Acta Protozool. (2011) 50: 105–119
http://www.eko.uj.edu.pl/ap

ACTA
PROTOZOOLOGICA

New Contribution to the Morphological Taxonomy of Three Marine Cyrtophorid Ciliates from the Yellow Sea, China (Ciliophora: Cyrtophorida)

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Summary. The morphology and infraciliature of three marine cyrtophorid ciliates, *Dysteria lanceolata* Claparède and Lachmann, 1859, *Lynchella nordica* Jankowski, 1968 and *Chlamydonyx paucidentatus* Deroux, 1976, collected from the coastal waters of Qingdao, China, were investigated using live observations and the protargol impregnation method. *D. lanceolata* was oval in body outline, about 65 × 45 µm *in vivo*, with a subcaudally positioned podite, six to seven right kineties, two or three frontoventral kineties, and two ventral contractile vacuoles. The improved diagnosis for *L. nordica* and a key to all known *Lynchella* species are supplied. The rediscovery of *C. paucidentatus* enables us to accept its taxonomic identification (*e.g.*, separation from a morphologically similar species *Trochilioides recta*). The genus *Trochilioides* Deroux, nov. gen., which was a nomen nudum according to ICZN (1999), is re-established.

Key words: Cyrtophorida, Dysteriidae, Lynchellidae, Hartmannulidae, new genus, taxonomy.

INTRODUCTION

Cyrtophorids are highly specialized ciliates often occurring in the periphyton, biofilm and benthic surface of freshwater and marine habitats. Morphologically, cyrtophorid ciliates are highly compressed in body shape, with a buccal basket and reduced ciliature restricted to ventral side (Kahl 1931, Dragesco 1966, Wilbert 1971, Borror 1972).

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Since Deroux's contribution (Deroux 1965, 1970, 1975, 1976a, b, c), new cyrtophorid taxa have been described using silver staining method, for instance, by Agamaliev (1978), Foissner *et al.* (1981, 1991), Dragesco and Dragesco-Kernéis (1986), Aliev (1987, 1991), Blatterer and Foissner (1990), Agatha *et al.* (1993), Alekperov and Asadullayeva (1997), Petz *et al*. (1995), Song and Packroff (1997), Song and Wilbert (2002), Song (2003), and Hu and Suzuki (2005). Based on the survey conducted for the last one decade on ciliate fauna in the Bohai Sea and Yellow Sea, northern China, over 40 cyrtophorid species have been identified (*e.g.*, Gong *et al*. 2002, 2003, 2005b, 2007, 2009a; Gong and Song 2004, 2006; Shao *et al*. 2008).

The current work reports a part of the result of the faunistic study of marine ciliates in the north China seas performed recently (Chen *et al*. 2008, 2009, 2010; Ji *et al*. 2009; Gong *et al*. 2009b; Gao *et al*. 2010; Pan *et al*. 2010; Zhang *et al*. 2010). Three poorly described cyrtophorid species, collected from mariculture waters near Qingdao are redescribed following examination using modern techniques.

MATERIALS AND METHODS

Sample collection, observation, and identification

All samples were collected from mariculture waters of Qingdao (N36°08′; E120°43′), China, using artificial substrates in the form of glass slides, which were immersed in water till the biofilm is formed (Gong *et al.* 2005a). Subsequently after ten days exposure, the slides were carefully taken out and transferred to Petri dishes with marine waters from the sampling site. *Dysteria lanceolata* and *Chlamydonyx paucidentatus* were isolated (March 2006) from an indoor tank for culturing marine fish (*Psetta maxima*). The water temperature was about 16°C, salinity was approximately 31‰ and pH about 7.8. Two populations of *Lynchella nordica* were collected (May 2005, June 2006) from scallop-culturing waters (*Argopecten irradians irradians*). The water temperature was about 18°C, salinity 30‰ and pH ca. 8.0.

Living cells were observed by differential interference microscopy. The infraciliature was revealed using the protargol impregnation method according to Wilbert (1975). Living individuals were examined and measured at 1,000 × magnification; drawings of stained specimens were performed at 1250 × with the aid of a camera lucida. Systematic scheme and terminology are mainly according to Corliss (1979), Petz *et al.* (1995) and Gong *et al*. (2003).

Deposition of slides

Protargol-impregnated voucher slides were deposited in the Laboratory of Protozoology, OUC, China, with registration numbers: *D. lanceolata*, CXR-20060324-01, CXR-20060324-02; *L. nordica*, CXR-20050519, CXR-20060611; *C. paucidentatus*, CXR-20060322.

RESULTS AND DISCUSSION

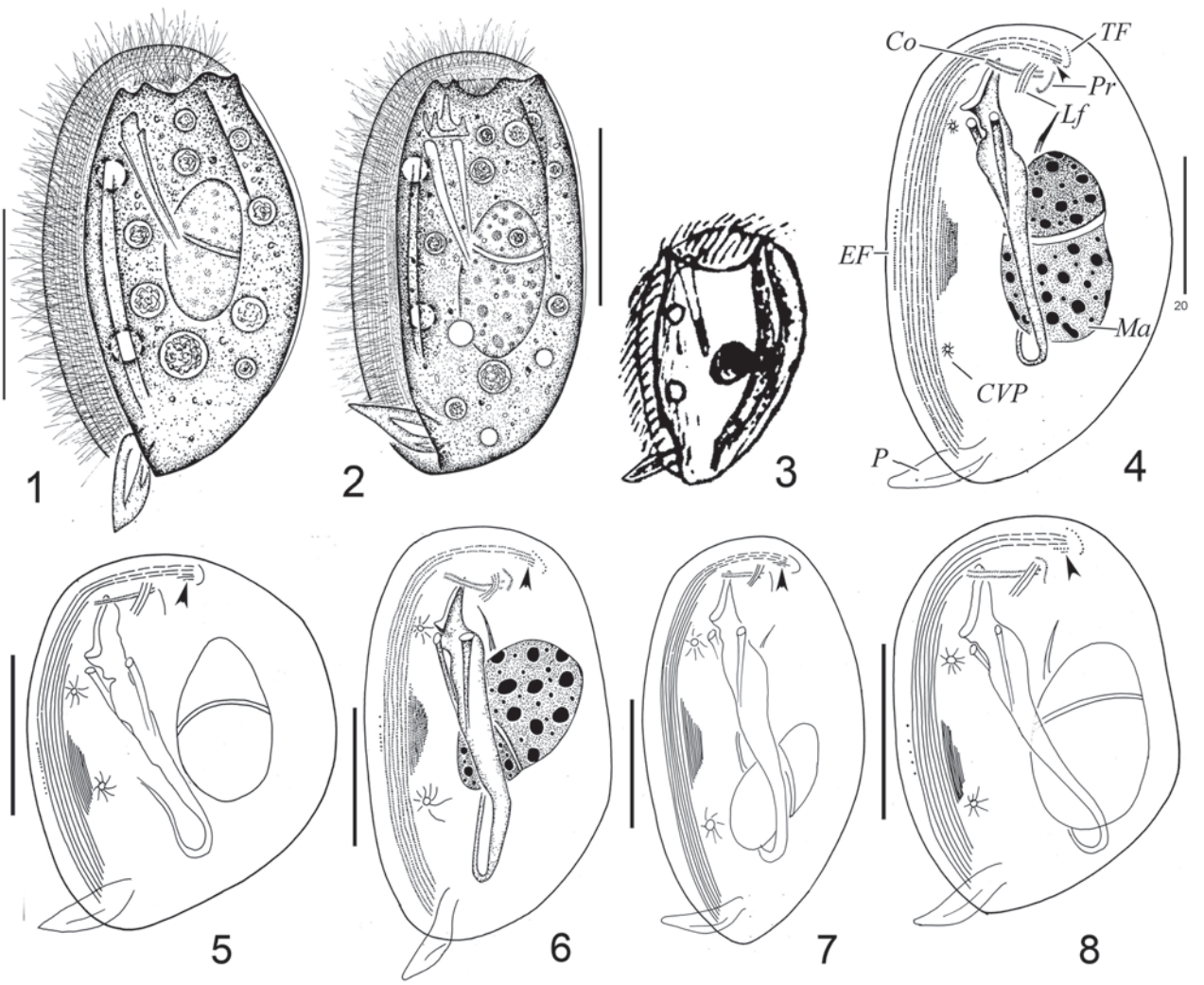
Dysteria lanceolata Claparède and Lachmann, 1859 (Tables 1, 2 and Figs 1–34)

