

## Redescriptions of Three Cyrtophorid Ciliates from Marine Biofilm, with Establishment of a New Genus, *Wilbertella* nov. gen. (Ciliophora: Cyrtophorida: Lynchellidae)

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**Summary.** The morphology of live cells and the infraciliature of three marine cyrtophorid ciliates, *Chlamydonellopsis calkinsi* (Kahl, 1928) Blatterer *et* Foissner, 1990, *Chlamydonella pseudochilodon* (Deroux, 1970) Petz, Song *et* Wilbert, 1995 and *Chlamydonella derouxi* Song, 2003, collected from the coastal water off Qingdao, China, were investigated. An improved diagnosis of the little-known *C. calkinsi* is suggested: marine *Chlamydonellopsis* with asymmetrical oval body shape, 35-70 × 20-40 μm *in vivo*, two rows of club-shaped protuberances on ventral side; 15-18 somatic kineties; two contractile vacuoles diagonally positioned; 12-15 nematodesmal rods, two micronuclei. Based on the Qingdao populations and previous descriptions, redefined diagnoses of *C. pseudochilodon* and *C. derouxi* are also supplied. A new genus *Wilbertella* nov. gen. is suggested: Lynchellidae with a distinct blank zone in left posterior of cell; perioral kineties in flattened Y-shaped; left kineties distinctly shortened, right kineties extending to posterior end; no distinct gap between left and right ciliary field. Two nominal species are transferred into this new genus: *W. distyla* (Wilbert, 1971) nov. comb. [basonym: *Parachilodonella distyla* Wilbert, 1971] and *W. stricta* (Deroux, 1976) nov. comb. [basonym: *Chlamydonella stricta* Deroux, 1976].

**Key words:** *Chlamydonellopsis*, *Chlamydonella*, morphology and infraciliature, Lynchellidae, *Wilbertella* nov. gen.

### INTRODUCTION

Cyrtophorid ciliates are commonly found in aquatic biofilms or periphytons on a variety of immersed surfaces such as on stones (Cairns and Yongue 1968, Foissner *et al.* 1992), macrophytes (Baldock *et al.* 1983, Gismervik 2004) and artificial substrates (Deroux 1970, Gong *et al.* 2005a). In the 1970s, using glass

slides as artificial substrate and silver staining methods, Deroux investigated extensively more than 50 cyrtophorid species from French coast off the Atlantic, contributing greatly to the taxonomy and biogeography of these taxa (Deroux 1970, 1976).

More recently, during surveys of ciliate fauna of the Yellow Sea, north China, we isolated diverse cyrtophorids from marine biofilms. Many of these ciliates were found to be new or little known (Gong and Song 2003, 2004 a, b, c, 2006; Gong *et al.* 2002, 2003, 2005b). This paper describes three lynchellid species from the Jiaozhou Bay off Qingdao, and suggests a new genus, *Wilbertella* nov. gen.

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## MATERIALS AND METHODS

Glass slides as artificial substrate were submerged in the marine water at a depth of 1 m allowing microbial colonization. After 15 days' exposure, glass slides with developed biofilm were transported to a jar with seawater from the sample sites. Specimens were transferred with a micropipette and then maintained in the laboratory for about 4 days in Petri dishes with adding several rice grains to support microbial growth.

The populations of *Chlamydonellopsis calkinsi* (Kahl, 1928) Blatterer *et* Foissner, 1990 and *Chlamydonella derouxi* Song, 2003 were collected in August 2002, from an open abalone culturing pond near Qingdao. Isolation of *Chlamydonella pseudochilodon* (Deroux, 1970) Petz, Song *et* Wilbert, 1995 was made from a scallop farming water in the Jiaozhou Bay, Qingdao.

Live cells were observed with differential interference contrast microscopy and their infraciliature was revealed using the protargol impregnation method according to Wilbert (1975). The Chatton-Lwoff silver nitrate method was used to reveal the silverline system (Song and Wilbert 1995). Live individuals were examined and measured at 1,000 $\times$  magnification; counts, measurements and drawings of stained specimens were performed at 1,250 $\times$  with the aid of a camera lucida.

Terminology and taxonomic scheme are according to Deroux (1976), Gong *et al.* (2002) and Corliss (1979), respectively.

Protargol impregnated voucher slides of three species are deposited in the Laboratory of Protozoology, OUC, China, with the following registration numbers: *Chlamydonellopsis calkinsi*, G020810011; *Chlamydonella pseudochilodon*, G001122012; *Chlamydonella derouxi*, G03081031.

## RESULTS AND DISCUSSION

### Redescription of *Chlamydonellopsis calkinsi* (Kahl, 1928) Blatterer *et* Foissner, 1990 (Figs 1, 2; Tables 1, 2)

**Improved diagnosis.** Marine *Chlamydonellopsis* with asymmetrical oval body outline, size 35-70  $\times$  20-40  $\mu\text{m}$  *in vivo*; 15-18 somatic kineties, 12-15 nematodesmal rods; two contractile vacuoles diagonally positioned; two rows of club-shaped protuberances on ventral surface; two micronuclei.

