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Redescription of Two Known Species, *Gastrocirrhus monilifer* (Ozaki et Yagiu, 1942) and *Gastrocirrhus stentoreus* Bullington, 1940, with Reconsideration of the Genera *Gastrocirrhus* and *Euplotidium*

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Summary. The living morphology and infraciliature of two poorly known planktonic ciliates, *Gastrocirrhus monilifer* (Ozaki et Yagiu, 1942) and *G. stentoreus* Bullington, 1940, collected from coastal mollusc-farming waters off Qingdao, P. R. China, were described based on observations of specimens *in vivo* and following protargol impregnation. Since no recent data deriving from silver staining methods on these two species are available, detailed redescriptions were presented. Based on the previous and current studies, improved redefinition for two hitherto confused genera *Gastrocirrhus* and *Euplotidium* are supplied. The diagnosis for *Gastrocirrhus*: marine planktonic Gastrocirrhidae, cells generally cup- or bell-shaped with anterior end truncated; oral field broad and opening anteriorly; adoral zone of membranelles dominant, terminated deeply near cytostome after spiraling around bell-edge in one turn; undulating membrane single-structured; frontoventral cirri arranged in two rows, which are formed by multi-anlagen during morphogenesis; 5 or more well-developed transverse cirri; marginal and caudal cirri absent. Diagnosis for the genus *Euplotidium*: marine Gastrocirrhidae, body shape cylindrical to dorso-ventrally flattened, buccal apparatus being of *Euplotes*-pattern; about 10 frontoventral cirri sparsely distributed but not in rows; *ca* 5 transverse and one or more left marginal cirri; no caudal cirri. Based on the new definition and the data available, 5 nominal species are recognized in the genus *Euplotidium*: *E. itoi* Ito, 1958; *E. psammophilius* (Vacelet, 1961) Borror, 1972 [basonym: *Euplotes psammophilius* Vacelet, 1961]; *E. arenarium* Magagnini et Nobili, 1964; *E. helgae* Hartwig, 1980 and *E. prosaltans* Tuffrau, 1985, and 5 in *Gastrocirrhus*: *G. intermedius* Lepsi, 1928; *G. stentoreus* Bullington, 1940; *G. monilifer* (Ozaki et Yagiu, 1942) Curds et Wu, 1983 [junior synonym: *G. adhaerens* Fauré-Fremiet, 1954; *G. trichocystus* Ito, 1958]; *G. agitatus* (Noland, 1937) comb. n. [basonym: *Euplotidium agitatum* Noland, 1937] and *G. smalli* (Lei Y., Choi J. K. et Xu K., 2002) comb. n. [basonym: *Euplotidum smalli* Lei Y., Choi J. K. et Xu K., 2002].

Key words: *Euplotidium*, *Gastrocirrhus*, infraciliature, morphology, new combination.

INTRODUCTION

As in many other little-known marine ciliates, much disarray remains in the plankton euplotids, *Gastrocirrhus-Euplotidium-Cirrhogaster*-complex in terms of their generic separation as well as species identification (Kahl 1932, Bullington 1940, Borror 1972, Hill 1980, Curds and Wu 1983, Borror and Hill 1995). This confusion derives from many forms having been described on the basis of insufficient living observations. Other reasons include: (1) some features (e.g. distribution or arrangement of frontoventral cirri, number of transverse cirri, presence/absence of the marginal cirrus) are likely variable or inconspicuous, and hence are easily overlooked in some

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cases but often, unfortunately, used as a reliable diagnostic character and (2) many authors paid insufficient attention to comparing their populations with previous studies. Therefore, morphological data based on modern techniques, especially the structure of oral and somatic ciliature for most congeners of these genera are extremely necessary for accurate species identification.

Recently, two *Gastrocirrhus* species were found in maricultural waters along the coasts of Qingdao, China. Subsequent studies demonstrate that they belong to two known but poorly described organisms. Based on the comparison of related taxa, the re-definition of the confused *Gastrocirrhus-Euplotidium-Cirrhogaster*-complex and relationships among them are reconsidered and outlined. In the present paper, redescriptions of living morphology and infraciliature of these two species as well as the redefinitions of the genera *Gastrocirrhus* and *Euplotidium* are documented here.

MATERIALS AND METHODS

Samples were collected from the molluscs culturing waters off the coast of Qingdao (Tsingtao, 36°08'N; 120°43'E), China in August 2000 and May 2001. Salinity was about 32‰, water temperature was about 25°C and 15°C for *Gastrocirrhus monilifer* and *G. stentoreus*, respectively, and pH was *ca* 8.2. After isolation, a pure culture was kept for a few days at room temperature (25°C or so) in boiled seawater, to which crushed rice grains were added as a food source for bacteria.

Ciliates were examined with an Olympus microscope with bright field and differential interference contrast equipment. The protargol silver staining method according to Wilbert (1975) was used to reveal the infraciliature. All drawings on prepared specimens were performed at a magnification of x1250 with the help of a camera lucida. Measurements were made with an ocular micrometer.

