotype and since they mentioned the collection (Biology Centre of the Upper

Austrian Museum in Linz) the description is valid. We found only the holotype slide and one (not three) paratype slide in the Foissner archive in Salzburg. The type slides (the slide containing the holotype [Fig. 10.6a, b; accession number 2013/50] and one paratype slide [Fig. 10.6c, d; 2013/51]) have been deposited in the Biology Centre of the Upper Austrian Museum in Linz (LI), together with the slides of the other species treated in the present book.⁷

⁷ Note by H. Berger: The two slides and protocols did not contain the

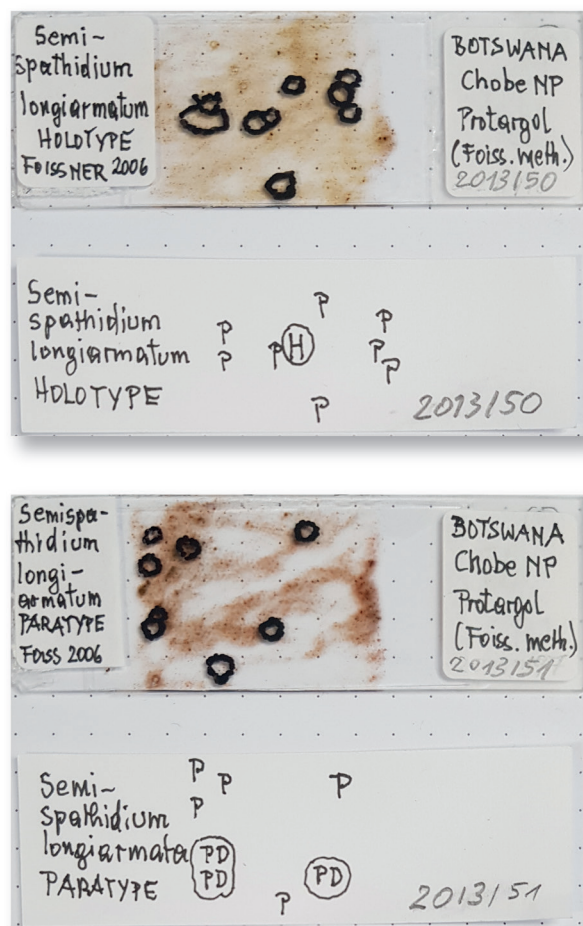


Fig. 10.6a–d *Semispathidium longiarmatum* Foissner & Vdačný in Vdačný, Slovák & Foissner, 2014 (originals. Protargol slides). **a, b:** Slide (a) and protocol (b) containing holotype (H) and paratypes (P). Accession number (LI): 2013/50. **c, d:** Slide (c) and protocol (d) containing paratypes drawn (PD) and paratypes (P). Accession number (LI): 2013/51. For details, see nomenclature.

Diagnosis (from Vdačný et al. 2014, p. 331, slightly modified): Body size about $230 \times 40 \mu\text{m}$ in vivo. Body shape narrowly to very narrowly ellipsoidal with slightly to moderately oblique oral bulge. Macronucleus narrowly to very narrowly ellipsoidal and usually slightly curved; one micronucleus. Two types of oral bulge extrusomes: type I very narrowly cuneate, about $9\text{--}11 \times 1 \mu\text{m}$ in size, forms a bundle in central bulge area; type II oblong, about $2.0 \times 0.3 \mu\text{m}$ in size, occupies peripheral bulge area. On average 30 ciliary rows, three anteriorly differentiated into a distinctly heterostichad dorsal brush with longest row 2 occupying about 27% of body length.

Remarks: *Semispathidium longiarmatum* is the last species so far described in this genus (Vdačný et al. 2014). Therefore, we take over the comparison section of this work word for word (however, “S.” written out as *Semispathidium*): “Among the congeners, *Semispathidium longiarmatum* nov. spec. is most similar to *Semispathidium armatum* and *Semispathidium breviarmatum*. They can be separated from each other by the shape and pattern of the extrusomes. *Semispathidium longiarmatum* exhibits two shape and size types of oral extrusomes: type I is very narrowly cuneate and $9\text{--}11 \mu\text{m}$ long and type II is oblong and only about $2 \mu\text{m}$ long. *Semispathidium armatum* and *Semispathidium breviarmatum* display only one type of oral extrusomes, obclavate with a rod-shaped anterior process in the former, and narrowly ovate and only $5\text{--}7 \mu\text{m}$ long in the latter. Morphometrically, *Semispathidium longiarmatum* is separated from *Semispathidium armatum* by the higher number of ciliary rows ($27\text{--}36$ vs. $20\text{--}23$), and from *Semispathidium breviarmatum* by the much lower number of dikinetids in brush row 1 ($24\text{--}52$ vs. $52\text{--}102$). *Semispathidium longiarmatum* resembles *Semispathidium lagyniforme*, as redescribed by Foissner (1984), in the macronuclear pattern but differs by the larger body ($165\text{--}300 \mu\text{m}$ vs. $100\text{--}160 \mu\text{m}$) and the shape and size of the extrusomes (very narrowly cuneate and $9\text{--}11 \mu\text{m}$ long vs. oblong to bluntly fusiform and about $5 \mu\text{m}$ long). Finally, *Semispathidium longiarmatum* is distinguished from the three remaining congeners by the macronuclear pattern. Specifically, the macronucleus is elongate ellipsoidal in *Semispathidium longiarmatum* while it is fragmented into about 21 nodules in *Semispathidium enchelyodontides* (Foissner et al. 2002) and is a nodulated, tortuous strand in *Semispathidium fraterculum* and *Semispathidium pulchrum* (Foissner et al. 2010). Moreover, *Semispathidium longiarmatum* differs from these species by the shape of the type I extrusomes: filiform in *Semispathidium enchelyodontides* and *Semispathidium fraterculum*, and very narrowly fusiform in *Semispathidium pulchrum*.”