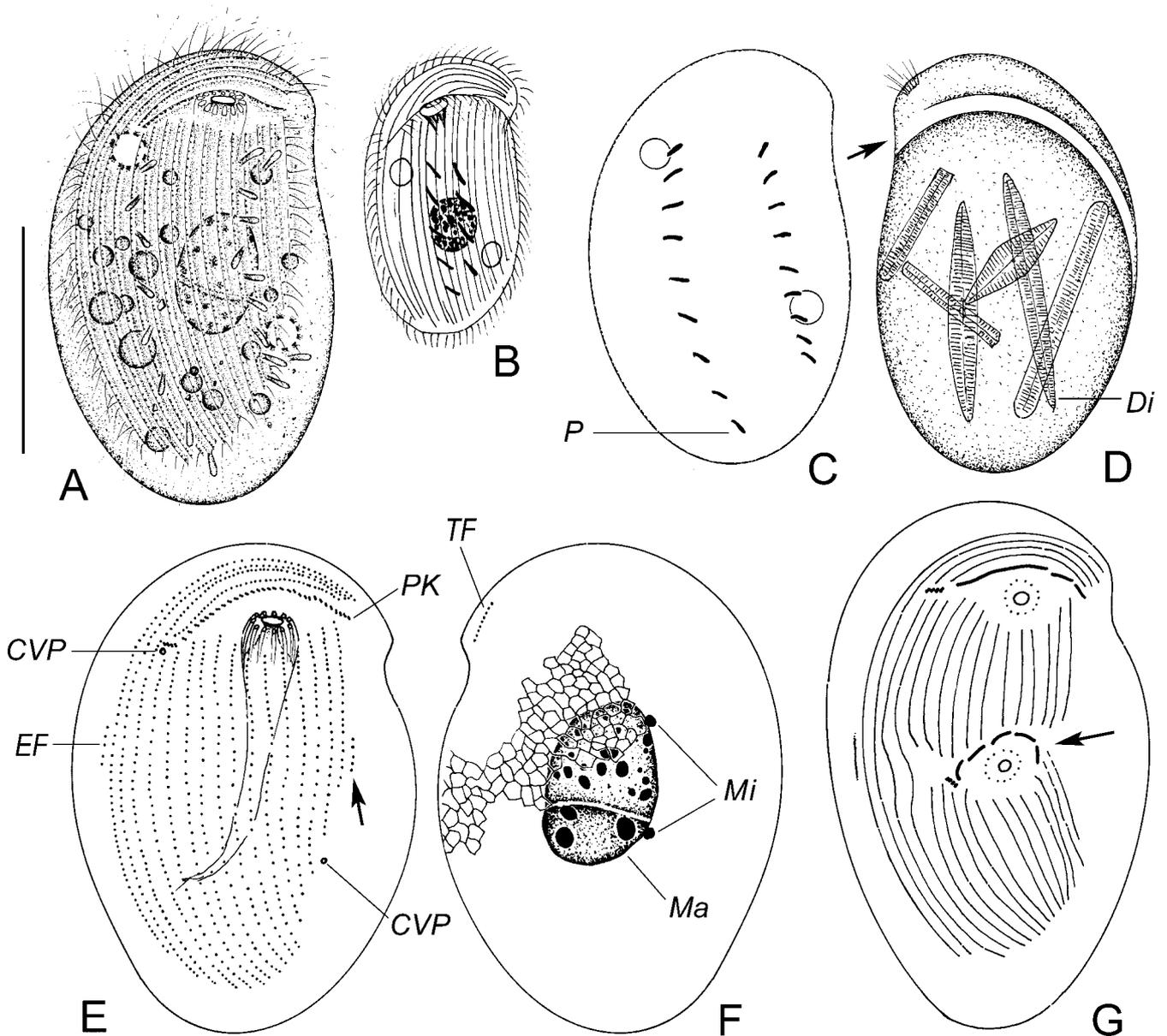
**Description.** Size 35-70  $\times$  20-40  $\mu\text{m}$  *in vivo*, usually 60  $\times$  35  $\mu\text{m}$  (Table 1). Body reniform to oval in outline, with anterior left end inconspicuously prominent; both ends broadly rounded (Figs 1A, C-F; 2A). Dorsoventrally flattened, ratio of width to thickness  $\sim$  2:1. Ventral side flat, dorsal side hunched, with an arched depression at anterior 1/6 of body length (arrows, Figs 1D, 2D). Cytostome prominent,  $\sim$ 5  $\mu\text{m}$  in diameter, sub-apically located. Cyrtos extending into endoplasm slightly left-posteriorly. Endoplasm colorless, containing several large

globular granules (2-5  $\mu\text{m}$  in diameter) and numerous tiny particles (across  $<$  1  $\mu\text{m}$ ); many rod- and shuttle-like ingested diatoms (Di) frequently observed (Fig. 1D). Macronucleus ovoid, positioned near body center. About 18 immobile club-shaped protuberances (P) on ventral surface, each 3  $\mu\text{m}$  long and 0.8  $\mu\text{m}$  in diameter, arranged in two longitudinal rows (Figs 1A, C; arrows in Fig. 2C). Two contractile vacuoles (arrows in Fig. 2B), each  $\sim$  4  $\mu\text{m}$  in diameter, diagonally located, pulsing interval 2 mins on average. Cilia 8  $\mu\text{m}$  long *in vivo*. Movement slow, gliding on substrates, sometimes swimming with rotation.

A total of 15-18 somatic kineties on ventral side (see Table 1). The rightmost four kineties almost extending over whole body length, with anterior portion transversely arched and anterior of oral field; usually the inner one or two rows interrupted by perioral kinety (PK). Other kineties terminating anteriorly below cytostome level; the leftmost 5-6 rows slightly progressively shortened from right to left. One terminal fragment (TF) consisting of about 10 basal bodies, dorso-anteriorly positioned (Figs 1F, 2G). Usually two short equatorial fragments (EF), one on right and one on left margin (arrow in Fig. 1E) of ciliary field, composed of 2-14 and 0-12 unciliated kinetosomes, respectively (Figs 1E; 2E, I). Macronucleus (Ma) oval, positioned in body center; usually two micronuclei (Mi) adjacent to macronucleus, each  $\sim$  2  $\mu\text{m}$  in diameter. Mostly two contractile vacuole pores (CVP) recognizable in protargol impregnated specimens, anterior one between kinety 3 and 4 from right, posterior one near the end of kinety 2 or 3 from left (Figs 1E, 2F).

Oral structure typical of genus: one perioral kinety basically transversely arched and continuous, composed of  $\sim$  30 dikinetids, with the rightmost 3-4 basal body pairs slightly detached (Figs 1E, 2E). Perioral kinety in opisthe are formed by  $\sim$  6 short segments of kineties, which can be detected at late stages of morphogenetic process (Figs 1G, 2J). Cyrtos composed of 12-15 nematodesmal rods, extending  $\sim$  60% of cell length. Silverline system irregularly reticulate (Figs 1F; 2K, H).

**Remarks.** Kahl described two new *Chilodon* species in 1928: *C. calkinsi* and *C. pediculatus*, which both were emended as members of the genus *Chilodonella* Strand, 1926 because the generic name *Chilodon* Ehrenberg, 1834 had been synonymized with the latter (Kahl 1931, Aescht 2001). Meanwhile, Kahl (1931) regarded *Chilodonella pediculatus* as a synonym of *Chilodonella calkinsi*. This revision was obviously accepted by Blatterer and Foissner (1990), who trans-