RESULTS

Reconsideration of the genus *Gastrocirrhus* Lepsi, 1928

Syn. *Cirrhogaster* Ozaki et Yagiu, 1942

Since only very few studies on the *Gastrocirrhus-Euplotidium*-complex have been performed using silver staining or other modern methods, there is still some confusion in separation at the generic level considering their diagnosis and description on the patterns of infraciliature. Morphologically, however, the genus *Gastrocirrhus* could be clearly outlined, in our opinion, due to the features of non-differentiated frontoventral cirri, absence of marginal cirri, body shape, highly developed transverse cirri and the buccal apparatus (Lepsi 1928, Fauré-Fremiet 1954, Curds and Wu 1983, Dragesco and Dragesco-Kernéis 1986). Based on previous descriptions and the present data, we supply here an improved diagnosis for the genus *Gastrocirrhus*.

Diagnosis of the genus *Gastrocirrhus*: marine planktonic Gastrocirrhidae, cells generally cup- or bell-shaped with anterior end truncated; oral field broad and opening anteriorly; adoral zone of membranelles dominant, terminated deeply near cytostome after spiraling around bell-edge in one turn; undulating membrane single-structured; frontoventral cirri arranged in two rows, which are formed by multi-anlagen during morphogenesis; 5 or more transverse well-developed cirri; marginal and caudal cirri absent.

Remarks: as revealed recently, the morphogenesis of this genus is of the pattern of multi-anlagen (non-5-anlagen) considering the origin of the frontoventral cirri (Lei *et al.* 2002), which is thus clearly different from that of most "typical" euplotids (i.e. *Euplotes, Diophrys, Uronychia, Aspidisca*) (Deroux and Tuffrau 1965; Diller 1966; Song and Packroff 1993; Song 1995, 2003). This indicates that *Gastrocirrhus* might represent a "lower" and isolated group among "traditional" hypotrichs (Corliss 1979; Hill 1980, 1981; Curds and Wu 1983; Tuffrau and Fleury 1994; Lynn and Small 2000).

We agree with Curds and Wu (1983) that the genus *Cirrogaster* Ozaki et Yagiu, 1942 should be synonymized with *Gastrocirrhus.*

In 1937, Noland described a new marine form, *Euplotidium agitatum,* using it as the type species, and he established a monotypic genus, *Euplotidium*. Unfortunately, the infraciliature of this species remains hitherto unknown. Based on the living morphology and the arrangement of cirri in original description, nevertheless, it is reasonable to identify it as a member of *Gastrocirrhus*. Hence, we suggest a new combination, *G. agitatus* (Noland, 1937) comb. n. It differs from the "true" *Euplotidium* in the non-differentiated frontoventral cirri and absence of marginal cirri (see also below).

Recently, Lei *et al.* (2002) described a new form under the name of *Euplotidium smalli.* Considering the body shape and ciliary pattern, this species should be clearly assigned - as a new combination - to *Gastrocirrhus*: *G. smalli* (Lei Y., Choi J. K. et Xu K., 2002) comb. n.

Recognized species in the genus *Gastrocirrhus*: totally, 5 morphospecies are involved in this genus: *G. intermedius* Lepsi, 1928; *G. stentoreus* Bullington,

