Morphological description of three marine ciliates (Ciliophora, Scuticociliatia), with establishment of a new genus and two new species

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Abstract

Three marine scuticociliates, \textit{Falcicyclidium fangi} nov. gen., nov. spec., \textit{Falcicyclidium atractodes} nov. spec., and \textit{Cristigera media} Kahl, 1928 were investigated using live observation and silver impregnation methods. The genus \textit{Falcicyclidium} is distinguished by the combination of: (i) dorsoventrally flattened body, (ii) hook-like (falciform) paroral membrane, (iii) anterior end of paroral membrane posterior to anterior end of membranelle 1, and (iv) multiple caudal cilia. \textit{Falcicyclidium fangi} nov. spec., the type of the new genus, can be recognized by the combination of its large size, extremely dorsoventrally flattened (3:1) body, consistently 10 somatic kineties, and the broad, elongate buccal area occupying 60% of the body length. \textit{Falcicyclidium atractodes} nov. spec. is mainly characterized by a unique spine projecting from both the anterior and posterior end. The uncommon form, \textit{Cristigera media} is redescribed based on the population from Qingdao, the statistic data and additional features, especially the morphology of the living cells, are documented.

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Keywords: \textit{Cristigera}; \textit{Cyclidium}; \textit{Falcicyclidium}; Infraciliature; New taxa; Taxonomy

Introduction

The ciliates in the subclass Scuticociliatia Small, 1967 are common, free-living members of limnetic and marine ecosystems as well as symbionts of some aquatic animals. Several recent studies demonstrate that the entire diversity of this group is still far from being described (e.g., Fan et al. 2009, 2010; Foissner et al. 2009; Gao et al. 2010; Guggiari and Peck 2008; Miao et al. 2009, 2010; Pan et al. 2010; Wang et al. 2009a,b).

The family Cyclidiidae Ehrenberg, 1838 comprises several genera (e.g., \textit{Apocyclidium} Foissner et al., 2002; \textit{Protocyclidium} Alekperov, 1993) with close morphological similarities to \textit{Cyclidium} Müller, 1773. All cyclidiids share a generally similar pattern of infraciliature with \textit{Cyclidium} but, at the same time, exhibit some substantive differences (Alekperov 1993; Foissner et al. 2002; Small and Lynn 1985). Therefore, care should be taken in description of new species and with acceptance of those species of \textit{Cyclidium} that never have been redescribed (Borror 1963, 1965; Dragesco 1963; Kahl 1931, 1935; Vuxanovici 1962; Wenzel 1962; Wilbert 1986; Yagi 1933). Morphological characters that have been employed in the investigation of this complicated group include shape of the body, especially the ratio of length to width and degree of dorsoventral flattening; size of the buccal field of oral
infraciliature relative to the entire body; infraciliature of the
buccal apparatus; number of caudal cilia and somatic kineties;
and number of kinetids in each somatic kinety (especially in
somatic kineties 1 and n) (Borror 1963, 1965; Dragesco 1963;
Song 2000; Song and Wilbert 2000, 2002; Vuxanovici 1962;
Wenzel 1962; Yagiu 1933).

The genus Cristigera Roux, 1899 is characterized by a
longitudinal, ventral groove in its body and was reduced to
12 species through having three species synonymized by
Esteban and Olmo (1997). As far as is known, most species
in the genus are freshwater forms, and only three species
have been described in any detail (Esteban and Olmo 1997;

Faunistic surveys of ciliates in intertidal sandy areas in
the vicinity of Qingdao, China yielded samples of three
cyclidiids. Investigation of the morphology of living cells
and infraciliature after silver staining revealed that they
represent two undescribed species of Falcicyclidium nov.
gen. and the poorly known species Cristigera media Kahl,
1928.

Material and Methods

Falcicyclidium atractodes nov. spec. was collected on 11
June 2008 from the surface of sandy littoral sediments of the
Bathing Beach No. 1 (water temperature 13 ˚C, salinity 28‰)
in Qingdao, China (36°3′25′′N; 120°20′10′′E). Falcicyclid-
ium fangii nov. spec. and Cristigera media were collected on
30 October 2008 from the same sediments at the same locality
(water temperature 17 ˚C, salinity 29‰).
Sand and seawater were taken from the top 5 cm of the sediment. Cells were isolated and observed in vivo using differential interference contrast microscopy. Staining with protargol (Wilbert 1975) and Chatton–Lwoff wet silver–nitrate (Song and Wilbert 1995) methods was done to reveal the infraciliature and argyrome (silverline pattern). Drawings of stained specimens were made with the help of a camera lucida. Measurements were made under 100–1250× magnification. Classification and terminology follow Lynn (2008).