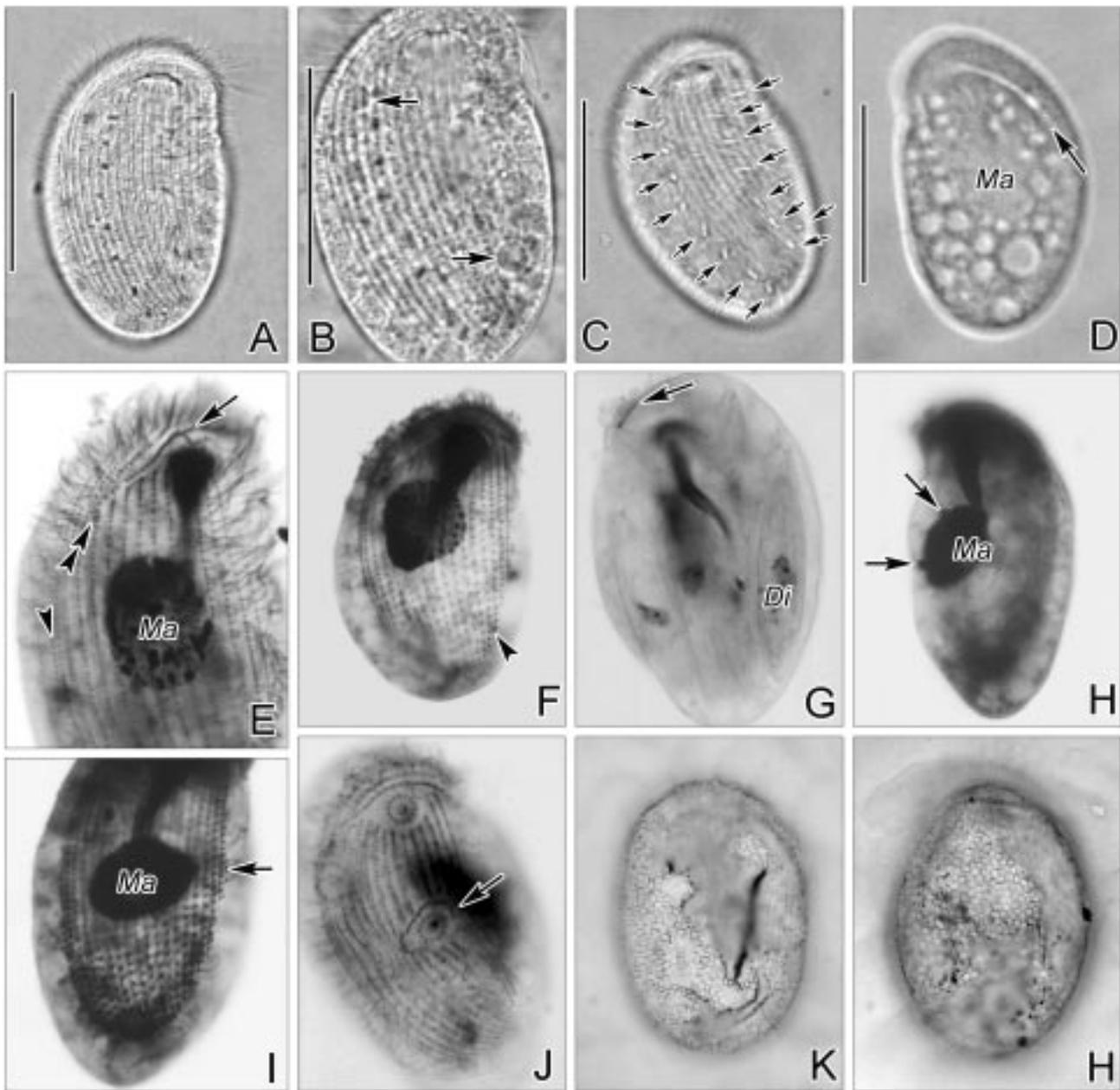


**Figs 1A-G.** Morphology and infraciliature of *Chlamydonellopsis calkinsi* from life (A, C, D, original; B, after Kahl 1931), after protargol (E-G) and Chatton-Lwoff impregnation (F). **A, B** - ventral views; **C, D** - showing the ventral club-shaped protuberances (C) and dorsal view (D), arrow indicates the arched depression; **E, F** - ventral (E) and dorsal (F) views of infraciliature and a part of silverline system; arrow marks the left equatorial fragment; **G** - an individual in morphogenesis, to note the fragmented perioral kinety (arrow) in opisthe. CVP - contractile vacuole pore; Di - diatom; EF - equatorial fragment; Ma - macronucleus; Mi - micronuclei; P - club-shaped protuberances; PK - perioral kinety; TF - terminal fragment. Scale bar: 30  $\mu$ m.

ferred *Chilodonella calkinsi* Kahl, 1928 into their newly erected genus *Chlamydonellopsis* Blatterer et Foissner, 1990.

According to the original descriptions by Kahl (1928), *Chilodon pediculatus* is very similar to *Chilodon*

*calkinsi* in terms of the body shape, size, position of terminal fragment and marine habitat. As for ventral protuberances, Kahl (1928) gave no information for the latter, but stated that there were 14-15 ventral protuberances in the former. Despite this difference, we believe



**Figs 2A-H.** Photomicrographs of *Chlamydonellopsis calkinsi* from life (A-D), after protargol (E-J) and Chatton-Lwoff impregnation (K, H). **A-C** - ventral views, focusing on cytostome and ciliary rows (A), contractile vacuoles (B, arrows) and two rows of club-shaped protuberances (C, arrows); **D** - dorsal view, arrow marks the arched depression on dorsal surface; **E** - ventral view of the anterior portion, to note the perial kinety (arrow), anterior contractile vacuole pore (double-arrowheads) and left equatorial fragment (arrowhead); **F** - to note the posterior contractile vacuole pore (arrowhead); **G** - arrow indicates the terminal fragment; **H** - showing the two micronuclei (arrows) adjacent to macronucleus. **I** - arrow refers to the left equatorial fragment; **J** - infraciliature of an individual in morphogenesis, arrow indicates the segmented perial kinety in opisthe; **K, L** - dorsal views of silverline system. Di - diatom; Ma - macronucleus. Scale bars: 30  $\mu$ m.

that the synonymization of these two taxa should be reasonable because, as Kahl (1931) mentioned, the protuberances can be easily overlooked during living observation. The redescription of *C. calkinsi* by Kahl

(1931) is thus virtually authoritative for species identification: oval body shape and size (40-60  $\mu$ m), having ~ 15 ciliary rows, two rows of club-shaped protuberances on ventral side, two diagonally positioned

**Table 1.** Morphometric characteristics of *Chlamydonellopsis calkinsi* (upper line), *Chlamydonella pseudochilodon* (middle line) and *Chlamydonella derouxi* (lower line). Data from protargol impregnated specimens; measurements in  $\mu\text{m}$ . CV - coefficient of variation in %, Max - maximum, Mean - arithmetic mean, Min - minimum, n - number of individuals examined, SD - standard deviation.