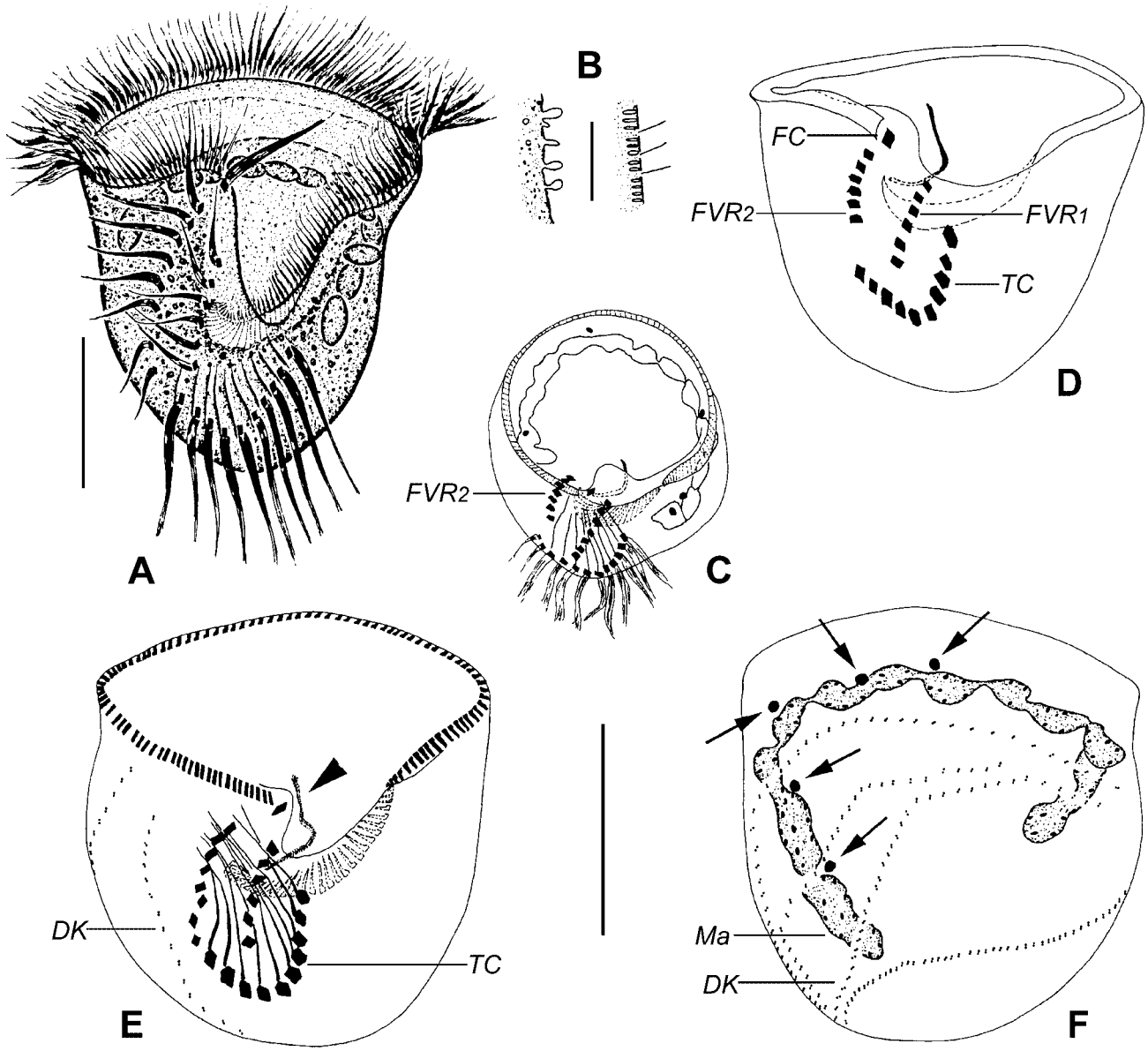

Fig. 1. Morphology of *Gastrocirrhus monilifer* from life (A, B) and after protargol impregnation (C-F). **A** - ventral view *in vivo*; **B** - pellicular structure; **C** - apical view, note infraciliature and nuclear apparatus; **D, E, F**- ventral (D,E) and dorsal (F) views of infraciliature, arrowhead-paroral membrane, arrows-micronuclei. DK - dorsal kineties, $FVR_{1,2}$ - left and right fronto-ventral row, Ma - macronucleus, TC - transverse cirri. Scale bars 50 µm (A, E, F); 10 µm (B).

1940; *G. monilifer* (Ozaki et Yagiu, 1942) Curds et Wu, 1983 [junior synonym: *G. adhaerens* Fauré-Fremiet, 1954; *G. trichocystus* Ito, 1958]; *G. agitatus* (Noland, 1937) comb. n. [basonym: *Euplotidium agitatum* Noland, 1937] and *G. smalli* (Lei Y., Choi J. K. et Xu K., 2002) comb. n. [basonym: *Euplotidum smalli* Lei Y., Choi J. K. et Xu K., 2002].

Redefinition of the genus *Euplotidium* Noland, 1937

Syn. *Paraeuplotidium* Lei, Choi et Xu, 2002

Similar to *Gastrocirrhus*, this genus is also insufficiently described considering its diagnosis and separation and no clear definition has been given though a "typical" *Euplotidium* might be more *Euplotes*-like as noticed by

Table 1. Morphometric data on *Gastrocirrhus monilifer* (first line) and *Gastrocirrhus stentoreus* (second line). All data based on protargol-impregnated specimens. Measurements in µm.

Character	Min	Max	Mean	SD	SE	CV	n
Body, length	80	136	101.4	15.01	3.64	14.8	17
	84	112	97.9	8.93	2.23	9.1	16
Body, width	80	118	93.6	9.78	2.37	10.4	17
	66	82	75.4	5.11	1.28	6.8	16
Adoral zone of membranelles, length	44	80	59.8	11.12	2.70	18.6	17
	50	71	61.4	6.09	1.52	9.9	16
Number of adoral membranelles	105	134	120.2	8.95	2.17	7.4	17
	73	91	83.4	6.18	1.55	7.4	16
Number of frontal cirri	1	1	1	0	0	0	17
	1	1	1	0	0	0	16
Number of cirri in fronto-ventral row (left row) 1	6	8	6.8	0.66	0.16	9.8	17
	5	6	5.1	0.25	0.06	4.9	16
Number of cirri in fronto-ventral row 2* (right row)	6	11	8.8	1.15	0.28	14.8	17
	8	10	8.6	0.62	0.15	8.1	16
Number of transverse cirri	10	10	10	0	0	0	17
	7	8	7.1	0.26	0.07	3.7	15
Number of macronuclear segments	10	14	-	-	-	-	-
	1	1	1	0	0	0	16
Macronucleus length of each segment	12	20	16.6	2.53	0.68	15.3	14
	-	-	-	-	-	-	-
Macronucleus width	5	12	8.5	1.79	0.48	21.0	14
	-	-	-	-	-	-	-
Number of micronuclei	4	9	5.4	1.22	0.30	22.8	17
	2	2	2	0	0	0	16
Micronucleus diameter	2.5	3	-	-	-	-	16
	4	4	4	0	0	0	16
Number of dorsal kineties	5	5	5	0	0	0	12
	5	5	5	0	0	0	16

* Including frontal cirrus

previous authors (Noland 1937, Ito 1958, Magagnini and Bobili 1964, Curds and Wu 1983, Lei *et al.* 2002). As a result deduced from the data obtained, the following diagnostic characters for this taxon can be summarized:

Diagnosis of the genus *Euplotidium*: marine Gastrocirrhidae, body shape cylindrical to dorso-ventrally flattened with buccal apparatus being of *Euplotes*-pattern; about 10 frontoventral cirri sparsely distributed; *ca* 5 transverse and one or more left marginal cirri; no caudal cirri.