Results and Discussion

Subclass Scuticociliatia Small, 1967
Family Cyclidiidae Ehrenberg, 1838
Falcicyclidium nov. gen.

Diagnosis: Cylidium-like pattern of ciliation; anterior end of paroral membrane posterior to anterior end of membranelle 1, posterior end of paroral membrane distinctly curved into a hook. Body strongly flattened dorsoventrally, with multiple caudal cilia. Ciliary rows straight and unbroken, consisting of closely spaced dikinetids in anterior sections and more widely spaced monokinetids toward the posterior.

Etymology: The Latin prefix Falc- (from genitive singular of falx; sickle), refers to the falciform shape of the paroral membrane, one of the more visible differences between Falcicyclidium and Cyclidium.

Type species: Falcicyclidium fangi nov. spec.

Comparison with closely related genera: Falcicyclidium differs from Apocyclidium Foissner et al., 2002 mainly by having straight vs. twisted ciliary rows. It differs from Pseudocyclidium Small and Lynn, 1985 in the arrangement and type of kinetids in somatic kineties (dikinetids closely spaced in anterior part and monokinetids more widely spaced posteriorly vs. dikinetids evenly distributed within all somatic kineties) (Foissner et al. 2002; Small and Lynn 1985). Protocyclidium Alekperov, 1993 can be distinguished clearly from the new genus by its pattern of oral membranelles (membranelles 2 and 3 barely separated and forming a ciliary field composed of almost equidistant, transversely oriented
Fig. 3. *Falcicyclidium atractodes* nov. spec. in vivo (A–E) and after staining with protargol (F–H). (A) Ventral view of a typical individual; arrowheads indicate the caudal cilia. (B) Different individuals showing variation in shape. (C) Left lateral view. (D) An individual turned slightly to the side. (E) Anterior part of cell; arrowheads indicate the sites of indentations in the pellicle, and the double-arrowhead marks the spine at the anterior pole; arrow indicates the triangular shield overhanging the buccal field. (F, G) Ventral (F) and dorsal (G) view of the holotype specimen; arrow in F indicates the anterior spine, arrowhead indicates the shorter somatic kinety \( n \), and the two parts of the scutica are circled; arrow in (G) marks the macronucleus and the double-arrowhead indicates the posterior spine. (H) Detail of oral infraciliature; arrow marks the origin of the paroral membrane near membranelle 1. DP, discharge pore; M1–3, membranelles 1–3; PM, paroral membrane; Sc, scutica; SK1, \( n \), somatic kineties 1, \( n \). Scale bars = 20 \( \mu \)m.

rectangles increasing in width from anterior to posterior vs. membranelles 2 and 3 distinctly separated and composed of irregular groups of kinetosomes) (Alekperov 1993; Foissner et al. 2002).

*Cyclidium* is a confusing and ill-defined genus, but the type species, *C. glaucoma*, and other unquestioned morphospecies in the genus differ from *Falcicyclidium* by having a rounded, unflattened body together with a single caudal cilium and L-shaped paroral membrane beginning anteriorly at about the same point as membranelle 1 (Foissner et al. 1994; Guggiari and Peck 2008; Song 2000; Wilbert 1986) vs. a dorsoventrally flattened body with multiple caudal cilia and hook-like (falciform) paroral membrane beginning anteriorly posterior to the anterior end of membranelle 1 (Fig. 5A–D).

Searching the literature of *Cyclidium* species, revealed *C. plouneouri* Dragesco, 1963 and *C. borrori* Small and Lynn, 1985 to be potential members of *Falcicyclidium* because they show the two distinctive features of its paroral membrane, (1) the hook-like posterior end, and (2) the posterior placement of its anterior end relative to that of membranelle 1 (Fig. 5E, G). However, these two species cannot be assigned to *Falcicyclidium* with confidence until the degree to which the body is flattened and the number of caudal cilia are known. Wilbert (1986) also described a population of *C. plouneouri* from Lake Ontario. We think that this might be a misidentification because the ratio of the length of its buccal field to length of the body was only 1.2 vs. 2.3 to 3.4, and it had fewer somatic kineties (11–12 vs. 14–16) than reported in the original description. Instead, this population may represent yet another possible member of *Falcicyclidium* (Fig. 5F; Wilbert 1986).