Characters	Min	Max	Mean	SD	CV	n
Body length	38	70	54.7	7.2	13.2	34
	49	67	59.1	5.7	9.7	21
	17	29	22	3.3	15.0	20
Body width	24	40	32.1	4.3	13.4	34
	38	51	45.1	4.8	10.7	21
	12	19	15.1	2.7	17.9	20
Number of somatic kineties	15	18	16.5	0.8	4.9	34
	18	19	18.8	0.4	2.1	21
	12	13	12.1	0.3	2.5	20
Number of preoral kineties	4	4	4	0	0	34
	4	4	4	0	0	21
	4	4	4	0	0	20
Number of nematodesmal rods	12	15	13.4	0.8	6.0	12
	16	21	17.8	1.4	7.7	21
	11	13	12.3	0.8	6.5	20
Number of basal bodies in terminal fragment	6	12	9.3	1.9	20.4	18
	7	10	8.6	0.8	9.5	21
	4	6	4.4	0.6	13.6	20
Number of basal bodies in right equatorial fragment	2	14	6.8	3.7	54.4	34
	0	13	6.8	4.8	69.8	21
	0	4	1.4	1.0	71.4	16
Number of basal bodies in left equatorial fragment	0	12	5.8	3.8	65.5	34
	0	14	7.4	4.0	54.1	21
	0	3	2.1	1.1	52.4	9
Length of macronucleus	13	24	17.9	2.5	14.0	18
	15	34	25.9	4.9	18.9	21
Width of macronucleus	6	12	8.2	1.6	19.5	18
	6	16	10.7	2.6	24.3	18
	6	10	7.8	1.3	16.2	21
Number of micronuclei	4	9	5.8	1.1	19.0	20
	1	2	1.8	0.5	27.8	12
	1	6	4.0	2.5	62.5	21
Number of contractile vacuole pores	1	1	1	0	0	14
	2	3	2.1	0.3	14.3	18
	2	2	2	0	0	21
	2	2	2	0	0	5

contractile vacuoles and marine habitat (Kahl 1931; Fig. 1B). Our organisms match well the authoritative description by Kahl (1931) and the infraciliature-based diagnosis for the genus *Chlamydonellopsis* by Blatterer and Foissner (1990), so that the identification is beyond doubt.

**Comparison with related species.** *Chlamydonellopsis calkinsi* (Kahl, 1928) has two congeners: *C. plurivacuolata* Blatterer et Foissner, 1990 and *C. polonica* (Foissner, Czapik et Wiackowski, 1981) Blatterer et Foissner, 1990, which are both freshwater species (Blatterer and Foissner 1990, Foissner et al.

1991). Morphologically, *Chlamydonellopsis calkinsi* differs from the type species *C. plurivacuolata* in the numbers of somatic kineties (15-17 vs. 19-23), preoral kineties (4 vs. 5-8), nematodesmal rods (12-15 vs. 17-20), contractile vacuoles (2 vs. 4), ventral protuberances (ca 18 vs. ca 10) and macronuclear size (18 × 11 vs. 27 × 16  $\mu\text{m}$ ) (Foissner et al. 1991; Table 2).

*Chlamydonellopsis calkinsi* is similar to *C. polonica* with respect to the body shape and size, macronuclear size, number and position of contractile vacuoles (Foissner et al. 1981; Table 2). However, the former can be recognized by having fewer somatic kineties (15-17 vs.

18-20), preoral kineties (4 vs. 6), nematodesmal rods (12-15 vs. 16-18) and the biotopes (marine vs. freshwater).

**Redescription of *Chlamydonella pseudochilodon* (Deroux, 1970) Petz Song et Wilbert, 1995 (Figs 3, 4; Table 1)**

The previously invalid genus *Chlamydonella*, originally established by Deroux (1970), has been reactivated according to ICZN (1999) with the designation of *Chlamydonella pseudochilodon* as the type (Petz *et al.* 1995, Aesch 2001). To authors' knowledge, however, the type species has never been clearly defined.

**Improved diagnosis:** Marine *Chlamydonella* 30-75 × 20-50 µm *in vivo*, asymmetrically oval to reniform in outline; ~ 14-20 somatic kineties, of which 4 rows extend apically; 11-21 nematodesmal rods; two contractile vacuoles diagonally positioned; one to several micronuclei.

**Description of the Qingdao population:** Size 50-70 × 35-50 µm *in vivo*, usually 60 × 45 µm. Body oval in outline, with inconspicuous indentation on anterior left; both ends rounded, left margin roughly straight, right convex (Figs 3A, B). Conspicuously dorsoventrally flattened, ratio of width to thickness ~ 4:1. Ventral side flat, dorsal slightly vaulted. Pellicle robust and flexible. Cytoplasm colourless and hyaline with posterior portion slightly grayish, usually containing several ingested diatoms and numerous tiny granules (~ 1 µm across). Cytostome (Cs) prominent, located slightly left of median and at anterior 1/5 of body length, diagonally oriented, ~12 µm long *in vivo*. Cytos (Cy) composed of 16-21 nematodesmal rods (Figs 3C, 4B). Macronucleus longitudinally positioned, slightly left of midline; size about 26 × 8 µm after protargol impregnation, containing differently-sized, globular to elongated nucleoli, usually with central portion more heavily impregnated than others (Figs 3D, 4D). One to six (on average 4) globular micronuclei, each 1.5-3 µm in diameter, mostly arranged left of macronucleus (Figs 3D; 4E, F). Two contractile vacuoles (CV), typically diagonally positioned (Figs 3A, B); two contractile vacuole pores (CVP) symmetrically positioned between kinety 3 and 4, from outer to inner (Figs 3C; 4G, H). Club-shaped protuberances (P) mostly arranged near perimeter of ventral surface, each 2-3 µm long (Fig. 3B). Cilia ~5 µm long *in vivo*. Movement slow, gliding on substrate; highly thigmotactic, attaching to substrate firmly when stimulated.

Somatic kineties ~17 rows (Figs 3C, 4A; Table 1). Four frontoventral kineties, of which the outermost one

is loosely ciliated, especially in its anterior portion (Fig. 3D; arrowheads in Fig. 4B), and the innermost one is bisected by perial kinety near the anterior contractile vacuole pore (Figs 3C, 4B). Other kineties slightly C-shaped, terminating anteriorly at about cytostome level and posteriorly at body margin. Basal bodies generally densely spaced; no distinct sparsely-ciliated zone (= zone de raréfaction cinétosomienne, Deroux 1970) recognizable. Terminal fragment (TF) consisting of ca 9 basal bodies, dorsally positioned on left-anterior end of cell (Fig. 3D; arrow in Fig. 4C); right (REF) and left equatorial fragment (LEF, arrow in Fig. 3C) composed of ~7 and 4 basal bodies, respectively. Several leftmost somatic kineties join to form the oral primordium during stomatogenesis (Fig. 4I).

