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* 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)

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

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.

*Cardiostomatella 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 kinetosomes 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

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

<table>
<thead>
<tr>
<th>Author</th>
<th>Length µm</th>
<th>Width µm</th>
<th>Macro-nuclei No.</th>
<th>Micro-nuclei No.</th>
<th>Somatic kinetics No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khal, 1928 1)</td>
<td>200–350</td>
<td>?</td>
<td>5–8</td>
<td>5–8</td>
<td>?</td>
</tr>
<tr>
<td>Borror, 1963</td>
<td>350–450</td>
<td>70–117</td>
<td>10</td>
<td>?</td>
<td>&gt;150</td>
</tr>
<tr>
<td>Hartwig, 1980 1)</td>
<td>120–320</td>
<td>?</td>
<td>10–16</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Ricci et al., 1982 1)</td>
<td>380</td>
<td>60</td>
<td>15–17</td>
<td>?</td>
<td>50</td>
</tr>
<tr>
<td>Dragesco et al., 1995</td>
<td>300–500</td>
<td>?</td>
<td>1–2</td>
<td>1–&gt;8</td>
<td>100–110</td>
</tr>
<tr>
<td>Dragesco (unpublished data, 1994–1999)</td>
<td>90–305 (n=36)</td>
<td>42–110 (n=36)</td>
<td>4–18 (n=61)</td>
<td>2–11 (n=18)</td>
<td>90–112 (n=11)</td>
</tr>
<tr>
<td>present study</td>
<td>140–301 (n=30)</td>
<td>41–115 (n=30)</td>
<td>7–14 (n=75)</td>
<td>5–9 (n=75)</td>
<td>89–109 (n=30)</td>
</tr>
<tr>
<td>C. mononucleata</td>
<td>300</td>
<td>~70 2)</td>
<td>1</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Dragesco, 1963 1)</td>
<td>75</td>
<td>~25 2)</td>
<td>1</td>
<td>?</td>
<td>32</td>
</tr>
<tr>
<td>C. minuta</td>
<td>~150 2)</td>
<td>~70 2)</td>
<td>2</td>
<td>~9 2)</td>
<td>~70 2)</td>
</tr>
</tbody>
</table>

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

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

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