Since the original report by Claparède and Lachmann (1859) and redescription by Kahl (1931), *Dysteria lanceolata* has never been examined using modern methods. We, therefore, supply a detailed description of both living morphology and infraciliature of the population found in Qingdao.

Improved diagnosis. Marine *Dysteria* with oval body outline, about 65 × 45 μm *in vivo*; with six to seven right kineties, two or three frontoventral kineties; macronucleus 25 × 20 μm in size; two ventral contractile vacuoles; podite subcaudally positioned.

Description. Size range about 60–80 × 30–60 μm *in vivo*, usually about 65 × 35 μm, body bilaterally flattened about 1:2. When viewed from lateral aspect, most of the cells are nearly oval in outline, dorsal side usually are more convex than ventral, anterior margin is evenly rounded, and posterior region slightly narrowed (Figs 1, 9, 10); few individuals are approximately rectangular in outline, ventral and dorsal sides slightly convex, both anterior and posterior margin bluntly rounded (Figs 2, 11). Right plate is conspicuously wider than the left plate by about 1/4 body width. A inconspicuous groove, about 2 μm in width and 20 μm in length is present *in vivo*, which is longitudinally arranged near ventral border of left plate (Figs 1, 2, 9, 12). Surface of two plates is covered with many rod-shaped ectosymbiotic bacteria (Fig. 12). Podite about 10 μm long, subcaudally positioned (Figs 1, 2, 9–12). Cytoplasm colourless to grayish, usually containing numerous tiny granules and several food vacuoles (up to 10 μm in diameter). Cytostome is in anterior 1/6 of cell and is ventrally located. Cytopharynx is conspicuous *in vivo*, longitudinally oriented and extending to posterior end of cell, supported by two relatively strong nematodesmal rods, tipped with one complex tooth measuring about 6 μm in cross (Fig. 11). Two ventral contractile vacuoles, each 2–4 μm in diameter are present, usually one in anterior third and the other in posterior third of the body (Figs 1, 2, 10, 11). Macronucleus is ovoid, about 25 × 18 μm *in vivo*, centrally positioned, characteristically heteromerous. Micronucleus is not detected. Cilia are about 10 μm long. Movement is usually slow, crawling on substrate and occasionally swimming in water.

Infraciliature as shown in Figs 4–8, 14–19. Usually seven right (seldom six) kineties. Two or three rightmost rows of right kineties (*i.e*., frontoventral kineties) are almost equal in length (each composed of about 170 basal bodies, see Table 1), and extending anteriorly to dorsal margin; other right kineties are progressively shortened from right to left; and the inmost right kinety terminates anteriorly near cytostome. About six to eleven left kineties with densely arranged basal bodies are positioned around equator and close to right kineties (Figs 4–8, 18, 19). One hook-like terminal fragment is antero-dorsally positioned, comprising of six to

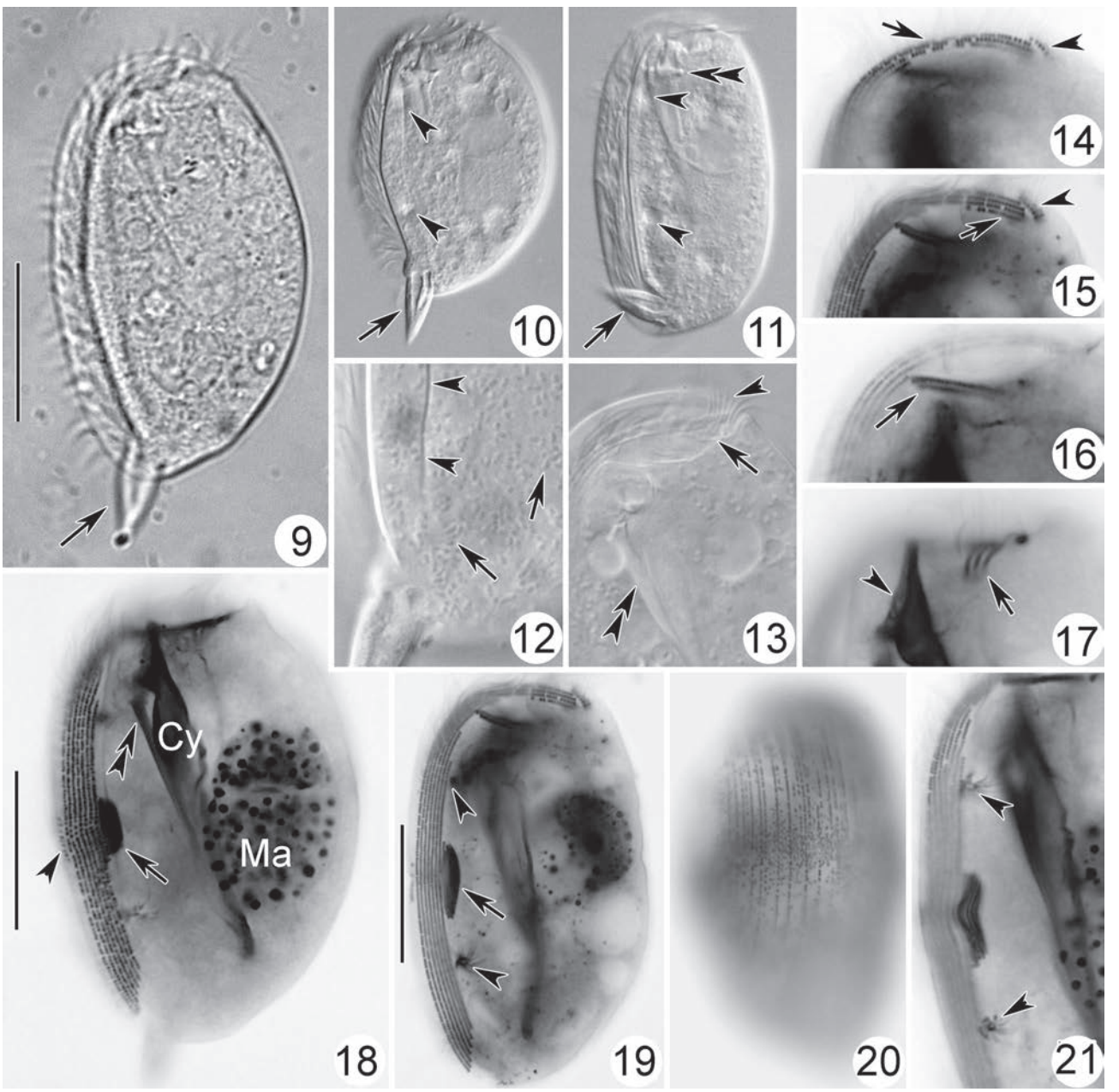


Figs 1–8. *Dysteria lanceolata* from life (1–3) and after protargol impregnation (4–8). **1–2 –** left side view of two individuals with slightly different body shape; **3 –** left side view (from Kahl 1931); **4–8** – showing infraciliature, arrows indicate the short row near the anterior end of the frontoventral kineties. Co – circumoral kineties, CVP – contractile vacuole pore, EF – equatorial fragment, Lf – left frontal kineties, Ma – macronucleus, P – podite, Pr – preoral kineties, TF – terminal fragment. Scale bars: 20 μm.