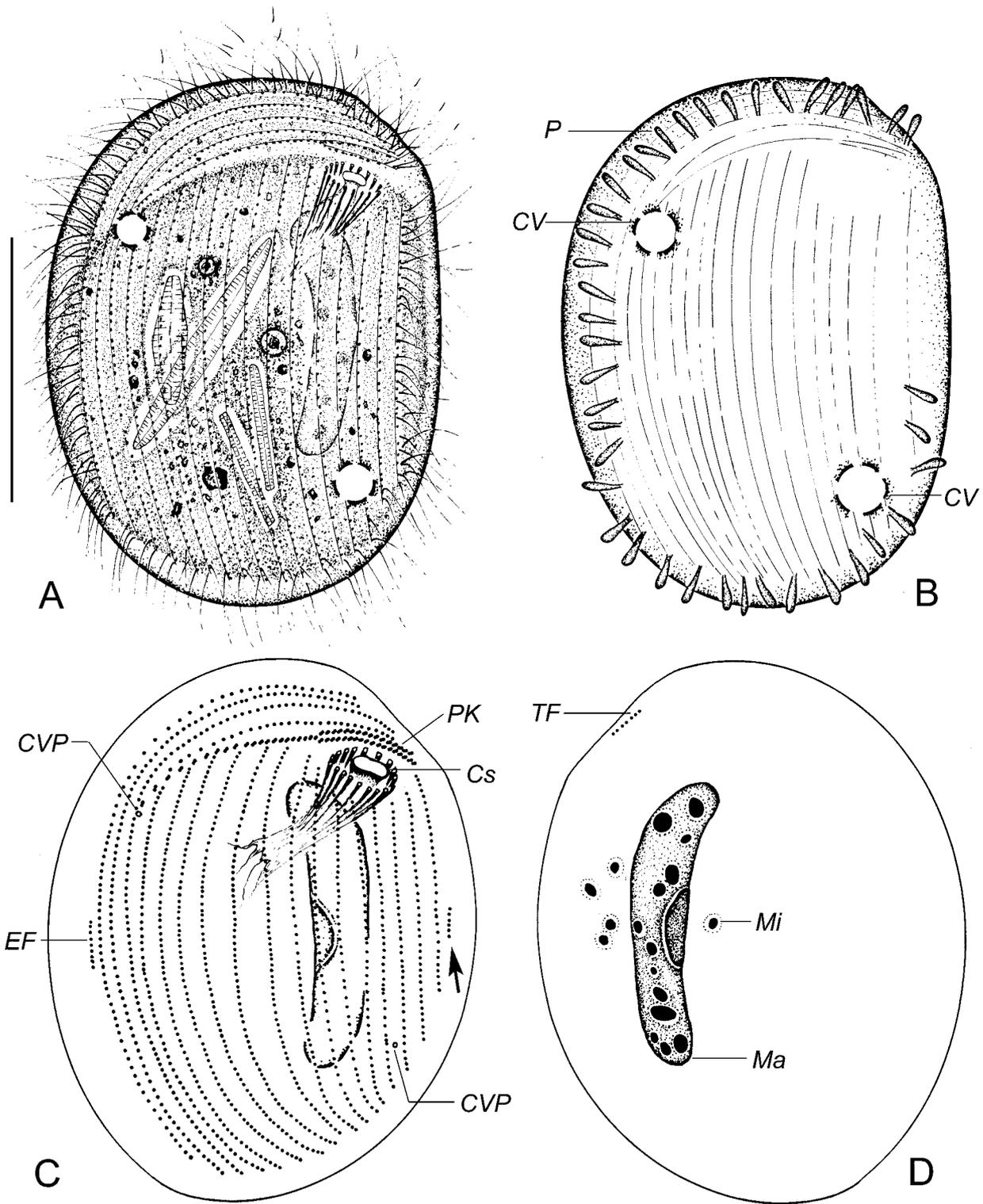
Oral structure typical of genus: Y-shaped perial kineties (2 short arms on left and 1 long on right), completely composed of dikinetids (Fig. 3C; arrow in Fig. 4B).

**Remarks:** Considering the body shape and size, the infraciliature and the number/position of contractile vacuoles, the Qingdao population basically corresponds with the original description by Deroux (1970) and the redescription by Petz *et al.* (1995). The differences are the shape (elongate vs. oval or ellipsoidal) and the size (see Table 3) of the macronucleus, which is basically considered to be an intra-species feature as to authors' knowledge. In addition, there are moderately large coefficients of variations for macronuclear length (18.9%) and width (16.2%) in the Qingdao population (Table 1), indicating the unreliability of merely using macronuclear shape/size for taxa separation at species levels.

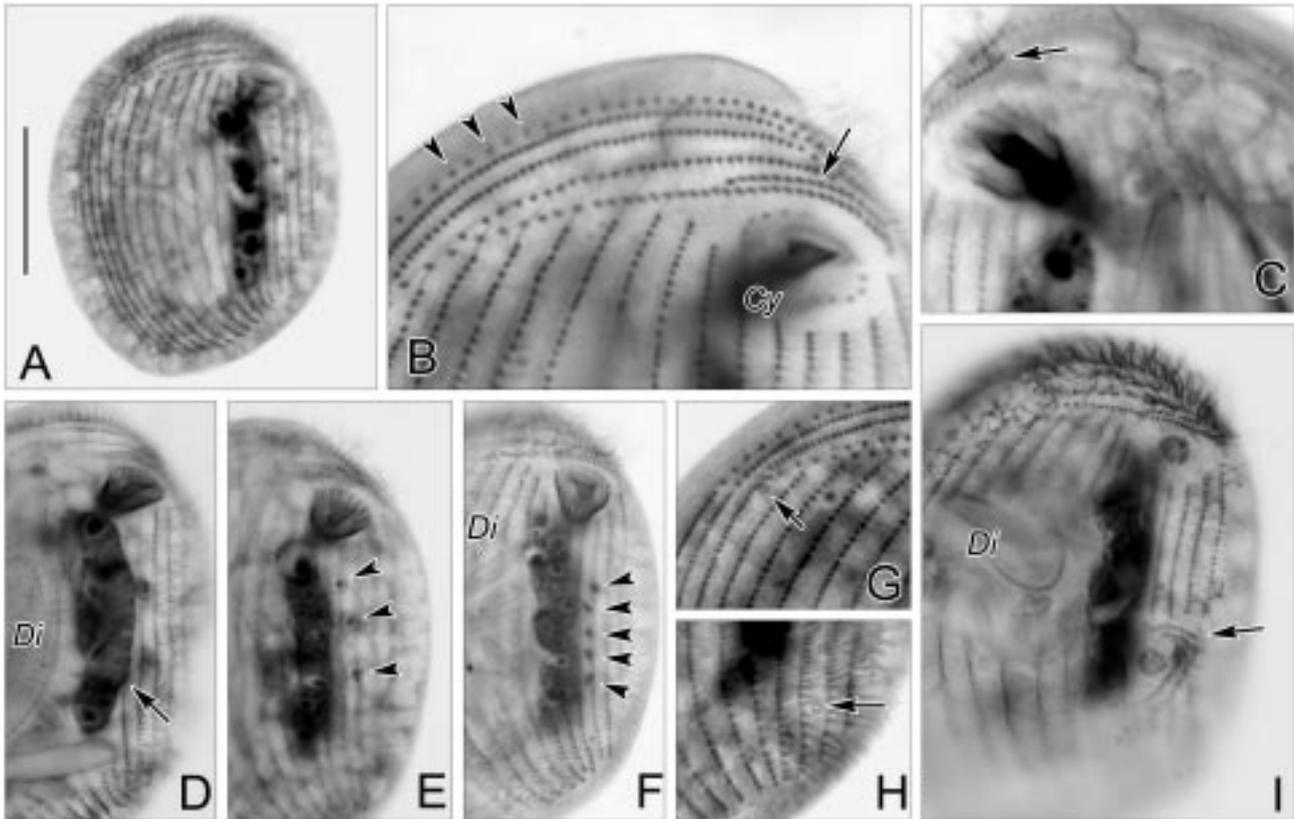
As for the feature of ventral protuberances, our observation is basically in accordance with Deroux's (1970). While Petz *et al.* (1995) did not mention these organelles, which could be overlooked during observations of live cells. Nevertheless, we identify our population mainly based on the infraciliature.