Remarks: this genus was established by Noland (1937) with a monotype *Euplotidium agitatum.* Afterward several nominal species were added to this genus, which share, with the exception of the type species *E. agitatum* (see above), the same ciliary pattern (Ito 1958, Vacelet 1961, Magagnini and Bobili 1964, Hartwig 1980). According to the new definition, this taxon differs from the similar genus *Gastrocirrhus* in the presence of left marginal cirri and the fronto-ventral cirri being (basically) distributed in a sparse pattern (*vs.* in two-rowed pattern in the latter) (the pattern in *E. itoi* might be very likely misinterpreted). In addition, though morphogenetic data is still lacking, the frontoventral cirri of this genus possibly develop from 5-anlagen during divisional process, i.e. like most typical euplotids.

Lei *et al.* (2002) established a new genus, *Paraeuplotidium* to involve formerly *Euplotidium*-forms, which have single left marginal cirrus and (seemingly) sparsely distributed frontoventral cirri. We disagree with this arrangement because the genus *Euplotidium* is well known for a long time with several relatively clearly outlined morphotypes. Hence, we suggest a redefinition for this genus for the sake of stability and treat *Paraeuplotidium* as a junior synonym.

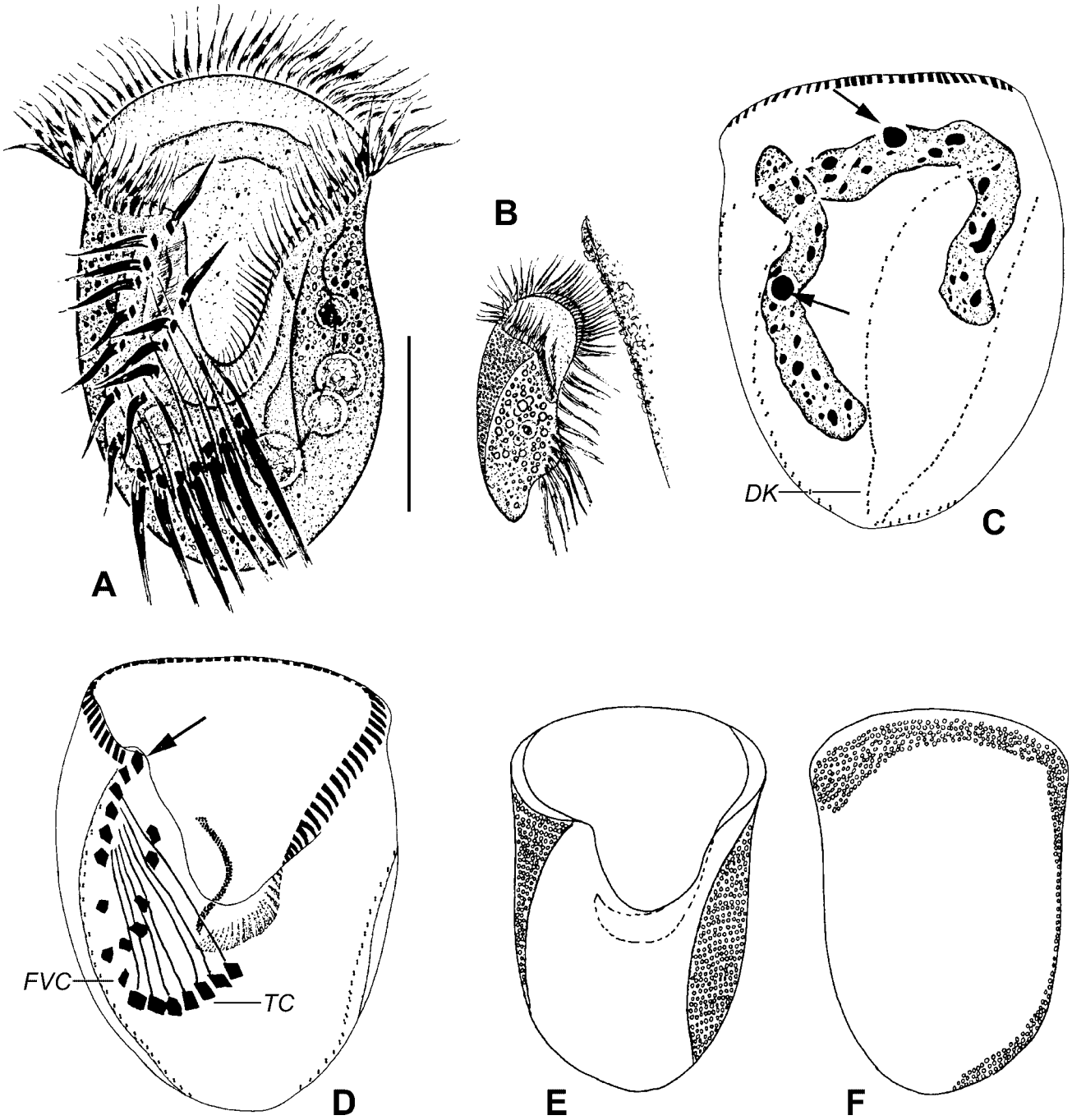

Fig. 2. Morphology of *Gastrocirrhus stentoreus* from life (A, B, E, F) and after protargol impregnation (C, D). **A** - ventral view *in vivo*; **B** - individual attaching to substrate when feeding; **C, D** - ventral and dorsal views of infraciliature, arrows in C - micronuclei, arrow in D - frontal cirrus; **E, F** - ventral and dorsal views, note the arrangement of trichocysts. DK - dorsal kineties, FVC - fronto-ventral cirri, TC - transverse cirri. Scale bar 40 μm.