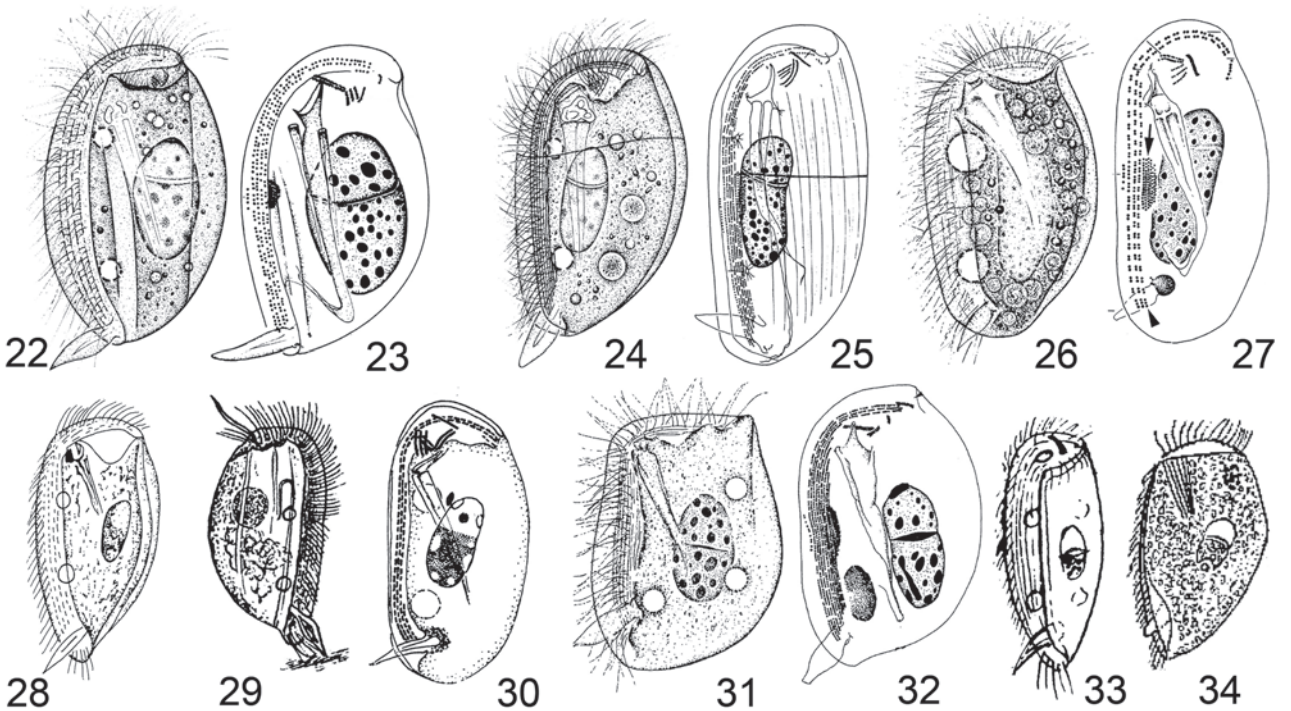
eight basal bodies (Figs 4, 14, 15). Equatorial fragment is composed of six to twenty seven basal bodies. Constantly two short rows are positioned near and parallel to the anterior ends of the rightmost right kineties; outer row consisting of about five to ten kinetosomes, and inner three to five kinetosomes (Figs 4–8, 15).

Two circumoral kineties are parallel to each other and almost equal in length, transversely positioned; preoral kinety is relatively short, located anteriorly with orientation almost orthogonal to, circumoral kineties; left frontal kineties are in three short rows, almost longitudinally oriented, positioned between circumoral and preoral kineties (Figs 4–8, 16, 17). Many fine and straight stripes on the surface of plates are recognized after protargol impregnation (Fig. 20).

Comparison with congeners. In the original description of *Dysteria lanceolata* by Claparède and Lachmann (1859), only a few living features (body shape and size, two contractile vacuoles, macronucleus shape) were described, Kahl (1931) did not supply new data of the species in his review either. In the absence of any information of infraciliature, we identify the test organism as *D. lanceolata*, on the basis of its body shape and size, presence of two contractile vacuoles and its marine habitat.



Figs 9–21. Photomicrographs of *Dysteria lanceolata* from life (9–13) and after protargol impregnation (14–21). **9–11 –** left side view of typical individuals, showing the podite (arrows), the contractile vacuoles (arrowheads), and the cytopharynx (double-arrowheads); **12** – surface of the left plate, showing the longitudinal groove (arrowheads), and the ectosymbiotic bacteria (arrows); **13** – a close-up of the anterior portion, double-arrowheads indicate the cytopharynx, arrowhead marks the terminal fragment, and arrow indicates the short row near the anterior end of the frontoventral kineties; **14–15** – left side view of the anterior portion, arrow in (14) notes the frontoventral kineties, arrow in (15) marks the short row near the anterior end of the frontoventral kineties, arrowheads in (14, 15) indicate the terminal fragments; **16–17** – oral area showing the oral infraciliature, arrow in (16) marks the circumoral kineties, arrow in (17) indicates the left frontal kineties, arrowhead notes the cytostome; **18** – left side view of an oval individual showing the infraciliature, arrow indicates left kineties, arrowhead depicts the equatorial fragment, double-arrowheads mark the cytopharynx; **19** – left side view of a rectangular individual, arrow marks left kineties, arrowheads note the contractile vacuole pores; **20** – showing the fine stripes on lateral plate; **21** – showing two distinct contractile vacuole pores. Scale bars: 20 μm.



Figs 22–34. Morphology and infraciliature of related *Dysteria* species. **22–23** – *D. semilunaris* (Gourret and Roeser, 1886) Kahl, 1931 (from Gong *et al.* 2007); **24–25** – *D. pectinata* (Nowlin, 1911) Kahl, 1931 (from Gong *et al.* 2007); **26–27** – *D. cristata* (Gourret and Roeser 1888) Kahl, 1931 (from Gong *et al*. 2002); **28–29** – *D. proraefrons* James-Clark, 1866 (from Kahl 1931); **30** – *D. ovalis* (Gourret and Roeser 1886) Kahl, 1931 (from Fauré-Fremiet 1965); **31–32** – *D. parovalis* Wilbert and Song, 2005 (from Wilbert and Song 2005); **33** – *D. navicula* Kahl, 1928 (from Kahl 1928); **34** – *D. reesi* Khal, 1931 (from Kahl 1931).

Table 1. Morphometric characteristcs of *Dysteria lanceolata* from protargol-impregnated specimens.

