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Redescription of the marine ciliate *Cardiostomatella vermiforme* (Kahl, 1928) Corliss, 1960

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Summary

Cardiostomatella vermiforme, a large-sized loxocephalid ciliate, was found in the mesopsammon of the Saudi coast of the Red Sea at Jeddah, a biotope very similar to that, where Kahl (1928) discovered the type population. The morphology and infraciliature of *C. vermiforme* were studied in live and protargol-impregnated cells. The morphologic and morphometric data largely agree with the original description.

Key Words: marine ciliates, morphology, infraciliature, *Cardiostomatella vermiforme*

Introduction

The genus *Cardiostoma* of the family Loxocephalidae Jankowski (1964) was erected by Kahl (1928) to accommodate the new species *C. vermiforme* from the northern coast of Germany near Oldesloer. Later, Corliss (1960) renamed the genus to the current *Cardiostomatella* and agreed with Kahl's opinion that it contained only a single species. Subsequently, three more species were discovered; *C. mononucleata* (Dragesco, 1963), *C. minuta* (Dragesco, 1965) and *C. chesapeakensis* (Small and Lynn, 1985). However, several authors reported the most common species, *C. vermiforme* from various marine habitats, although, with many confusing morphological variations, which led one of the recent studies to suggest that all *Cardiostomatella*s should be combined into a single type species; *C. vermiforme* (Fenchel et al. 1995).

Cardiostomatella vermiforme has been investigated and described by several workers (Borror, 1963; Hartwig, 1980; Ricci et al. 1982; Fenchel et al. 1995). However, most redescriptions added little, if any, to Kahl's detailed original description. Thus, a complete redescription with copious figure documentation is provided in the present study, which should assist in future revision of the genus.

Material and Methods

Cardiostomatella vermiforme were collected from the mesopsammon (the upper few centimeters of submerged sand layer) of the Saudi coast of the Red Sea near Jeddah City (39º 11' E, 21º 30' N). The interstitial water had a pH of 8.2 and a salinity of 32 ‰. Samples were collected and treated as described by Fauré-Fremiet (1951). Attempts to establish pure cultures failed, but *C. vermiforme* could be maintained for weeks in the sampling jars. Specimens of various stages of division were occasionally observed in field samples only. Cells were studied in vivo using a high-power oil immersion objective, bright and dark field (Foissner 1991). The infraciliature was revealed by protargol impregnation (Wilbert 1975). Counts and measurements on non-dividing silvered specimens were performed at a magnification of x 1000. In vivo measurements were performed at magnifications of x 100–1000. Drawings were made with a camera lucida. Terminology is according to Corliss (1979).

Results and Discussion

Specimens investigated and type material

Redescription is based on 30 well-impregnated specimens; some others were of usable quality and served for completing morphometry. No type material from *C. vermiforme* has been mentioned in the literature. Thus, three neotype slides with protargol-impregnated cells have been deposited in the Zoological Museum, Zoology Department, College of Science, King Saud University, Riyadh.

Redescription

Morphometric and morphologic data of *C. vermiforme* are summarized in Table 1 and shown in Figs 1–16. Present data is compared with those reported earlier for *C.*

Table 1. Morphometric characteristics of *Cardiostomatella vermiforme* (data based on randomly selected protargol-impregnated specimens)

Character	x	M	SD	SE	Min	Max	CV	n
Length	228.2	224	52.4	12.7	140.4	301.6	22.9	30
Width	73.4	67.6	21.3	5.1	41.6	115	29.0	30
Macronuclei No.	10.2	10	2.1	0.47	7	14	20.5	75
Macronuclei diameter	10.3	10.5	0.8	0.2	8.9	12.1	7.7	15
Micronuclei No.	6.6	7.0	1.3	0.3	5	9	19.7	75
Micronuclei diameter	3.4	3.7	0.4	0.12	2.6	4.2	11.7	30
Trichocyst length	1.4	1.5	0.2	0.1	1.0	1.6	14.3	60
Somatic kineties No.	100.2	99.5	5.9	1.32	89	109	5.8	30

CV – coefficient of variation in %, M – median, Max – maximum, Min – minimum, n – number of individuals investigated, SD – standard deviation, SE – standard error of the mean, x – arithmetic mean; measurements are in µm.

vermiforme and other species by various authors (Table 2). The redescription is based the present investigation and literature data mentioned in Table 2.