**Falcicyclidium fangi** nov. spec. (Figs 1A–H, 2A–M, 5A, B; Table 1)

**Diagnosis:** Marine *Falcicyclidium*. Body measuring approximately 50 \( \mu \)m \( \times \) 20 \( \mu \)m in vivo, oval in outline, dorsoventrally flattened about 3:1. Buccal area comprising
Fig. 4. *Falcicyclidium atractodes* nov. spec. in vivo (A–I), and after staining with silver nitrate (J, K) and protargol (L). (A, B) Ventral view of two typical individuals. (C, D) Two individuals turned slightly to the side; arrowheads indicate the caudal cilia, and arrow marks the anterior spine. (E) Left lateral view; arrow and arrowhead indicate the anterior and posterior spine, respectively. (F) Anterior part of cell, with spine indicated by the arrow. (G) Posterior part of cell, with spine indicated by the arrow. (H) Arrow marks the posterior spine, and arrowhead indicates the triangular shield over the cytostome. (I) Ventral view; arrowhead indicates the discharge pore, and the arrow marks the posterior end of the paroral membrane. (J) Oral infraciliature; arrowhead, double-arrowhead, and arrow indicate membranelles 1–3, respectively. (L) Ventral view showing location of macronucleus in the anterior half of the body. Ma, macronucleus. Scale bars = 20 μm.

60% of length of body. Contractile vacuole sub-terminal, discharge pore posterior to kinety *n*. Six elongate caudal cilia and 10 somatic kineties.

**Type locality**: Bathing Beach No. 1, Qingdao, China (36°3′25″N; 120°20′10″E).

**Etymology and dedication**: The species is named in honor of our eminent colleague, Prof. Jingyun Fang of Beijing University, in recognition of his significant contributions to the field of ecology.

**Deposition of slides**: A protargol preparation (registry number FXP-2008-1030-03) has been deposited as the holotype slide in the collection of the Laboratory of Protozoology, OUC, China. The specimen shown in Fig. 1G, H is marked as the holotype. Another protargol preparation (registry number 2010:11:6:1) has been deposited as a paratype slide in the collection of the Natural History Museum, UK (NHMUK).

**Description**: Living cell measuring approximately 45–60 μm × 15–25 μm, oval in outline, dorsoventrally flattened, with ratio of 3:1, possessing a small, truncated, apical frontal plate (Figs 1A, B, 2A–D). Buccal area elongate, extending for approximately 60% of body length. Surface of cell slightly ridged. Cytoplasm colorless and hyaline, always with many small granules (Fig. 2F). Contractile vacuole subterminally located (nearer end of cell in a few specimens), slightly to distinctly left of midline, dilating to approximately 10 μm in diameter (Figs 1A, B, 2E, G). Macronucleus an irregular sphere (after fixation) measuring 8–10 μm in diameter; located in anterior portion of cell (Figs 1F–H, 2M). Extrusomes conspicuous, bar-shaped, approximately 5 μm long (Figs 1E, 2H). Somatic cilia approximately 10 μm long; paroral membrane well-developed, with cilia measuring approximately 25 μm in length. Usually six caudal cilia, 25–30 μm long; the one at the posterior extrem-
Table 1. Morphometric characterization of *Falcicyclidium fangi* nov. spec. (upper line in each group of values), *Falcicyclidium atractodes* nov. spec. (middle line), and *Cristigera media* Kahl, 1928 (lower line).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>CV</th>
<th>n</th>
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<tr>
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<td>57</td>
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<td>11.0</td>
<td>23</td>
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<tr>
<td>Width of body</td>
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<td>25</td>
<td>22.0</td>
<td>2.6</td>
<td>11.8</td>
<td>23</td>
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<tr>
<td>Length of buccal area</td>
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<td>34</td>
<td>30.7</td>
<td>1.9</td>
<td>6.3</td>
<td>23</td>
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<tr>
<td>Number of somatic kineties</td>
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<td>10</td>
<td>10.0</td>
<td>0.0</td>
<td>0.0</td>
<td>23</td>
</tr>
<tr>
<td>Number of kinetids in SK1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>32</td>
<td>38</td>
<td>34.8</td>
<td>2.3</td>
<td>6.5</td>
<td>8</td>
</tr>
<tr>
<td>Number of kinetids in SKn&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>24</td>
<td>21.8</td>
<td>1.4</td>
<td>6.4</td>
<td>13</td>
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<td>Length of macronucleus</td>
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<td>10</td>
<td>8.0</td>
<td>1.1</td>
<td>13.9</td>
<td>23</td>
</tr>
<tr>
<td>Width of macronucleus</td>
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<td>9</td>
<td>6.3</td>
<td>1.3</td>
<td>20.0</td>
<td>23</td>
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<sup>a</sup>Data from observations of protargol-stained specimens. Measurements in μm. Abbreviations: CV, coefficient of variation in %; Max, maximum; Mean, arithmetic mean; Min, minimum; n, number of specimens investigated; SD, standard deviation; SK1, n, somatic kineties 1, n; –, data unavailable.