Character	Min	Max	Mean	SD	SE	CV	n
Body length	52	75	61.8	7.1	1.23	11.5	33
Body width	36	56	43.2	4.8	0.84	11.1	33
No. of right kineties	6	7	6.6	0.5	0.08	7.6	42
No. of frontoventral kineties	2	3	2.8	0.4	0.06	14.3	42
No. of left kineties	6	11	8.7	1.4	0.32	16.1	19
No. of basal bodies in single row of frontoventral kineties	137	220	168.0	21.8	4.76	13.0	21
No. of basal bodies in terminal fragment	6	8	7.2	0.9	0.23	12.5	15
No. of basal bodies in equatorial fragment	6	27	14.4	6.3	1.11	43.8	32
Macronucleus length	23	32	26.2	3.0	0.46	11.5	42
Macronucleus width	15	24	18.4	2.1	0.32	11.4	42

All measurements in μm. CV – coefficient of variation in %; Max. – maximum; Mean – arithmetic mean; Min. – minimum; n – number of individuals examined; SD – standard deviation; SE – standard error of the mean.

Dysteria pectinata (Nowlin, 1911) Kahl, 1931 is very similar to *D. lanceolata* in terms of body size, having two contractile vacuoles, 6 or 7 right kineties, 2 or 3 frontoventral kineties and marine habitat (Table 2). However, these two taxa can be separated by the pattern of oral ciliature: two parallel rows of circumoral kineties obliquely (*vs*. transversely) positioned; three left frontal kineties positioned right of circumoral kineties (*vs*. between circumoral and preoral kineties, almost longitudinally oriented) (Figs 4, 25). In addition, *D. pectinata* is also different from *D. lanceolata* in body shape (semi-oval *vs.* oval) and macronucleus shape (elongate *vs.* ovoid) (Figs 1, 24; Gong *et al.* 2007).

Among the well-investigated *Dysteria* spp., *D. semilunaris* (Gourret and Roeser, 1886) Kahl, 1931 and *D. cristata* (Gourret and Roeser, 1888) Kahl, 1931 resemble *D. lanceolata* in terms of the oval body shape and marine habitat (Gourret and Roeser 1886, 1888; Kahl 1931; Gong *et al.* 2002, 2007). However, *D. semilunaris* differs from *D. lanceolata* in having smaller body size (20–40 × 12–20 *vs*. 60–80 × 30–60 μm), four right kineties (*vs*. six or seven) and 57–86 (*vs*. 137–220) basal bodies in each row of frontoventral kinety (Table 2; Figs 22, 23). *D. cristata* can be distinguished from *D. lanceolata* in having smaller body size (40–50 × 25–30 *vs*. 60–80 × 30–60 μm), three right kineties (six or seven) and five to seven left kineties (six to eleven) (Table 2; Figs 26, 27).

Dysteria ovalis (Gourret and Roeser, 1886) Kahl, 1931 and *D. parovalis* Wilbert et Song, 2005 more or less resemble *D. lanceolata* in body shape (Gourret and Roeser 1886, Kahl 1931, Fauré-Fremiet 1965, Wilbert and Song 2005). However, *D. ovalis* has four (*vs.* six or seven) right kineties, one (*vs*. two) contractile vacuole, and *D. parovalis* has nine (*vs*. six or seven) right kineties, three (*vs.* two) contractile vacuoles, therefore, these two taxa can be clearly separated from *D. lanceolata* (Table 2; Figs 30–32).

In terms of oval body shape, body size and marine habitat, *Dysteria lanceolata* is similar to *D. proraefrons* James-Clark, 1866 and *D. reesi* Kahl, 1931, the infraciliature of which remain unknown (Kahl 1931). Nevertheless, Kahl (1931) presented two illustrations of *D. proraefrons* showing that ribs might be present or absent on the left plate of the cell, while the dorsal margin in the posterior portion of the cell appears to be slightly sigmoid (*vs*. convex in *D. lanceolata*) (Table 2; Figs 28, 29). *D. reesi* differs from *D. lanceolata* mainly in the following two features: (1) two plates are almost equal in size (*vs*. the right plate is obviously the left in *D. lanceolata*), (2) a conspicuous pigment spot in the left anterior end (Table 2; Fig. 34).

Dysteria navicula Kahl, 1928, whose infraciliature has to be revealed, may resemble *D. lanceolata* in the body shape and marine habitat. However, *D. navicula* can be separated from *D. lanceolata* by the body length:width ratio (about 5:2 *vs*. 3:2), and having several (*vs.* two) contractile vacuoles (Table 2; Fig. 33; Kahl 1928).

Lynchella nordica Jankowski, 1968 (Tables 3, 4 and Figs 35–59)

In general, the Qingdao population corresponds well with the original description (Jankowski 1968) and the redescription (Deroux 1970). The following redescription emphasizes on details of the living morphology, updates the species definition as well as species separation within the genus.

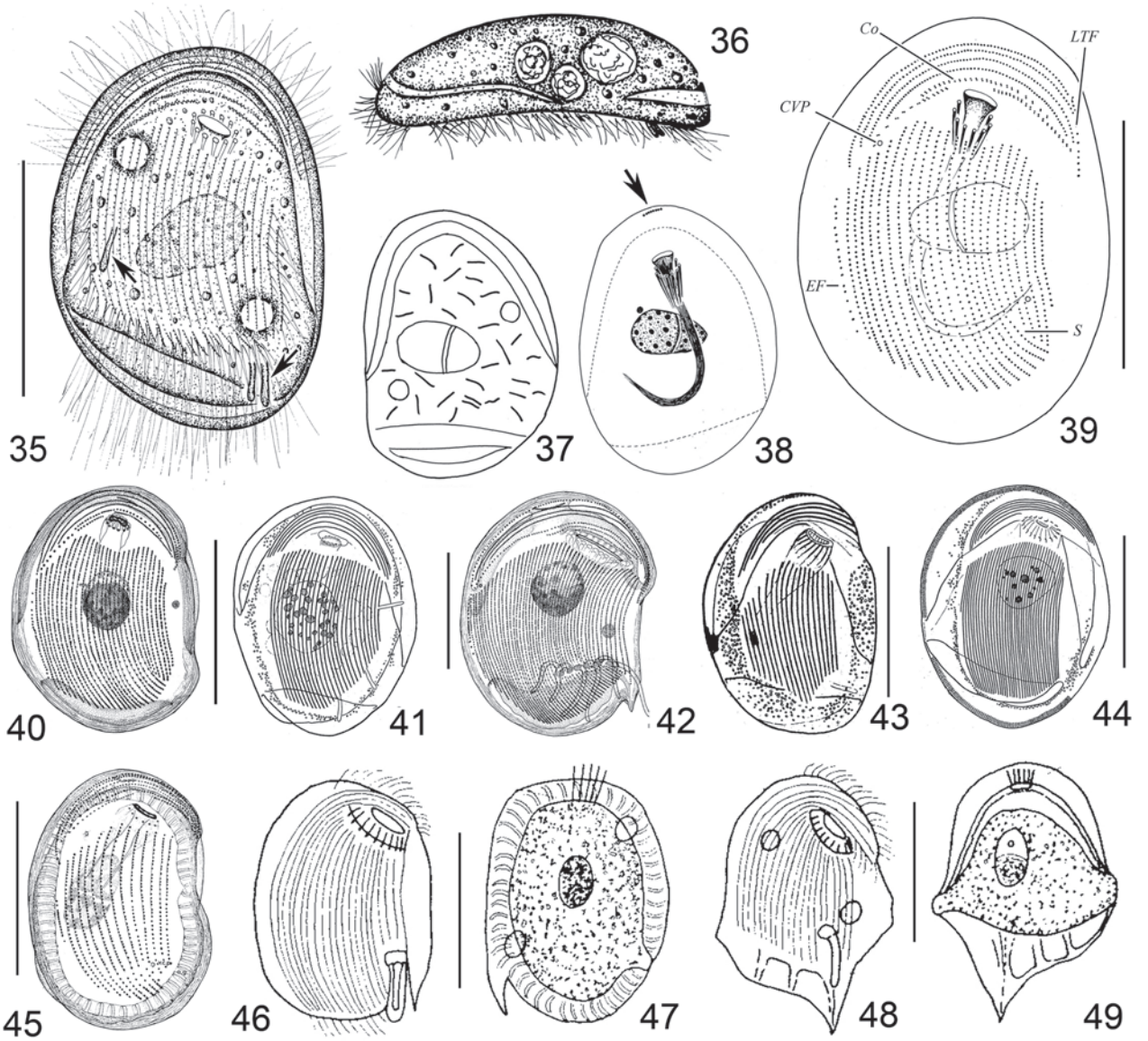
Improved diagnosis. Marine *Lynchella*, size about 50 × 35 μm *in vivo*; with consistently four preoral and 23–31 postoral kineties, three circumoral kineties; 12–16 nematodesmal rods; usually three finger-like tentacles on the ventral side; macronucleus ovoid; two contractile vacuoles diagonally located.