**Redescription of *Chlamydonella derouxi* Song, 2003 (Figs 5A-C, 6; Table 1)**

This population corresponds perfectly with the original description in living morphology (body size and shape, number of nematodesmal rods, and position of contractile vacuoles) and infraciliature (numbers of somatic kineties and preoral kineties) (Song 2003; Figs 5A-C, 6A-F; Table 1), by contrast, the numbers of (i) club-shaped protuberances on ventral side (1 vs. 3); (ii) basal bodies in equatorial fragments (1 vs. 1-4); and (iii) micronuclei (2 vs. 1) are different. Thus, we provide



**Figs 3A-D.** Morphology and infraciliature of the Qingdao population of *Chlamydonella pseudochilodon* from life (A-B) and after protargol impregnation (C, D). **A** - ventral view. **B** - showing the club-shaped protuberances; **C**, **D** - ventral (C) and dorsal (D) infraciliature. Cs - cytotome; CV - contractile vacuole; CVP - contractile vacuole pore; EF - equatorial fragment; Ma - macronucleus; Mi - micronuclei; P - club-shaped protuberances; PK - perioral kinety; TF - terminal fragment. Scale bar 30  $\mu$ m.



**Figs 4A-I.** Photomicrographs of *Chlamydonella pseudochilodon* after protargol impregnation. **A** - ventral view; **B** - oral field, arrow marks the Y-shaped perioral kineties, arrowheads indicate the loosely spaced basal bodies in the rightmost kinety; **C** - showing the terminal fragment (arrow); **D-F** - to note the macronucleus (arrow) and micronuclei (arrowheads); **G, H** - the right anterior (G) and left posterior (H) contractile vacuole pores; **I** - a stage of morphogenesis, arrow indicates the oral primordium for the opisthe. Cy - cyrtos; Di - diatom. Scale bar 30  $\mu\text{m}$ .

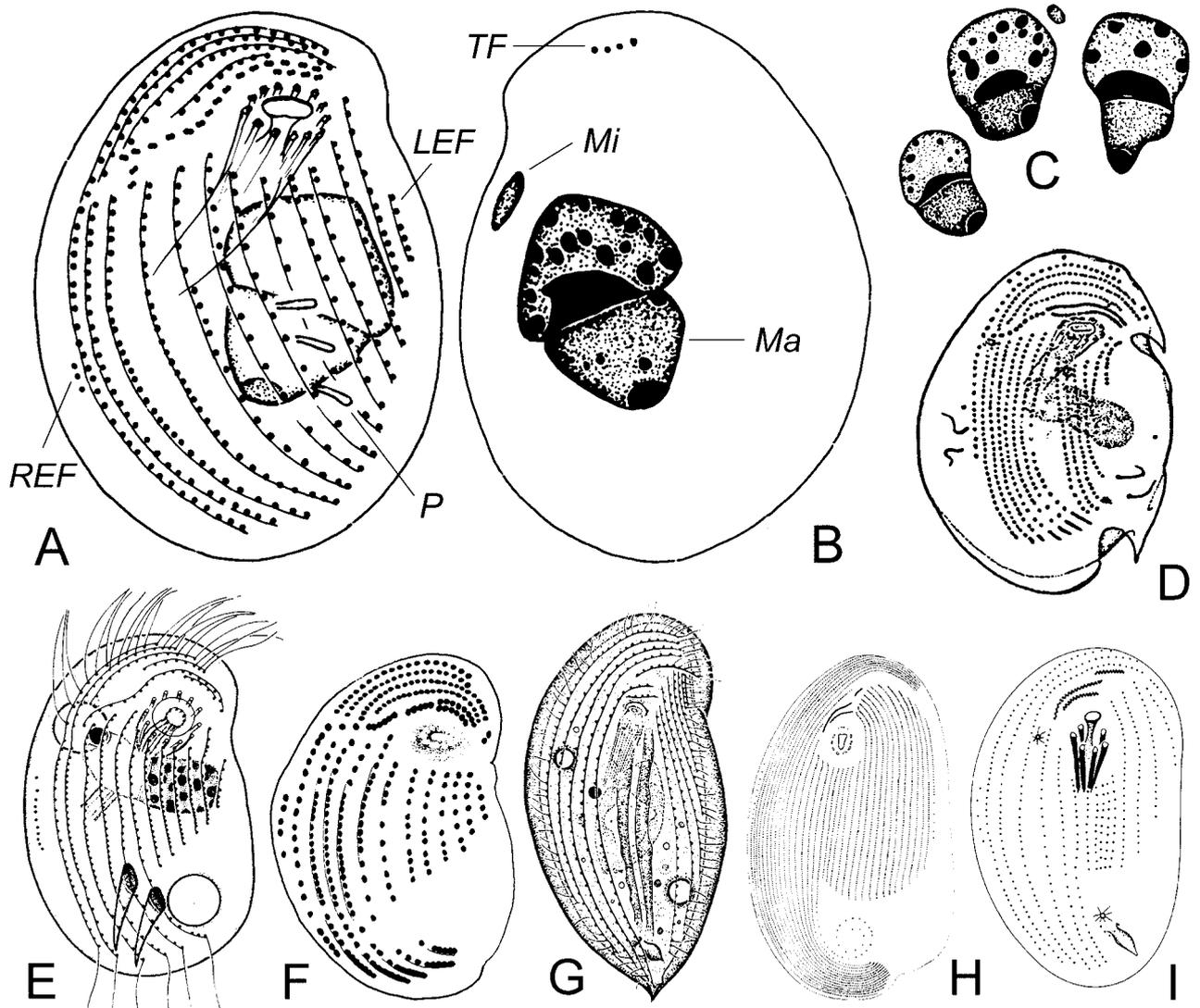
photomicrographs and suggest an improved definition for this species.

**Improved diagnosis:** Small marine *Chlamydonella* about  $20\text{-}30 \times 12\text{-}20 \mu\text{m}$  *in vivo*, body shape asymmetrical oval in outline; with one to several club-shaped protuberances on ventral surface, located slightly left of median and posterior portion of cell; ~12 somatic kineties and 12 nematodesmal rods; two contractile vacuoles diagonally positioned.