<sup>b</sup>Dikinetids accounted as single kinetal units.

Locomotion consists of swimming moderately fast and rotating around main axis of body, often remaining suspended motionless for a long time with lateral side of cell uppermost, somatic cilia stiffened, and paroral membrane spread out.

Somatic kineties always 10 in number, each with closely spaced dikinetids in its anterior third and more widely spaced monokinetids posteriorly (Fig. 1G, H). Somatic kinety 1 comprising approximately 35 kinetids. Anterior end of paroral membrane moderately far from the apical plate and forming a long, compressed hook at its posterior end (Figs 1G, 2I). Somatic kinety n distinctly shorter than the others, ending posteriorly at the level of the posterior “hook” of the paroral membrane. Three tightly packed oral membranelles occupying the anterior third of the buccal field; membranelle 1 consisting of 6–8 polykinetids formed of three kinetosomes each; membranelle 2 irregular in shape with several kinetal fragments; membranelle 3 small and composed of approximately 10 kinetosomes. Scutica composed of approximately six kinetosomes, located left of posterior end of paroral membrane (Figs 1C, G, 2L).

Argyrome composed of rectangular meshes; seven oral ribs converge on the cytostome; contractile vacuole discharge pore located near posterior end of somatic kinety n (Fig. 1C, D).

**Remarks and comparison:** *Cyclidium* resembles the new genus and includes many uncertain species; thus, a comparison should be made between *Falcicyclidium fangi* and some species of *Cyclidium*. Among those species of *Cyclidium* whose infraciliatures are still undescribed, *C. pellucidum* Kahl, 1931 and *C. heptatrichum* Schewiakoff, 1893 have a body shape, ratio of length to width (approximately 2.5:1), and an elongate buccal area (about 60% of body length) that resemble those of *F. fangi*. However, *F. fangi* differs from *C. pellucidum* by having multiple caudal cilia (vs. one) and a marine (vs. freshwater) habitat. It also can be easily separated from *C. heptatrichum* by its larger body size (approximately 50 μm long vs. 25 μm) and marine (vs. freshwater) habitat (Foissner et al. 1994; Kahl 1931).

Regarding its infraciliature, *F. fangi* should be compared with *C. glaucoma* Müller, 1786, *C. plouneouri* Dragesco, 1963, *C. setiger* Wilbert, 1986 and *C. borrori* Small and Lynn, 1985 (Borror 1965; Dragesco 1963; Song and Wilbert 2002; Wilbert 1986). *Cyclidium glaucoma*, the type species of *Cyclidium*, is very small (about 20 μm long) and has a single caudal cilium and an L-shaped paroral membrane; thus, it cannot be confused with *F. fangi* (Dragesco, 1986; Foissner et al. 1994; Song and Wilbert 2002). *Cyclidium plouneouri* is...
Diagnosis: Living cell measuring 40–50 μm × 18–22 μm, oval in outline with slender spines at anterior and posterior poles, dorsoventrally flattened 2:1. Pellicle slightly rigid. Buccal area extensive, comprising 60% of length and 50% of width of body. Contractile vacuole sub-terminal, discharge pore posterior to kinety n. Six elongate caudal cilia and 10 somatic kineties. Marine habitat.

Type locality: Bathing Beach No. 1 in Qingdao, China (36°3'25"N; 120°20'10"E).

Etymology: The species-group name attractodes (Greek, spindle-shaped) refers to the elongate, oval shape accentuated by the spines on the anterior and posterior poles of the body.

Deposition of slides: The protargol preparation (registry number FXP-2008-0611-01) has been deposited as the holotype slide in the collection of the Laboratory of Protozoology, OUC, China. The specimen shown in Fig. 3F, G is marked as the holotype. Another protargol preparation (registry number 2010:11:6:2) has been deposited as a paratype slide in the collection of the NHMUK.