Description. Size 45–60 × 30–45 μm *in vivo*. Body outline oval or slightly kidney shaped when viewed dorsoventrally; both ends broadly rounded, left margin straight to slightly concave, right distinctly convex (Figs 35, 50). Distinctly dorsoventrally flattened about 3:1. Ventral side flat, usually with inconspicuous depression, dorsal slightly vaulted (Figs 36, 54). Perimeter between ventral and dorsal surfaces with two distinct grooves (3 μm in width): anterior one C-shaped, positioned around anterior 3/4 of body perimeter, posterior one relatively shorter (Figs 35, 50, 51, 55). Pellicle rather robust. Resting extrusomes granule-like, each about 0.4–0.5 μm across *in vivo* (*ca.* 1.5 μm long after protargol impregnation), sparsely distributed on dorsal surface (Figs 37, 53). Usually three finger-like tentacles, each about 4 μm long; two tentacles located left posterior and one always located on right of equator (Figs 35, 52). Cytoplasm is colourless and hyaline with several to many differently sized granules and food vacuoles measuring 2–3 μm across (Fig. 35). Cytostome is prominent about 5 μm in diameter, positioned sub-apically and slightly left of midline. Cytopharyngeal basket is hook-like, about 70% of cell length after protargol impregnation is diagonally oriented, and

Table 2. Comparison of *Dysteria lanceolata* with its eight closely related congeners.

Character	*D. lanceolata*	*D. semilunaris*	*D. pectinata*	*D. cristata*	*D. proraefrons*	*D. ovalis*	*D. parovalis*	*D. navicula*	*D. reesi*
Body length *in vivo* (μm)	60–80	20–40	60–100	40–50	*ca.* 70	–	70–50	35–45	59–68
Body shape from side view	oval	oval	semi-oval	approx. oval	oval	rectangular	broadly oval	elongate	approx. oval
RK number	6–7	4	7	3	–	4	9	–	–
LK number	6–11	5–8	6–8	5–7	–	–	6–8	–	–
FvK number	2–3	2	2	2	–	2	3	–	–
Basal bodies in each FvK	137–220	57–86	110–157	72–90	–	–	–	–	–
Basal bodies in TF	6–8	2–5	9	3–5	–	–	–	–	–
Basal bodies in EF	6–27	2–9	3–27	3–9	–	–	ca. 10	–	–
Macronucleus shape after fixation	ovoid	ovoid	elongate	ellipsoid	ellipsoid	ellipsoid	ovoid	ovoid	ovoid
Macronucleus size after fixation (μm)	30 × 20	15 × 6	35 × 15	13 × 6	–	–	25 × 15	–	–
CV number	2	2	2	2	2	1	3	ca. 4	–
Podite position	subcaudally	caudally	subcaudally	subcaudally	subcaudally	subcaudally	in posterior 1/4 of body	subcaudally	in posterior 1/4 of body
Podite size *in vivo* (μm)	*ca.* 10	*ca.* 10	*ca.* 20	*ca.* 8	–	–	*ca.* 10	–	–
Geographical distribution	Yellow Sea, Qingdao	Yellow Sea, Qingdao	Yellow Sea, Qingdao	South China Sea, Zhanjiang	North Sea, Norwegian	Mediterranean, Marseilles	Antarctic, Potter Cove	North Sea, Germany	North Sea, Germany
Data source	original	Gong *et al.* 2007	Gong *et al.* 2007	Gong *et al.* 2002	Kahl 1931	Kahl 1931, Fauré-Fremiet 1965	Wilbert and Song 2005	Kahl 1928, 1931	Kahl 1931

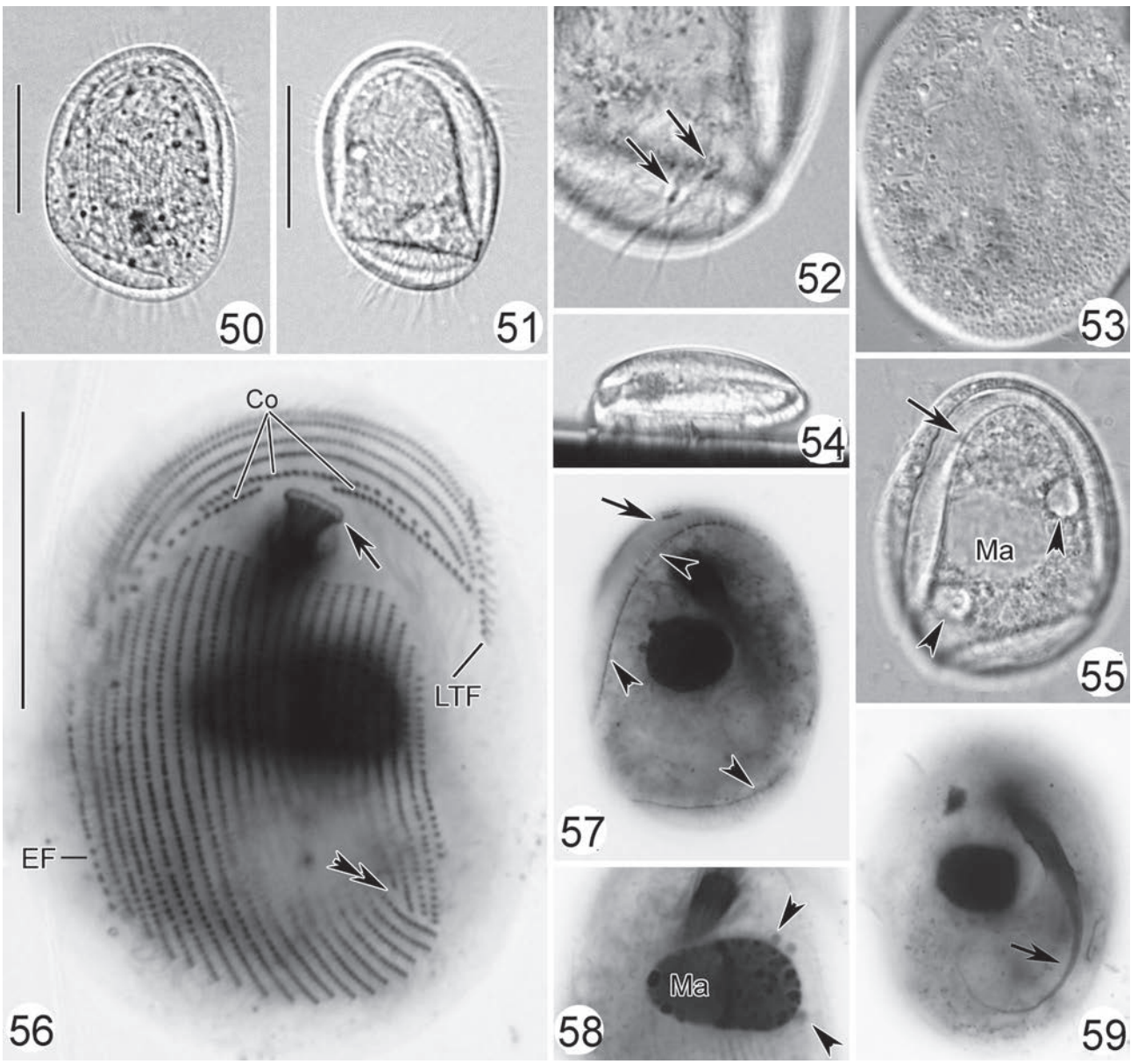
– Data not available.
CV – contractile vacuole; EF – equatorial fragment; Fvk – frontoventral kineties; LK – left kineties; RK – right kineties; TF – terminal fragment.