**Remarks:** Two nominal species *Parachilodonella distyla* Wilbert, 1971 and *Chlamydonella stricta* Deroux, 1976 resemble *C. derouxi* Song, 2003 in terms of the body size (*ca*  $20\text{-}30 \mu\text{m}$  in length) and the basic ciliary pattern (~12 somatic and 4 preoral kineties; Wilbert 1971, Deroux 1976), whereas the distinctness of these three taxa has not been explicitly discussed. We will review this matter briefly.

It should be noted that two specialized plasmatic organelles in cyrtophorids, the podite (or glandular adhe-

sive organelle, Griffel etc.) and the ventral protuberances (so called tentacle-like structures, finger-like tentacles, feet etc.) might not be clearly outlined in previous studies, which may hence lead to misunderstanding or misidentifications. Based on previous and the present work, we herein summarize the distinguishable aspects of the podite and the protuberances as follows: (1) shape (blade-like or foliform *vs.* club, finger-like); (2) size (usually  $8\text{-}10$  *vs.*  $3\text{-}5 \mu\text{m}$  in length); (3) number and position (consistently one, at posterior ventral surface *vs.* usually several to many, regularly or irregularly distributed between ventral kineties); (4) movement (actively mobile, moving around the base effectively *vs.* immobile); (5) with *vs.* without a furrow for discharging adhesive substance; and (6) usually several kinetosome-like dots present (*vs.* absent) beneath the base of organelles after protargol impregnation (this paper; Gong and Song 2003, 2004a, b, c, 2006; Gong *et al.* 2002, 2003). Furthermore, the podites are presumably used for

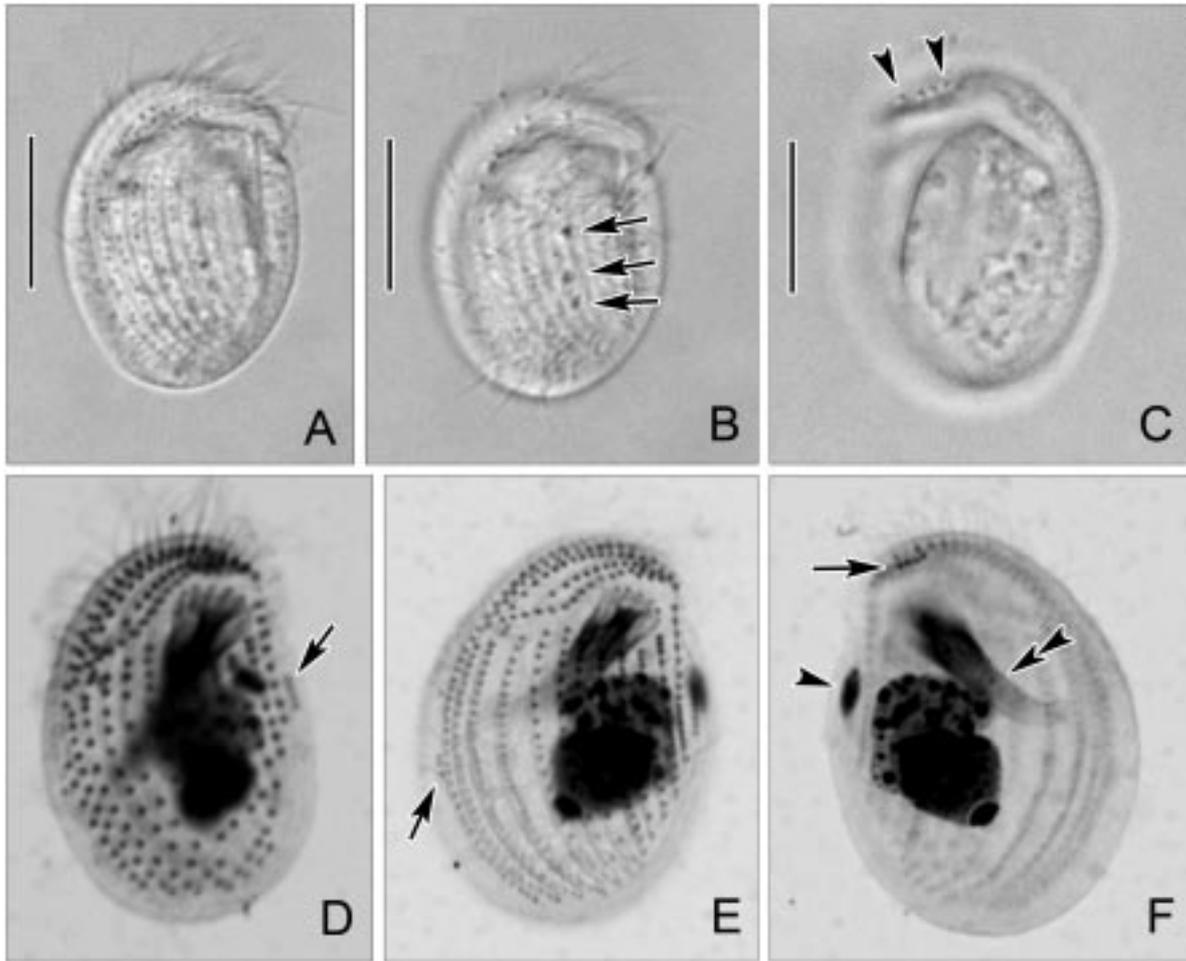


**Figs 5A-I.** Infraciliature of *Chlamydonella derouxi* (A-C, original) and related taxa (D-I). **A, B** - ventral (A) and dorsal (B) views; **C** - shape of macronucleus from three different individuals; **D** - *Atopochilodon distichum* (from Deroux 1976); **E** - *Wilbertella distyla* (from Wilbert 1971); **F** - *W. stricta* (from Deroux 1976); **G** - *Parachilodonella lygiae* (from Dragesco 1966); **H** - *Brooklynella hostilis* (from Lom and Nigrelli 1970); **I** - *Brooklynella sinensis* (from Gong and Song 2006). LEF - left equatorial fragment; Ma - macronucleus; Mi - micronucleus; P - club-shaped protuberances; REF - right equatorial fragment; TF - terminal fragment.

attaching the ciliate to the substrate (Fauré-Fremiet *et al.* 1968, Lom and Corliss 1971), whereas the ventral protuberances, though the function remains unclear, are apparently not used for clinging to substrate (Foissner *et al.* 1991, Lynn and Foissner 1994). Taxonomically, the presence of podites is exclusive for ciliates in two cyrtophorid families namely Hartmannulidae and Dysteriidae, whereas ventral protuberances have been

only observed so far in lynchellid taxa, e.g. *Coeloperix sleighi* Gong *et al.* 2004, *Chlamydonellopsis* Blatterer *et al.* Foissner, 1990, *Lynchella gradata* Kahl, 1933 and *Chlamydonella derouxi* Song, 2003 (Kahl 1933, Foissner *et al.* 1991, Gong and Song 2004c, this paper).