Description: For brief characterization, see diagnosis above; for detailed description, see Vdačný et al. (2014, p. 331).

Resting cyst: The resting cysts of *Semispathidium longiarmatum* are colourless in vivo, globular to rotund, about $60 \mu\text{m}$ in diameter; without escape apparatus (Vdačný et al. 2014). Cyst wall very conspicuous because about $7 \mu\text{m}$ thick, i.e., composed of a $2 \mu\text{m}$ thick, compact internal layer and an about $5 \mu\text{m}$ thick external layer with wrinkled and irregularly arranged ribs separated by furrows (for details, see Vdačný et al. 2014, p. 335).

Occurrence and ecology: To date, *Semispathidium longiarmatum* is recorded only from the type locality, that is, soil from the Chobe River floodplain (about 17.80°S 24.96°E), about 25 km west of the town of Kasane, on the so-called Kabolebole Peninsula of the

accession numbers. I labelled the holotype slide with the accession number 2013/50 and the paratype slide with 2013/51, as indicated in the original description.

Chobe riverfront) in the Chobe National Park, Botswana.⁸ For details, see Vdačný et al. (2014, p. 335).

***Semispathidium fraterculum* Foissner & Al-Rasheid
in Foissner, Hess & Al-Rasheid, 2010**

2010 *Semispathidium fraterculum* Foissner and Al-Rasheid nov. spec. – Foissner, Hess & Al-Rasheid, Eur. J. Protistol. 46: 62, Fig. 1–35, Table 1 (original description; the slide containing the holotype specimen [accession number 2011/398] and six paratype slides [2011/399–404] have been deposited in the Biology Centre of the Upper Austrian Museum in Linz [LI] according to Foissner et al. 2010, p. 62; see also Aescht 2013, p. 240; 2018, p. 488).

Nomenclature: For derivation of the species-group name, see Foissner et al. (2010, p. 62). It refers to the supposed vicariant relationship to *Semispathidium pulchrum*.

Diagnosis (from Foissner et al. 2010, p. 62, slightly modified): Body size about $170 \times 30 \mu\text{m}$ in vivo. Body cylindrical with conspicuous, oblique oral bulge about $15 \times 5 \mu\text{m}$ in size. Macronucleus a moderately nodulated, tortuous strand. Two size-types of oral bulge extrusomes: type I filiform, slightly curved, about $20.0 \times 0.3 \mu\text{m}$ in size; type II about $2.5 \mu\text{m}$, oblong, form a ring in margin of oral bulge. On average 20 ciliary rows, three of them anteriorly modified to a heterostichad, isomorphic dorsal brush occupying an average of 19% of body length with up to $3 \mu\text{m}$ long bristles.

Remarks: For comparison of species within the genus *Semispathidium*, see remarks at *Semispathidium longiarmatum* (p. 328) and key to species. For discussion if *Semispathidium fraterculum* and *Semispathidium pulchrum* are geographic vicariants, see Foissner et al. (2010, p. 72).

Description: For brief characterization, see diagnosis above; for detailed description, see Foissner et al. (2010, p. 62).

Resting cyst: Cysts of *Semispathidium fraterculum* in vivo colourless, $40\text{--}50 \mu\text{m}$ across, on average $43.4 \mu\text{m}$ ($n = 10$). Wall about $2 \mu\text{m}$ thick, consists of an about $0.5 \mu\text{m}$ thick, membrane-like external layer and a bright, soft internal layer $1.5 \mu\text{m}$ thick (for details, see Foissner et al. 2010, p. 67).

Occurrence and ecology: According to Foissner et al. (2010, p. 67), *Semispathidium fraterculum* is as yet found only at the type locality, that is, in the upper 5 cm soil layer from the Chobe River floodplain (about 17.80°S 24.96°E , about 25 km west of the town of Kasane, on the so-called Kabolebole Peninsula of the Chobe riverfront) in the Chobe National Park, Botswana.⁹ Thus, it remains unknown whether *Semispathidium fraterculum* prefers terrestrial or limnetic habitats. In the non-flooded Petri dish culture, the abundance was low, indicating that it is a limnetic species.