Figs 35–49. Morphology and infraciliature of *Lynchella nordica* (35, 36 from life, 37–41 after protargol impregnation) and related species. **35 –** ventral view of a typical individual, arrows indicate club-shaped protuberances; **36** – lateral view; **37** – showing the bar-shaped extrusomes scattered on the dorsal surface; **38** – showing the macronucleus and cytopharynx, arrow indicates the anterior terminal fragment; **39–41** – ventral views of infraciliature (39 original, 40 from Deroux 1970, 41 from Jankowski 1968); **42** – *L. tentaculata* (from Deroux 1970); **43** – *L. cypris* (from Jankowski 1968); **44** – *L. fencheli* (from Jankowski 1968); **45** – *Coeloperix dirempta* (Deroux, 1970) (from Deroux 1970); **46–47** – *Coeloperix aspidisciformis* (Kahl, 1933) (from Kahl 1933); **48–49** – *L. gradata* (from Kahl 1933). Co **–** circumoral kineties, CVP **–** contractile vacuole pore, EF **–** equatorial fragment, LTF **–** left anterior fragment, S **–** suture. Scale bars: 30 μm.

composed of twelve to fourteen toothed nematodesmal rods (Figs 38, 39, 59). Two contractile vacuoles are diagonally positioned (Figs 35, 55). Macronucleus is ovoid and heteromerous, on average 13 × 12 μm *in vivo*, positioned in body centre. Micronuclei are oval, three to five in number, adjacent to macronucleus. Most cilia are about 8 μm long, while those in posterior end of the body are longer (12–15 μm). Movement is by gliding on substratum or swimming. Feeds mainly on seaweed debris and microalgae.

Somatic kineties of monokinetids, distinctly separated into preoral and postoral regions at cytostome level. Consistently four preoral rows, arched along anterior margin of cell; 23–26 postoral rows, slightly



Figs 50–59. Photomicrographs of *Lynchella nordica* from life (50–55) and after protargol impregnation (56–59). **50–51** – ventral and dorsal views; **52** – details of posterior part, arrows indicate the club-shaped protuberances; **53** – focusing on the granule-like extrusomes on dorsal surface; **54** – lateral view; **55** – dorsal view, arrow indicates the dominant groove, arrowheads note two diagonally located contractile vacuoles; **56** – ventral view of infraciliature, arrow indicates the cytostome, double-arrowheads mark the suture between right and left fields of postoral kineties; **57** – general view of the dorsal surface, arrow marks the anterior terminal fragment, arrows denote the edge of groove after impregnation; **58** – showing several micronuclei (arrowheads) adjacent to macronucleus; **59 –** arrow indicates the long cytopharynx. Co – circumoral kineties, EF – equatorial fragment, LTF – left anterior fragment, Ma **–** macronucleus. Scale bars: 30 μm.

curved, anteriorly terminating at about cytostome level. Postoral kineties in left and right field making an inconspicuous suture (Figs 39, 56). Kinetosomes in posterior portion of right kineties relatively densely arranged (Fig. 39). Two terminal fragments: one antero-dorsally positioned, slightly left of midline, composed of about eight kinetosomes (Figs 39, 57, arrows); the other on anterior left margin of cell, with about ten kinetosomes (Figs 39, 56). Equatorial fragment consisting of about twenty kinetosomes, positioned near the right-most

Table 3. Morphometric characteristcs of *Lynchella nordica* from protargol-impregnated specimens. Population 20050519 upper line, Population 20060611 lower line.

Character	Min	Max	Mean	SD	SE	CV	n
Body length	38	51	45.8	4.2	1.33	9.1	10
	31	49	40.2	4.2	0.84	10.4	25
Body width	30	41	34.9	3.7	1.17	10.6	10
	27	38	30.9	2.7	0.54	8.7	25
No. of postoral kineties	24	25	24.9	0.3	0.09	1.2	10
	23	26	24.0	0.8	0.16	3.3	25
No. of preoral kineties	4	4	4.0	0	0	0	10
	4	4	4.0	0	0	0	25
No. of left kineties	6	6	6.0	0	0	0	10
	6	6	6.0	0	0	0	25
No. of right kineties	18	19	18.9	0.3	0.09	1.6	10
	17	20	18.0	0.8	0.16	4.4	25
No. of kinetosomes in left terminal fragment	8	12	10.6	2.3	0.73	21.7	10
	4	13	9.8	1.1	0.22	11.2	25
No. of kinetosomes in anterior terminal fragment	6	10	8.1	1.5	0.47	18.5	10
	6	10	7.5	1.2	0.24	16.0	25
No. of kinetosomes in equatorial fragment	5	47	23.6	14.4	4.55	61.0	10
	6	38	14.2	8.7	1.74	61.3	25
No. of nematodesmal rods	–	–	–	–	–	–	–
	12	14	12.2	0.7	0.23	5.7	9
Macronuclear length	10	14	12.6	1.3	0.41	10.3	10
	10	15	13.0	1.3	0.26	10.0	25
Macronuclear width	9	13	10.6	1.2	0.38	11.3	10
	8	12	10.1	1.2	0.24	11.9	25

All measurements in μm. CV – coefficient of variation in %; Max. – maximum; Mean – arithmetic mean; Min – minimum; n – number of individuals examined; SD – standard deviation; SE – standard error of the mean.

Table 4. Morphological comparison among three populations of *Lynchella nordica* and four related congeners.