Description: Living cell measuring 40–50 μm × 18–22 μm, with elongate oval outline, dorsoventrally flattened with ratio of 2:1. Pellicle slightly stiffened, with ridges running alongside somatic kineties (Figs 3E, 4F). Anterior pole with a cylindrical, obliquely truncate spine approximately 2 μm long (Figs 3A, E, F, 4C–F); posterior pole with a cylindrical spine measuring approximately 3 μm in length, slightly more slender than anterior spine, and with bluntly rounded tip (Figs 3A, G, 4G, H). Buccal area conspicuously large, comprising 60% of length and 50% of width of body; paroral membrane well developed, with cilia measuring 20–30 μm long when fully extended. Cytostome in center of buccal area, shielded by a triangular protrusion of the surface (Figs 3E, 4H, I). Cytoplasm often with many small granules (approximately 2 μm in diameter) concentrated in anterior part of body, middle part, or both (Fig. 3B). Extrusomes not seen. Contractile vacuole sub-terminal, dilating to approximately 8 μm in diameter. Macronucleus spherical, approximately 8 μm wide (Figs 3G, 4L), located in anterior part of body. Six caudal cilia, splayed outward while the cell is still, 20–25 μm long; one cilium slightly longer than the others and originating from the tip of the posterior spine. Locomotion as in F. fangi.

Somatic kineties always 10 in number, and seven of them (kineties 2 to n – 2) are composed of closely spaced dikinetids in their anterior third and more widely spaced monokinetids in the remaining part (Fig. 3G). Somatic kineties 1, n and n – 1 are composed of dikinetids in their anterior halves and monokinetids in their posterior halves (Fig. 3F). In a few specimens, dikinetids of somatic kineties n and n – 1 accounted for 2/3 of their length. Paroral membrane consisting of approximately 60 dikinetids, with posterior part curved sharply anteriad to form a hook. Membranelle 1 originating to the left of the anterior end of the paroral membrane, consisting of approximately eight polykinetids composed of
Fig. 6. *Cristigera media* Kahl, 1931 in vivo (A–D), and after staining with silver nitrate (E, H) and protargol (F, G). (A) Ventral view of a typical individual; arrowheads indicate the caudal cilia. (B) Left lateral view, arrow indicates the contractile vacuole. (C, D) Variation in size of the body and distribution of cytoplasmic granules. (E) Oral infraciliature; arrows mark the anterior and posterior ends of the paroral membrane, and arrowhead indicates oral ribs. (F, G) Ventral (F) and dorsal (G) views of the infraciliature; arrow in (F) indicates the curved posterior end of the paroral membrane; arrow and arrowhead in (G) mark the macronucleus and micronucleus, respectively. (H) Detail of the argyrome. Cs, cytostome; DP, discharge pore; Ex, extrusome; M1–3, membranelles 1–3; Sc, scutica. Scale bars = 25 μm.

three kinetosomes each. Membranelle 2 also consisting of a block of tripartite polykineties but with 5–10 irregularly arranged kinetosomes extending anteriad and posteriad from either end. Membranelle 3 small, consisting of an irregular, transversely oriented file of approximately 10 kinetosomes (Figs 3H, 4J, K). Scutica composed of 2–5 kinetosomes located near posterior end of paroral membrane. Contractile vacuole excretory pore below paroral membrane, near posterior end of somatic kinety n (Figs 3F, 4J). Silver nitrate preparations of insufficient quality to allow observation of argyrome.

**Remarks and comparison:** *Falciyclidium atractodes* can be separated from all known species in other genera of cyclidiids as well as from *F. fungi* by the prominent spines at the anterior and posterior poles of its body.

**Genus Cristigera Roux, 1899**

**The Qingdao population of Cristigera media** Kahl, 1931 (Figs 6A–H, 7A–O; Table 1)

Morphology in vivo and infraciliature of an American freshwater population of this species was briefly described by Wilbert (1986). We provide here a detailed description of a marine population from Qingdao.

**Deposition of slide:** One protargol preparation (registry number FXP-20081030-01) has been deposited as a voucher slide in the collection of the Laboratory of Protozoology, OUC, China.