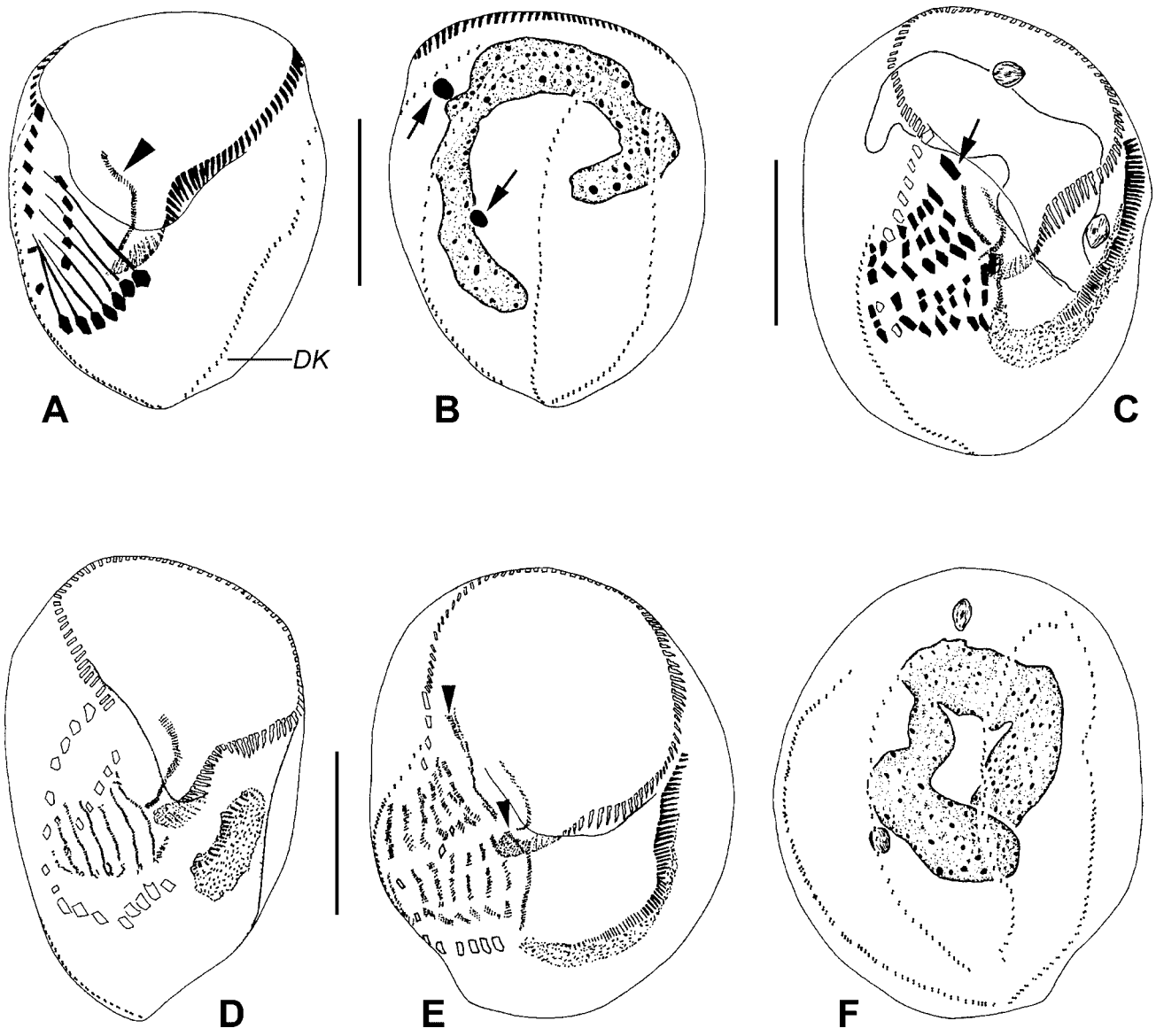

Fig. 3. Infraciliature (A, B) and morphogenesis (C-F) of *Gastrocirrrhus stentoreus* after protargol impregnation. **A, B** - ventral and dorsal views of infraciliature, arrowhead-paroral membrane, arrows-micronuclei; **C** - ventral view, note the formation of the new cirri and the development of the oral primordia, arrow-frontal cirrus; **D** - ventral view, the appearance of the oral primordia and the cirral anlagen; **E, F**- ventral and dorsal, arrowheads-the anlage for frontal cirrus. DK - dorsal kineties. Scale bars 40 μm.