Character	*L. nordica*	*L. nordica*	*L. nordica*	*L. tentaculata*	*L. cypris*	*L. fencheli*	*L. gradata*
Body size *in vivo* (μm)	50 × 40	62 × 45	40–55*	75–100*	50 × 36	70 × 52	50–60*
Body shape	oval	oval	oval	oval	oval	oval	with sharp pointed tail
No. of postoral kineties	23–26	28–31	28–30	45–50	19–22	38–39	–
No. of preoral kineties	4	–	4	4	–	–	–
No. of right kineties	17–20	–	ca. 22	ca. 40	–	–	–
No. of left kineties	6	–	7	7	–	–	–
No. of nematodesmal rods	12–14	15–16	12–14	20–24	14–16	19–20	–
No. of ventral tentacles	*ca.* 3	*ca.* 3	–	5–7	–	–	1
Data source	Present work	Jankowski 1968	Deroux 1970	Deroux 1970	Jankowski 1968	Jankowski 1968	Kahl 1933

– Data not available.
*Body length.

postoral ciliary row (Figs 39, 56). Two contractile vacuole pores usually recognizable after protargol impregnation. Circumoral kineties of dikinetids, comprising one anterior and two posterior rows, all transversely positioned. Anterior one is relative longer and parallel to posterior two rows. (Figs 39, 56).

Remarks. *Lynchella nordica* was originally described by Jankowski (1968) with notes of some important characters, such as body size and shape, the pattern of grooves in body perimeter, and the numbers of postoral somatic kineties and nematodesmal rods (Fig. 41). Subsequently, Deroux (1970) redescribed a French population in detail with additional information including somatic and perioral ciliary pattern (Fig. 40). We supply some living features of the species based on observations of the Qingdao population, *e.g.*, the number and positions of contractile vacuoles, the finger-like tentacles, the granule-like extrusomes, which could be helpful for species identification during ecological surveys.

Our rediscovery of *Lynchella nordica* in Qingdao has confirmed that the species indeed has no cross-striated band (CSB) in its lateral grooves. The absence or presence of CBS in grooves can, therefore, be a consistent character for species (or higher rank) separation, which further supports the re-establishment of the genus *Coeloperix* that highly resembles *Lychella* but differs in having a CSB (Gong and Song 2004).

Since several CSB-bearing "*Lynchella*" species (e.g. *Coeloperix dirempta* (Deroux, 1970) and *C. aspidisciformis* (Kahl, 1933)) have been transferred into the *Coeploperix* (Figs 45–47), a key to *Lynchella* spp. is here updated:

1	poterior end distinctly pointed	*L. gradata*
1'	poterior end rounded	2
2	three circumoral kineties parallel and almost equal in length	*L. cypris*
2'	three circumoral kineties comprising one longer anterior and two shorter posterior rows	3
3	fewer postoral kineties	*L. nordica*
3'	more than 35 postoral kineties	4
4	with five to seven ventral tentacles	*L. tentaculata*
4'	without ventral tentacle	*L. fencheli*

Chlamydonyx paucidentatus Deroux, 1976 (Table 5 and Figs 60–72)

The infraciliature of the Qingdao population corresponds well to the original description (Deroux 1976c). We here provide a brief redescription of the population.

Improved diagnosis. Marine *Chlamydonyx* with oval body shape, size about 40–75 × 30–50 μm *in vivo*; five to six right, seven postoral and nine to eleven left kineties; two circumoral and one preoral kineties; macronucleus ellipsoidal; three contractile vacuoles.

Description. Size usually 60 × 40 μm *in vivo*; body oval in outline when viewed from ventral side. Dorsoventrally flattened about 3:2, ventral side flat and dorsal side humped. Cytostome oval, ventrally located in anterior 1/5 of cell. About six nematodesmal rods are conspicuous *in vivo*. Cytoplasm is colourless and contains numerous small, greasily shinning globules and food vacuoles, which often render cells slightly grayish. Three contractile vacuoles are each about 3 μm in diameter, of which two lie on the right margin of the ventral side, and one is caudally positioned (Fig. 60). Podite is about 8 μm long and subcaudally positioned (Figs 60, 61, 66, 67). Cilia is about 4–5 μm. Movement is slow gliding.

Infraciliature as shown in Figs 63, 64, 69, 71. Somatic kineties of monokinetids. Five to six rows in right field, nine to eleven rows in left field, and consistently seven rows in postoral area. Rightmost two kineties are almost equal in length, extending anteriorly to anterior margin; other right kineties are progressively shortened from right to left, the innermost right kinety terminate anteriorly near cytostome. One terminal fragment consisting of about ten kinetosomes, always positioned at anterior ends of two rightmost kineties (Figs 64, 71). Postoral and left kineties are progressively shortened in their posterior ends from right to left in most specimens (Fig. 64), whereas in a few individuals, leftmost four postoral kineties are almost equal in length, and posterior terminated at same level with left kineties (Fig. 63). Equatorial fragment composed of about seven to twenty three closely spaced kinetosomes (Figs 64,

Table 5. Morphometric characteristcs of *Chlamydonyx paucidentatus* from protargol-impregnated specimens.

Character	Min	Max	Mean	SD	SE	CV	n
Body length	43	71	55.3	5.7	1.10	10.3	27
Body width	32	45	37.8	3.7	0.71	9.8	27
No. of preoral kinety	1	1	1.0	0	0	0	27
No. of circumoral kineties	2	2	2.0	0	0	0	27
No. of right kineties	5	6	5.4	0.5	0.10	9.3	27
No. of left kineties	9	11	10.6	0.6	0.12	5.7	27
No. of postoral kineties	7	7	7.0	0	0	0	27
No. of basal body-like granules near base of podite	8	13	10.8	1.4	0.27	13.0	27
No. of kinetosomes in equatorial fragment	7	23	15.9	4.8	0.92	30.2	27
Macronuclear length	16	27	22.4	3.0	0.57	13.4	27
Macronuclear width	15	18	17.0	1.1	0.21	6.5	27

All measurements in μm. CV – coefficient of variation in %; Max – maximum; Mean – arithmetic mean; Min – minimum; n – number of individuals examined; SD – standard deviation; SE – standard error of the mean.

69). Eight to thirteen kinetosome-like granules are invariably present near the base of podite (Figs 64, 72). Macronucleus is ellipsoidal, heteromerous, 22 × 17 μm after protargol impregnation. Micronucleus is not detected. Two circumoral kineties and one preoral kinety, all composed of dikinetids and are obliquely transverse positioned (Figs 64, 71). Cytopharyngeal basket is conspicuous after protargol impregnation (Fig. 70).

Remarks. *Chlamydonyx paucidentatus* is the only species known for this genus. The Qingdao population is identified mainly based on the body shape and size, the number of somatic kineties and the pattern of buccal ciliature, and the marine habitat (Deroux 1976c).

The nominal species *Trochilioides recta* (Kahl, 1928) must be mentioned, as it has similar body shape, body size (40–75 μm *vs*. 45–75 μm), and perhaps also general pattern of infraciliature with *Chlamydonyx paucidentatus* (see Fig. 63). However, the generic name *Trochilioides* is a nomen nudum according to ICZN (1999), because the type species has not been designated, since Kahl (1931) transferred four *Trochilia* species into the new taxon *Trochilioides*. Meanwhile, although species (*e.g.*, *T. recta*) have been described using silver impregnation (Deroux 1976c), a diagnostic description of *Trochilioides* is still needed for generic/species separation of *Trochilioides* and *Chlamydonyx*.

Re-establishment of *Trochilioides* Kahl, nov. gen.