Size highly variable, 90–510 x 41–117 µm, usually 150–300 x 50–100 µm. Body circular in cross-section, broadly rounded at both ends, almost parallel-sided or slightly tapering posteriorly. Anterior region distinctively darkened with endoplasmic granules, 2.5–3.5 µm in diameter, hyaline posteriorly. Pellicle filled with numerous trichocysts, 0.5–1.2 µm long. The shape and mode of locomotion of the ciliate superficially resembles that of *Paramecium*. Contractile vacuole posteriorly located, with a collecting canal. Food vacuoles many, each measured 10–15 µm in diameter.

There are about 90–115, usually 110 somatic kineties, 2–4 µm apart at equator. Cilia about 3–5 µm long. At posterior pole, cilia elongate to form a tuft of caudal cilia.

A preoral suture arises from the disposition of the anterior somatic kineties. It extends from the mouth up to the dorsal surface at the anterior end. The right ventral somatic kineties insert on the preoral suture. There are four to six postoral kineties.

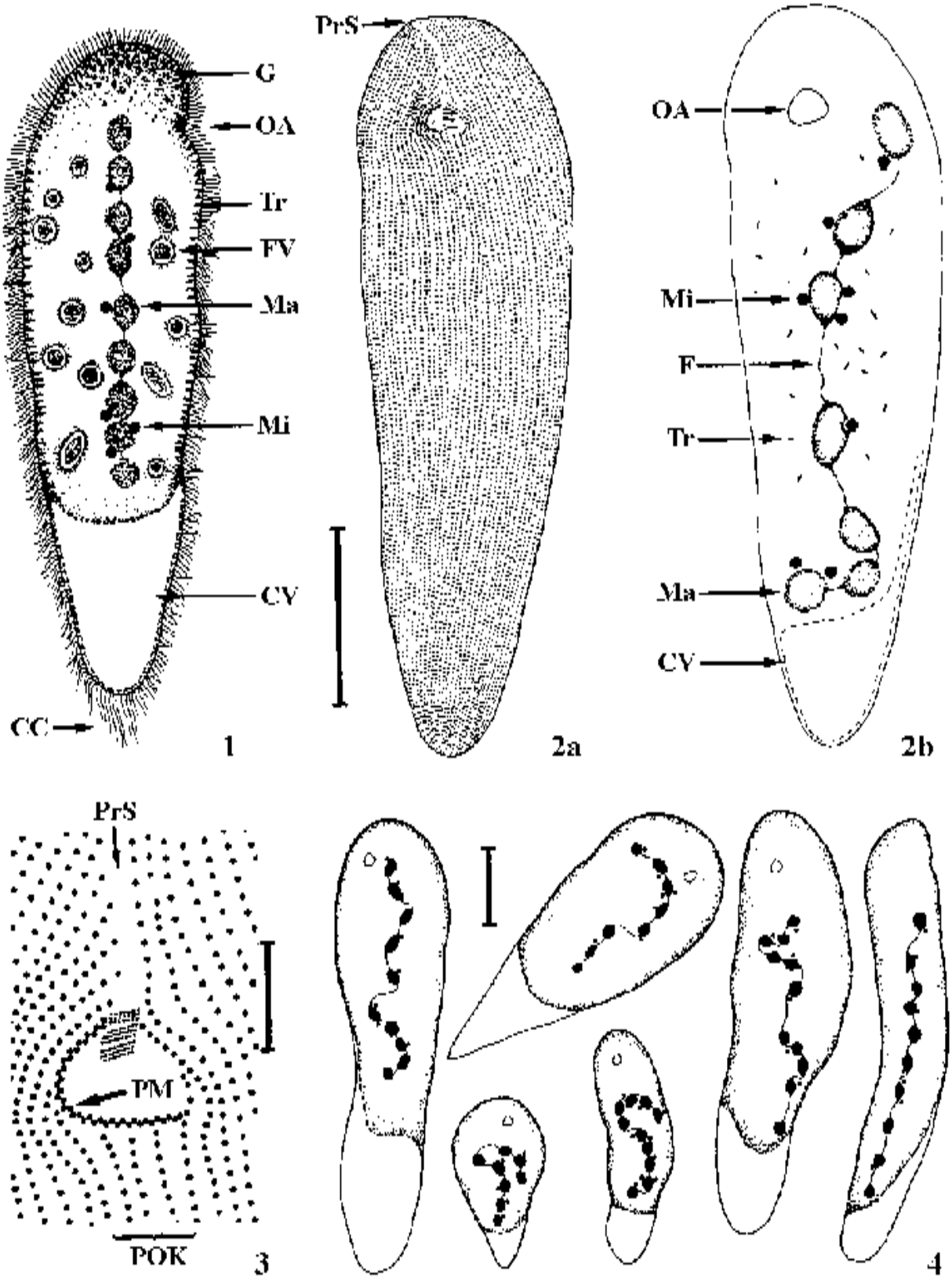
Oral apparatus rounded to inverted hart-shape, 9–12 µm in diameter, about 1/10 from anterior end, equipped with paroral membrane on the right side, which has 38–44 paired kinetosmes in zigzag-formation. There are three oral polykinetid membranelles inside the oral cavity; membranelle 1 is situated at the same level as the beginning of the paroral membrane; membranelle 2 lies parallel to membranelle 1; membranelle 3 is placed behind membranelles 1 and 2 and oriented slightly obliquely to them. Each membranelle is formed by three parallel rows of kinetosomes, each of which has 7–9 kinetosomes.