**Description:** Living cell measuring 45–60 μm × 20–25 μm, elongate and elliptical in outline, with anterior end truncated; dorsoventrally flattened with length to width ratio of 2.5:1 (Figs 6A, B, 7B, C). Ventral side with large, medial, longitudinal groove (Figs 6A, 7D). Buccal area located in anterior half of groove and extending approximately to the midpoint of the cell. Cilia of paroral membrane approximately 30 μm long, lying flat in ventral groove when cell is motionless (Figs 6A, 7G). Pellicle with shallow indentations between alveoli (Fig. 7I). Cytoplasm transparent, often containing many granules with diameters of approximately 2 μm (Figs 6C, D, 7H). Contractile vacuole dilating to approximately 10 μm in diameter, sub-terminal on dorsal side (Figs 6B, 7A, B). Macronucleus spherical, approximately 10 μm in diameter, usually located...
Fig. 7. Photomicrographs of *Cristigera media* Kahl, 1931 in vivo (A–I), and after staining with protargol (J, K) and silver nitrate (L–O). (A, B) Ventral view of two typical individuals; arrows mark the contractile vacuole. (C) Left lateral view. (D) Dorsal view (seen from ventral) of a slender individual; arrows indicate the ventral, medial groove visible through the cytoplasm. (E) Ventral view of a typical individual with several caudal cilia (arrows). (F) Oral region of cell; arrows mark the paroral membrane. (G) Ventral view; arrows point to cilia of the paroral membrane lying down against the right half of the body. (H) Macronucleus and cytoplasmic granules (arrows). (I) Arrowheads indicate indentations in the pellicle; arrows indicate the edge of the ventral groove. (J) Oral infraciliature and anterior half of somatic kineties with closely spaced kinetids. (K) Macronucleus and micronucleus (arrow). (L) Oral ribs. (M, N) Membranelles 1 (arrow), 2 (arrowhead), and 3 (double-arrowhead). (O) Part of argyrome. Ma, macronucleus. Scale bars = 30 μm.

in posterior half of body (Figs 6G, 7H), accompanied by a small micronucleus (Fig. 7K). Somatic cilia approximately 10 μm long, more closely spaced in the anterior part of body than in the posterior. With six caudal cilia measuring 30 μm in length (Figs 6A, 7E).

Locomotion by rapid swimming while rotating around the longitudinal axis of the body, seldom remaining still, and when motionless, with ventral side uppermost.

Infraciliature as shown in Figs 6F, G, 7I. Somatic kineties numbering 14 or 15, each one composed of dikinetids in anterior half and monokinetids in posterior half. Somatic kinety 1 slightly shorter than the others (Fig. 6F, G). Paroral membrane composed of closely spaced dikinetids, extending from the anterior end of the body to its midpoint (Figs 6F, 7F). Membranelle 1 located posterior to anterior end of paroral membrane and comprising several irregular, obliquely
oriented polykinetids, each one of which consists of approximately six kinetosomes. Membranelle 2 located posterior to and near membranelle 1, consisting of a group of irregularly arranged kinetosomes. Membranelle 3 small and consisting of approximately eight kinetosomes in an irregular, transversely oriented line (Figs 6E, 7J, M, N). Scutica composed of approximately four kinetosomes located near posterior end of paroral membrane (Fig. 6F).

Argyrome comprising a rectangular mesh, with a kineto- some located in the left, anterior angle of each rectangle; six oral ribs present (Figs 6H, 7L, O). Pore of contractile vacuole located in the ventral groove of the body at approximately 75% of the distance to the posterior end (Fig. 6F).

**Remarks and comparison:** The original description of *Cristigera media* was made by Kahl (1931), based on a marine population and consisting mainly of the morphology of the living cell. Wilbert (1986) redescribed the species from a freshwater population collected in Ontario, Canada. The infraciliature, morphometric data, number of somatic kineties, and the number of kinetosomes in somatic kinety 1 of the marine population of *C. media* from Qingdao are similar to those of the freshwater population from Ontario. Furthermore, descriptions of both populations correspond well with the original description in Kahl (1931). Therefore, our identification and Wilbert’s are both strongly supported. The discrepancy in habitat of Ontario population may be evidence that *C. media* is euryhaline.

*Cristigera media* resembles *C. pleuronemoides* Roux, 1899 in shape and size of the body but can be distinguished clearly from it by having 14 or 15 somatic kineties (vs. 19–23 in the latter) and evenly spaced kinetids in somatic kineties (vs. kinetids clearly grouped into four regions within each kinety; Esteban and Olmo 1997).

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