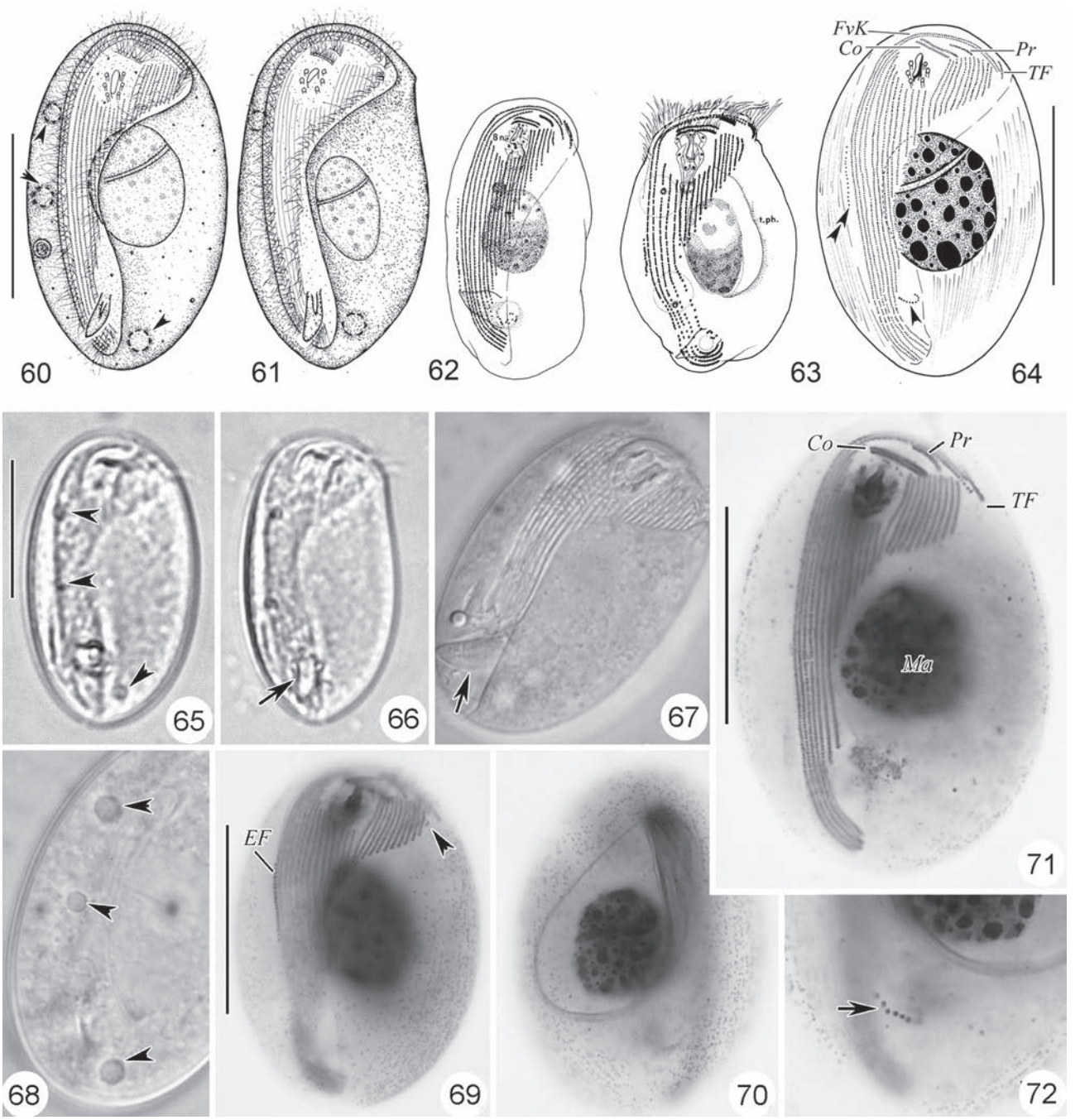
Improved diagnosis: Hartmannulids with one preoral and two circumoral kineties, number of nematodesmal rods generally six; postoral and left kineties short, roughly equal in length and positioned anterior of equator.

Type species: *Trochilioides recta* (Kahl, 1928), nov. comb. (basionym: *Trochilia recta* Kahl, 1928).

Species assignable: *Trochilioides recta* (Kahl, 1928), nov. comb., *T. trivialis* (Fenchel, 1965) nov. comb., *T. littoralis* (Jankowski, 1967) nov. comb., *T. bathybius* (Jankowski, 1967) nov. comb., *T. tenuis* (Deroux, 1976) nov. comb., *T. dispar* (Fauré-Fremiet, 1965) nov. comb., *T. crassa* (Levander, 1894) nov. comb., *T. striata* (Buddenbrock, 1920) nov. comb. and *T. dubia* (Wallengren, 1903) nov. comb.

Compared with related genera: Within the family Hartmannulidae, features like the number and patterns of oral kineties, the number of nematodesmal rods, and the pattern of postoral and left kineties have been considered important for generic separation (Foissner 1984, Deroux 1994, Gong *et al*. 2009a). *Trochilioides* most resembles to *Chlamydonyx*, but differs in the pattern of postoral and left kineties (short, roughly equal in length and positioned anterior of equator *vs.* usually progressively shortened in posterior ends, and not all of them are positioned anterior of equator).

Based on our study and previously described forms of *T. recta*, we agree with Foissner *et al*. (1991) that the freshwater morphospecies *T. fimbriatus* Foissner, 1984 should be a junior synonym of *T. recta*, because of their exactly matched morphology and infraciliature (Deroux 1976c, Foissner 1984, Foissner *et al*. 1991).



Figs 60–72. *Chlamydonyx paucidentatus* from life (60–61, 65–68) and after protargol impregnation (62–64, 69–72). **60–61** – ventral views, arrowheads indicate the contractile vacuoles; **62** – ventral view of infraciliature (from Deroux 1976c); **63** – *Trochilioides recta* (Kahl, 1928) (from Deroux 1976c); **64** – ventral views of infraciliature, arrowhead indicates several kinetosomes-like granules arranged in a line near the base of podite, double-arrowheads mark the equatorial fragment; **65–66** – ventral views, arrowheads indicate the contractile vacuoles, arrows mark the podite; **67** – details of ventral view, showing the ciliary pattern, arrow marks the podite; **68** – arrowheads indicate the contractile vacuoles; **69**, **71** – infraciliature ventral view, arrowhead marks a short left kinety; **70** – showing the hook-shaped nematodesmata; **72** – arrow indicates several kinetosomes-like granules arranged in a line near the base of podite. Co – circumoral kineties, FvK – frontoventral kineties, Pr – preoral kineties, TF – terminal fragment. Scale bars: 30 μm.

Microxysma Deroux, 1976 is similar to *Trochilioides* with respect to their short postoral and left kineties (Deroux 1976c). However, these two genera can be separated by the number of nematodesmal rods (four *vs*. six). *Trochilioides* has three (*vs.* two) oral kineties, of which two are anterior to cytostome and one is in anterior left (*vs.* one is anterior left and one is anterior right to cytostome).

Acknowledgements. This work was supported by the Natural Science Foundation of China (Project number:41006086, 40976099), a grant from FANEDD (No. 2007B27) to JG, the Center of Biodiversity Research, King Saud University, Saudi Arabia, Ningbo Natural Science Foundation (No. 2011A610014), Scientific Research Fund of Zhejiang Provincial Education Department (No. Y201017789), the Discipline Project of Ningbo University (No. xkc11006), the Key Laboratory of Mariculture of Ministry of Education, Ocean University of China (No. 2009002) and K. C. Wong Magna Fund in Ningbo University. Thanks are due to Mr. Hongan Long for his help in sampling and kindly reading the first draft.

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Received on 2nd December, 2010; revised on 17th February, 2011; accepted on 3rd March, 2011