There are 4–18, usually 10 beads of macronuclei in a single strand, each two connected by a thread (funiculus), variable in shape and number, ranging from almost ovoid to spherical, about 15 µm in diameter. Micronuclei spherical, 2–11, usually 8 in number, 3–4 µm in diameter, closely arranged around the macronuclei.

Occurrence and ecology

There are about 20 records of *C. vermiforme* in the literature, indicating that it has a world-wide distribution. Some details on the ecology of *C. vermiforme* have also

Figs 1–4. Schematic drawings of *Cardiostomatella vermiforme* from life (**1**) and after protargol impregnation (**2–4**): **1** – right lateral view showing the general appearance, many food vacuoles and the terminal contractile vacuole; **2a** – infraciliature of ventral sides showing preoral suture starts from the oral apparatus; **2b** – details of the position of oral apparatus, the strand of macronuclei, micronuclei, trichocysts and the terminal contractile vacuole; **3** – details of the structure of paroral membrane, the three oral membranelles, postoral kineties and the preoral suture; **4** – variations in size and shape. CC – caudal cilia, CV – contractile vacuole, F – funiculus, FV – food vacuoles, G – granules, Ma – macronucleus, Mi – micronucleus, OA – oral apparatus, PM – paroral membrane, POK – postoral kineties, PrS – preoral suture, Tr – trichocysts. Scale bars: 50 µm for 1, 2a,b, 4 and 10 µm for 3. ➢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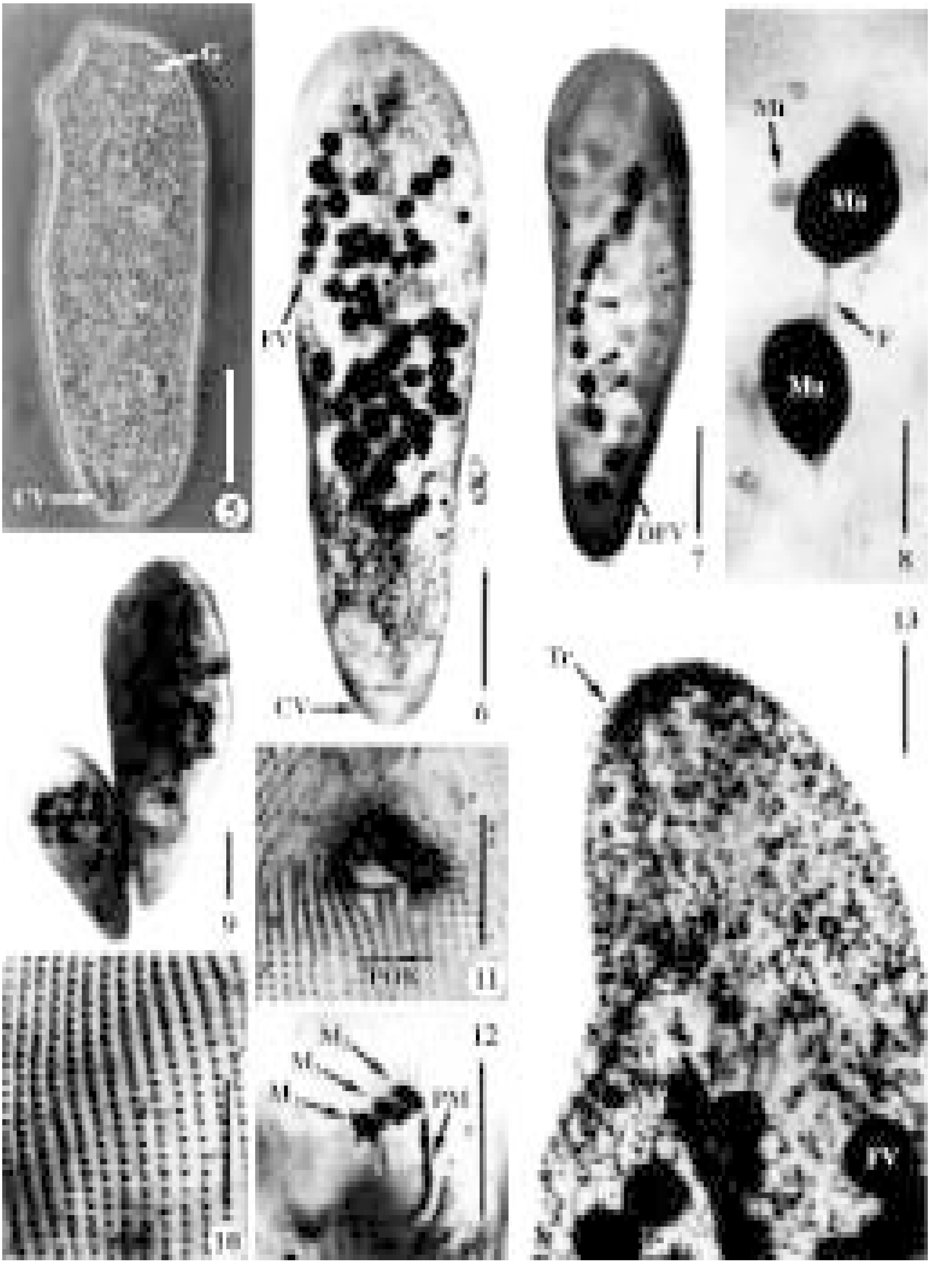
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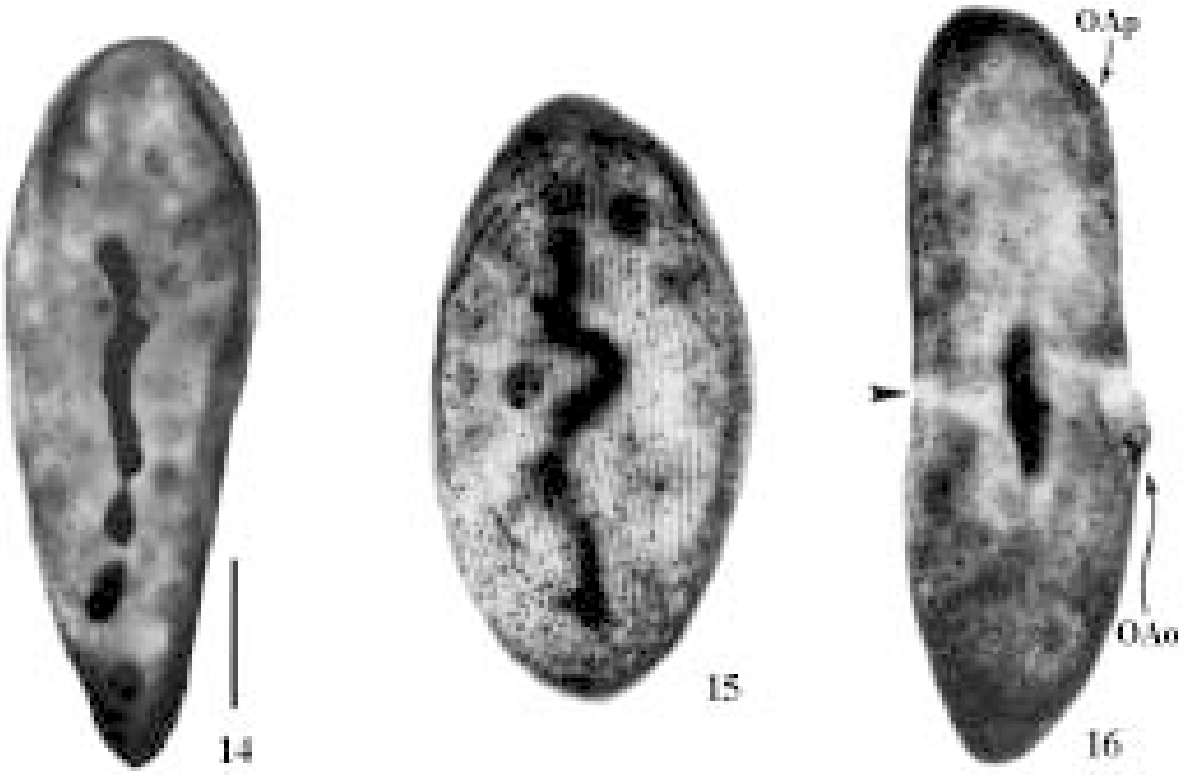