Since the original type species, *Euplotidium agitatum* Noland, 1937 is transferred into the genus *Gastrocirrhus* (see above), according to ICZN (1999), article 70.3, a new type species is fixed:

Type species: *Euplotidium itoi* Ito, 1958

Recognized species in the genus *Euplotidium*: Based on the new understanding, this genus presently comprises the following five species: *E. itoi* Ito, 1958; *E. psammophilius* (Vacelet, 1961) Borror, 1972 [basonym: *Euplotes psammophilius* Vacelet, 1961]; *E. arenarium* Magagnini et Nobili, 1964; *E. helgae* Hartwig, 1980 and *E. prosaltans* Tuffrau, 1985.

Redescription of two known *Gastrocirrhus* species

Both species described below are known for a long time but no data concerning their infraciliature is avail-

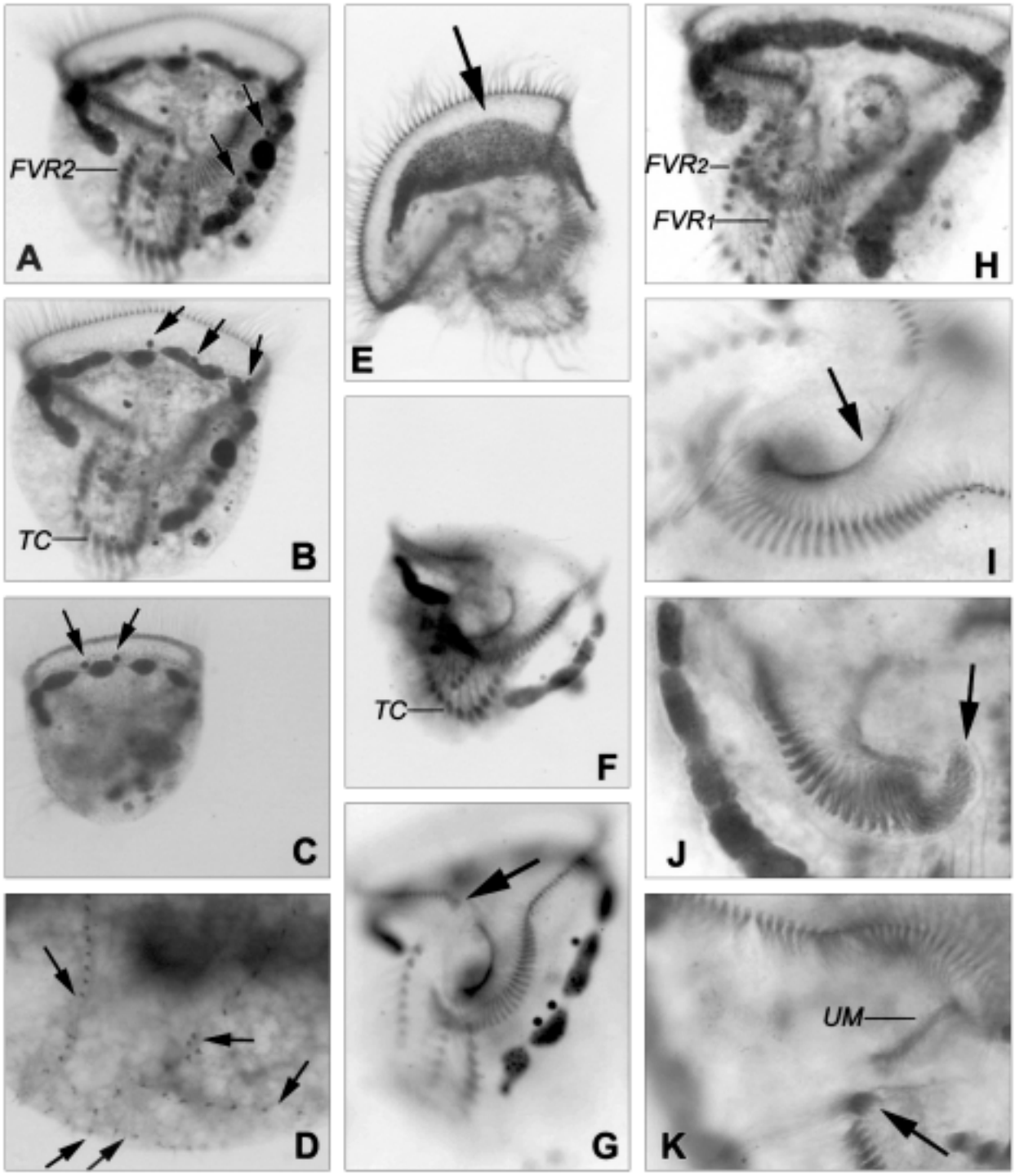

Fig. 4. Photomicrographs of morphology of *Gastrocirrhus monilifer* after protargol impregnation. **A, B, F-H, K** - ventral views of infraciliature, arrows in A, B - micronuclei, arrow in G, K - frontal cirrus; **C** - dorsal view, arrows - micronuclei; **D** - dorsal view, arrows - dorsal kineties; **E** - ventral view, arrow to show macronucleus just after division; **I** - ventral view, arrow to show undulating membrane; **J** - arrow - curvation at the posterior end of adoral zone of membranelles. $FVR_{1,2}$ - left and right fronto-ventral rows, TC - transverse cirri, UM - undulating membrane.