The genus *Parachilodonella* was erected by Dragesco (1966) to include a single marine species, *P. lygiae* Dragesco, 1966. Main generic characteristics



**Figs 6A-F.** Morphology and infraciliature of the Qingdao population of *Chlamydonella derouxi* from life (A-C) and after protargol impregnation (D-F). **A, B** - ventral views, arrows indicate the three club-shaped protuberances on ventral side; **C** - dorsal view, arrowheads mark the terminal fragment; **D, E** - ventral infraciliature, showing the left (arrow in D) and right (arrow in E) equatorial fragment; **F** - dorsal infraciliature, to note the terminal fragment (arrow), the micronucleus (arrowhead), and the cyrtos (double-arrowheads). Scale bars 10  $\mu$ m.

of this taxon are: (1) *Chilodonella*-like infraciliature and (2) possessing a typical podite on ventral side (Dragesco 1966, Fig. 5G). According to these two points, the nominal species *P. distyla*, a freshwater form, is likely misplaced because it has a different ciliature-pattern and two ventral cytoplasmic protuberances (Wilbert 1971). Nevertheless, although similar to the well-known *Chlamydonella* regarding the general ciliature, *P. distyla* can be clearly distinguished from *Chlamydonella* (including *C. derouxi* described above) in the presence (vs. absence) of a distinct non-ciliated zone in left

posterior of ventral surface (Fig. 5E), which should be considered as a feature at the generic level. Likewise, another nominal species, *Chlamydonella stricta*, which was originally isolated from marine biofilms (Deroux 1976), should be a congener with *P. distyla* (Fig. 5F). Based on these understanding, a new genus, *Wilbertella* is suggested:

***Wilbertella* nov. gen.**

**Diagnosis:** Lynchellidae with a distinct blank zone in left posterior portion of cell because left kineties dis-

**Table 2.** Comparison between *Chlamydonellopsis calkinsi* and its congeners.

Characters	<i>C. calkinsi</i>	<i>C. plurivacuolata</i>	<i>C. polonica</i>
Body size ( $\mu\text{m}$ )	50-70 $\times$ 30-45	50-110 $\times$ 30-55	55-80 $\times$ 38-52
Number of protuberances	ca 18	ca 10	?
Number of preoral kineties	4	5-8 (mean 6)	6
Number of somatic kineties	15-17 (mean 16)	19-23 (mean 21)	18-20 (mean 19)
Number of nematodesmal rods	12-15 (mean 13)	17-20 (mean 18)	16-18
Number of basal bodies in terminal fragment	6-12	10-20	12
Macronuclear size ( $\mu\text{m}$ )	18 $\times$ 11	27 $\times$ 16	22 $\times$ 12
Number and position of contractile vacuoles	2, diagonally positioned	4, two on left, another two on right	2, diagonally positioned
Habitat	marine	freshwater	freshwater
Data resource	present work	Blatterer and Foissner 1990	Foissner <i>et al.</i> 1981

? Data not available.

**Table 3.** Comparison between populations of *Chlamydonella pseudochilodon*.

Character	<i>C. pseudochilodon</i>	<i>C. pseudochilodon</i>	<i>C. pseudochilodon</i>
Body length (in $\mu\text{m}$ ) <i>in vivo</i>	50-70	30-45	43-73
Body width (in $\mu\text{m}$ ) <i>in vivo</i>	35-50	20-25	24-38
Number of somatic kineties	18-19	14-20	14
Number of preoral kineties	4	4	4
Number of nematodesmal rods	16-21	11-16	12-18
Club-shaped protuberances	present	present	?
Macronuclear length	15-34	7-15	29
Macronuclear width	6-10	8-10	10
Macronuclear shape	elongate	oval	ellipsoidal
Number of micronuclei	1-6	1	1
Number of contractile vacuoles	2	2	2
Habitat	Marine	Marine	Marine
Sample location	Yellow Sea, China	Atlantic, France	Antarctica
Data source	Original	Deroux 1970	Petz <i>et al.</i> 1995

? Data not available.

tinctly shortened, right kineties extending to posterior end; perioral kineties in flattened Y-shaped; no distinct gap between left and right ciliary fields.

**Type species:** *Parachilodonella distyla* Wilbert, 1971.

**Dedication:** This new genus is dedicated to Prof. Norbert Wilbert, Institut für Zoologie, Universität Bonn, Germany, in recognition of his eminent contribution to ciliatology. Feminine gender.

**Species assignable:** *Wilbertella distyla* (Wilbert, 1971) nov. comb. [basonym: *Parachilodonella distyla*

Wilbert, 1971]; *Wilbertella stricta* (Deroux, 1976) nov. comb. [basonym: *Chlamydonella stricta* Deroux, 1976].

**Comparison with related genera:** Both the genera *Chlamydonella* Deroux in Petz Song *et* Wilbert, 1995 and *Atopochilodon* Deroux, 1976 resemble *Wilbertella* nov. gen. with respect to the flattened Y-shaped perioral kineties (Deroux 1970, 1976; Petz *et al.* 1995; this paper; Fig. 5D). However, the new genus can be distinguished from the former two in the structure of the left kineties which are distinctly shortened posteriorly (*vs.* extending to cell end in *Chlamydonella* and *Atopochilodon*). In

addition, the left and right ciliary fields are distinctly separated in *Atopochilodon* (*vs.* continuous in *Wilbertella*).

Compared with *Wilbertella*, another similar taxon, *Parachilodonella* Dragesco, 1966 can be recognized by having a podite (*vs.* ventral club-shaped protuberances or absent in *Wilbertella*) and *Chilodonella*-like infraciliature (Dragesco 1966, Fig. 5F), that is, left and right ciliary fields are separated as parenthesis marks (*vs.* continuous in *Wilbertella*).

The posterior ends of left kineties in *Brooklynella* Lom *et* Nigrelli, 1970 are also greatly shortened relative to right ones, leaving a blank area in posterior left of ventral surface (Lom and Nigrelli 1970, Gong and Song 2006; Figs 5H, I). Nevertheless, *Brooklynella* differs from *Wilbertella* in: (1) arrangement of oral structure (one preoral and two circumoral kineties *vs.* flattened Y-shaped perioral kinety); (2) absence (*vs.* presence) of the interruption between frontoventral and oral kineties; and (3) presence (*vs.* absence) of a typical podite.

*Thigmogaster* Deroux, 1976 may also resemble *Wilbertella* in terms of the shortened left kineties (Deroux 1976). However, *Thigmogaster* can be easily recognized by the following features: (1) macronucleus centric (*vs.* juxtaposed) heteromeric; (2) perioral kineties *Chilodonella*-like (one preoral and two circumoral kineties *vs.* flattened Y-shaped); (3) somatic kineties in right field continuous (*vs.* interrupted by perioral kineties); and (4) left and right ciliary fields slightly detached (*vs.* continuous).

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