Figs 14–16. *C. vermiforme* after protargol impregnation: **14** – lateral view of an early dividing cell: macronuclei are starting to aggregate together; **15** – middle divider: macronuclei are in a filiform-shape and the cell transforms into a distinct ovoid shape; **16** – late divider: macronuclei are already fused into ellipsoidal mass just before division, the newly formed oral apparatus of the opisthe with the three oral membranelles and the paroral membrane (arrowhead marks the division furrow). OAo- oral apparatus of the opisthe, OAp- oral apparatus of the proter. Scale bar: 50 μm.

been reported, mainly by Fenchel (1969) and Fenchel et al. (1995). Kahl (1928) supposed that *C. vermiforme* possibly occurs in the mesopsammon and in saline waters. Fenchel et al. (1995) confirmed that *C. vermiforme* could be found only in aerobic environments.

C. vermiforme feeds on small diatoms, algae and bacteria. Similar feeding spectrum was recorded by Fenchel (1969) and Fenchel et al. (1995). Nearly all newly-formed food vacuoles were about 10–15 μm in diameter, almost equal to the diameter of the oral apparatus. This could explain why no large diatoms could be observed inside the cell. Old food vacuoles which already contain digested food were much larger in size and its food materials were indistinguishable.

Dividing specimens

As mentioned earlier, several stages of dividing *C. vermiforme* specimens were observed in field material (Figs 14–16). No further attempts were made at the present study to follow the morphogenesis process, but it was documented for further studies.

Comparison with other species

The available data of the other three known species of *Cardiostomatella* are presented in Table 2. Despite the fact that the infraciliature and many morphometric data are lacking for *C. mononucleata*; *C. minuta* and *C. chesapeakensis*, it is obvious that those authors (Dragesco, Small and Lynn) observed many differences between those species and *C. vermiforme*, in key struc-

Figs 5–13. *C. vermiforme* from life (**5**) and after protargol impregnation (**6–13**): **5** – right lateral view of a slightly compressed organism showing the general appearance, endoplasmic granules and the terminal contractile vacuole; **6** – infraciliature of ventral side; **7** – nuclear apparatus (arrowheads mark micronuclei) and digested food vacuole (arrow); **8** – part of the nuclear apparatus: two of the macronuclei connected by funiculus and a micronucleus; **9** – two cells highly variable in size; **10** – view of somatic infraciliature; **11** – the inverted hart-shaped oral apparatus and the postoral kineties; **12** – isolated oral apparatus showing the three oral membranelles and the paroral membrane; **13** – the numerous trichocysts distributed all over the cell. CV – contractile vacuole, DFV – digested food vacuole, F – funiculus, FV – food vacuole, G – granules, M1 – M3 – oral membranelles, Ma – macronucleus, Mi – micronucleus, PM – paroral membrane, POK – postoral kineties, Tr – trichocysts. Scale bars: 50 μm for 5–7, 9, 15 μm for. 8, 10, 11, 13 and 10 μm for 12.

Table 2. Comparison of morphometric data of *Cardiostomatella vermiforme* populations and other species of *Cardiostomatella*

Author	Length µm	Width µm	Macro-nuclei No.	Micro-nuclei No.	Somatic kineties No.
Khal, 1928 [1)]	200–350	?	5–8	5–8	?
Borror, 1963	350–450	70–117	10	?	>150
Hartwig 1973 [1)]	200–510	?	6–8	?	?
Czapik and Jordan, 1977	200–300	?	5–7	?	50
Hartwig, 1980 [1)]	120–320	?	10–16	?	?
Ricci et al., 1982 [1)]	380	60	15–17	?	50
Fenchel et al., 1995	300–500	?	1–2	1–>8	100–110
Dragesco (unpublished data, 1994–1999)	90–305 (n=36)	42–110 (n=36)	4–18 (n=61)	2–11 (n=18)	90–112 (n=11)
present study	140–301 (n=30)	41–115 (n=30)	7–14 (n=75)	5–9 (n=75)	89–109 (n=30)
C. mononucleata Dragesco, 1963 [1)]	300	~70 [2)]	1	?	?
C. minuta Dragesco, 1965 [1)]	75	~25 [2)]	1	?	32
C. chesapeakensis Small and Lynn, 1985	~150 [2)]	~70 [2)]	2	~9 [2)]	~70 [2)]

[1)] Possibly in vivo or not definitely stated so.
[2)] Data extracted from the author's drawings.

tures, such as somatic kineties and macronuclei numbers. Therefore, the suggestion of Fenchel et al. (1995) of recombining all species of *Cardiostomatella*s into a single species should be dealt carefully until further detail studies on other species of *Cardiostomatella* were made.

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