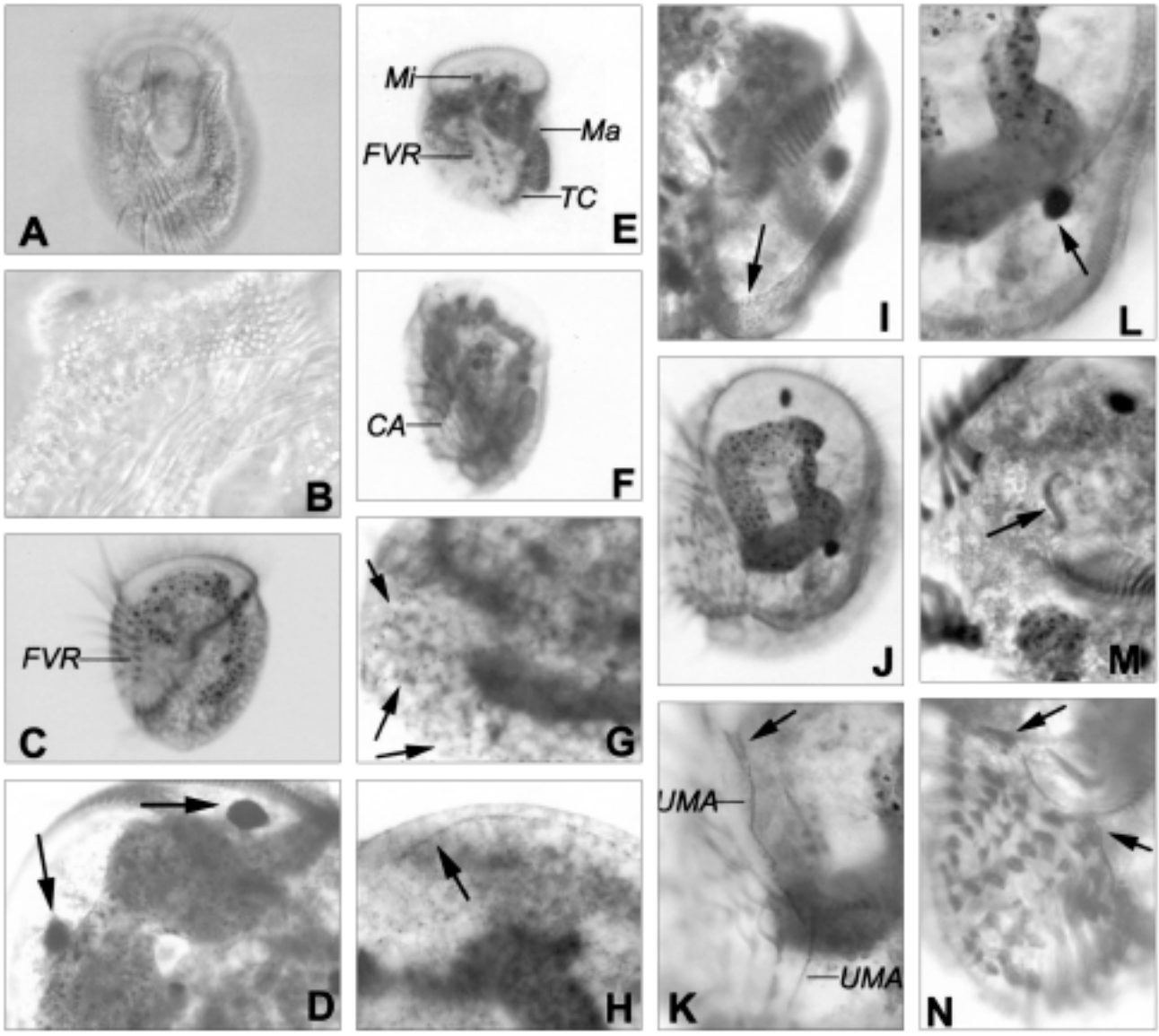

Fig. 5. Photomicrographs of morphology and morphogenesis of *Gastrocirrrhus stentoreus* from life (A, B) and after protargol impregnation (C-N). **A** - ventral view *in vivo*; **B** - trichocysts; **C, E** - infraciliature on ventral side; **D, L** - arrows-micronuclei; **F, J** - ventral view, note infraciliature in morphogenesis; **G** - dorsal view, arrows-dorsal kineties; **H** - arrow-dorsal kineties anlage; **I** - arrow-oral primordium in the opisthe; **K** - arrow-anlage for frontal cirrus; **M** - arrow-undulating membrane; **N** - ventral view, note the development of cirral anlagen, arrow -new frontal cirrus. CA - cirral anlagen, FVR - fronto-ventral rows, Ma - macronucleus, Mi - micronucleus, TC - transverse cirri, UMA - undulation membrane anlage.

able, hence their identification remains questionary. Based on the Qingdao populations we isolated recently, detailed redescriptions on both living morphology and infraciliature are supplied here.

***Gastrocirrhus monilifer* (Ozaki et Yagiu, 1942) (Figs 1, 4; Table 1)**

Syn. *Cirrhogaster monilifer* Ozaki et Yagiu, 1942
Gastrocirrhus adhaerens Fauré-Fremiet, 1954
Gastrocirrhus trichocystus Ito, 1958

This species was originally reported by Ozaki et Yagiu (1942) as *Cirrhogaster monilifer*. Thereafter no redescription was made on it until Curds et Wu (1983) in their revision paper transferred it to the genus *Gastrocirrhus* though the data about infraciliature on dorsal side are still lacking (Dragesco and Dragesco- Kernéis 1986; under the name of *Cirrhogaster adhaerens* Fauré-Fremiet, 1954). With reference to the living morphology (e.g. body size, shape, locomotion, and the general arrangement of the cirri), the Qingdao population corresponds

Table 2. Morphological comparison among the known *Gastrocirrhus*-species.