⁸ Note by H. Berger: Vdačný et al. (2014, p. 331) mention incorrect geographic co-ordinates, namely “ $E17^{\circ}50'$ $S25^{\circ}00'$ ”. Correct is (about) 17.80°S 24.96°E , that is, they confused the values for East and South.

⁹ Note by H. Berger: Foissner et al. (2010, p. 62) and Aescht (2018, p. 488) mention incorrect geographic co-ordinates, namely “ $E17^{\circ}50'$ $S25^{\circ}$ ”. Correct is (about) 17.80°S 24.96°E , that is, they confused the values for East and South.

Semispathidium pulchrum Foissner, Hess & Al-Rasheid, 2010

2010 *Semispathidium pulchrum* Foissner, Hess and Al-Rasheid, nov. spec. – Foissner, Hess & Al-Rasheid, Eur. J. Protistol. 46: 67, Fig. 36–62, Table 1 (original description; the slide containing the holotype specimen [accession number 2011/392] and six paratype slides [2011/393–397] have been deposited in the Biology Centre of the Upper Austrian Museum in Linz [LI] according to Foissner et al. 2010, p. 67; Aesch 2013, p. 242; 2018, p. 488 listed only five paratype slides¹⁰).

Nomenclature: For detailed derivation of the species-group name, see Foissner et al. (2010, p. 67). It refers to the “nice, crown-like oral bulge”.

Diagnosis (from Foissner et al. 2010, p. 67, slightly modified): Body size about $150 \times 20 \mu\text{m}$ in vivo. Body cylindric with conspicuous, oblique oral bulge about $15 \times 5 \mu\text{m}$ in size. Macronucleus a moderately nodulated, tortuous strand; several micronuclei. Two types of oral bulge extrusomes: type I very narrowly fusiform, about $9.0 \times 0.8 \mu\text{m}$ in size, occupy main area of oral bulge; type II broadly fusiform, about $2.0 \times 0.9 \mu\text{m}$ in size, form two rows in lateral lower half of oral bulge. On average 21 ciliary rows, three of them anteriorly modified to a heterostichad, isomorphic dorsal brush occupying an average of 25% of body length with up to $5 \mu\text{m}$ long bristles.

Remarks: For comparison of species within the genus *Semispathidium*, see remarks at *Semispathidium longiarmatum* (p. 328) and key to species. For discussion if *Semispathidium pulchrum* and *Semispathidium fraterculum* are geographic vicariants, see Foissner et al. (2010, p. 72).

Description: For brief characterization, see diagnosis above; for detailed description, see Foissner et al. (2010, p. 67).

Occurrence and ecology: *Semispathidium pulchrum* is so far recorded only from two sites. The type locality is the upper mud and soil layer of a shallow, ephemeral meadow puddle (Krauthügel pond; 47.9205°N 13.04480°E) in the surroundings of the “Krautwächterhäusel” (often incorrectly designated as “Henkerhaus” [house of the hangman])¹¹ near the centre of the town of Salzburg, Austria (Foissner et al. 2010, p. 67); for details on this pond, see Cotterill et al. (2013). Foissner et al. (2010) found *Semispathidium pulchrum* also in Upper Austria, i.e., in the surroundings of the village of Kefermarkt (about N48.442° E14.537°). Both records are from ephemeral habitats, i.e., from mud and soil collected from the ground of ephemeral meadow pools, indicating that it is a limnetic species (Foissner et al. 2010, p. 72).

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¹⁰ Note by H. Berger: The difference in the number of paratype slides is perhaps due to the fact that the slide containing the holotype also contains paratype specimens, that is, there are six slides containing paratypes.

¹¹ Note by H. Berger: For details, see “Krautwächterhäusel” at <https://www.sn.at/wiki/Krautwächterhäusel> (accessed 9 Aug 2023).

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Index

Systematic index

The index contains all ciliate names mentioned in the book, including vernacular names for example, haptorids. Designations as, for example, “haptorid ciliates” are mentioned under the corresponding vernacular name, that is, “haptorids” in present example. Names in singular (e.g., haptorid) are mentioned under the plural version (e.g., haptorids). The index is two-sided, that is, species appear both with the genus-group name first (for example, *Apospathidium atypicum*) and with the species-group name first (*atypicum*, *Apospathidium*). Valid (mainly in W. Foissner’s judgement) species and genera treated in detail are in boldface italics print. Valid taxa not treated in detail in the present book, invalid taxa, junior homonyms, synonyms, outdated combinations, incorrect spellings, and nomina nuda are not in bold. Suprageneric taxa are represented in normal type, valid ones treated in detail in the present work in boldface. A boldface page number indicates the beginning of the description of a valid taxon. “T” indicates the location of the table with the morphometric characterisation; “K” marks a key (e.g., of the genus *Apospathidium*) and the page where a taxon is mentioned in a key. The names on the slide figures and the names of the subchapter “Summary of nomenclatural acts and taxa described in Chapters 1–13” (see Chapter 1, pp. 18–20) are not included.

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