Species name	body length in µm	FVC, number*	TC, number	Ma, shape	MS, number	Reference
Gastrocirrhus intermedius	68	9	7	oval	1	Lepsi 1928
Gastrocirrhus monilifer Called *Cirrhogaster monilifer*	95-105	10	12	moniliform	11-15	Ozaki and Yagiu 1942
Gastrocirrhus monilifer Called *G. adhaerens*	100	16	12	moniliform	*ca* 12	Fauré-Fremiet 1954
Gastrocirrhus monilifer	95-103	18	13	moniliform	10-12	Ito 1958
Gastrocirrhus monilifer Called *Cirrhogaster adhaerens*	*ca* 100	16	12	bead-like	-	Dragesco and Dragesco-Kernéis 1986
Gastrocirrhus stentoreus	104	11	5	-	-	Bullington 1940
Gastrocirrhus smalli comb. n. Called *Euplotidium smalli*	100-140	13-14	7	C-shaped	2	Lei *et al.* 2002
Gastrocirrhus monilifer	100-140	12-19	10	moniliform	10-14	this study
Gastrocirrhus stentoreus	80-130	*ca* 13	7-8	ribbon-like	1	this study

* Including frontal cirrus; - No data available
FVC - fronto-ventral cirri; Ma - macronucleus; MS - macronuclear segments; TC - transverse cirri.

well with populations reported previously. Hence, the identification is rather certain.

Based on this study, a new diagnosis for this species is supplied here:

Diagnosis for *Gastrocirrhus monilifer*: *in vivo* about 100-140 µm long; macronucleus beaded with about 10-14 segments and 4-9 micronuclei; *ca* 120 membranelles; 6-8 frontoventral cirri in left row and 6-11 in right one; 10 transverse cirri; 5 dorsal kineties.

Morphology and infraciliature: body inverted-bell-shaped, *in vivo ca* 100-140 µm long. Oral field broad, opening anteriorly and concaved at middle-posterior portion, funnel-like (Fig. 1A). A well-developed adoral zone of membranelles (AZM) borders the C-shaped anterior body edge and winds clockwise down the left of the peristome, cilia of membranelles about 25 µm long; two oblique frontoventral rows, located to right of peristome (Figs 1C, D; 4A), of which frontal cirrus is rather thick, about 35 µm long and distributed anterior-most and near the distal end of AZM (FC - Figs1A, D; 4G, K, arrow). Transverse cirri situated along the posterior border, arranged in U-shaped (Figs 1D, E; 4B, F). Several ridges evidently occur between transverse cirri. Dorsal cilia about 4 µm long. Pellicle thin, sensitive to disturbance; cortical granules oval, *ca* 2 µm long, located vertical to pellicle (Fig. 1B). Endoplasm contains numerous granular inclusions, which render body dark at low magnification. Macronucleus moniliform, consisting of 10-14 pieces; 4-9 spherical micronuclei located adjacent to macronucleus (Figs 1C, F, arrows; 4A-C, arrows).

Locomotion by crawling on substrate or on bottom of Petri dish for most of the time, occasionally by jumping or swimming quickly for a short while.

Infraciliature as shown in Figs 1D-F and 4A-K. AZM composed of 105-134 membranelles; undulating membrane (UM) as a single structure, which is composed of rows of kinetosomes with 2-4 basal bodies each (Figs 1E, arrowhead; 4I, arrow, K). Eleven to eighteen frontoventral cirri in two rows (6-8 in left and 6-11 in right row); consistently 10 transverse cirri (n=17). Five dorsal kineties spiraled and converged at posterior end, of which the leftmost one is evidently longer than the others, with its anterior part transversely arranged, and the basal bodies in the fourth kinety (counted from left to right) are more densely packed (Figs 1E, F; 4D, arrows).

Comparison and discussion: this species can be clearly separated from its congeners by the following combined characters: the number of membranelles and the somatic cirri, as well as the presence of beaded macronucleus (Table 2).

Gastrocirrhus trichocystus Ito, 1958 is very possibly a junior synonym of *G. monilifer,* though the number of frontoventral cirri, as depicted in original report (Ito 1958) is higher than that in the latter. We consider them conspecific because this character is variable as well among individuals of our samples and we believe that this is a population-dependent feature.

In 1954, Fauré-Fremiet described a new species, *Gastrocirrhus adhaerens* without noticing the work by

Ozaki et Yagiu (1942), of which the infraciliature was (partly) studied by Dragesco and Dragesco-Kernéis (1986). Due to the great similarity to *G. monilifer*, in all aspects, i.e. the body size/shape, basic pattern of the ciliary organelles and the nuclear apparatus, both forms should be considered being conspecific (Dragesco, 1965). Hence, *Gastrocirrhus adhaerens* is synonymized with the former.

Gastrocirrhus stentoreus Bullington, 1940 (Figs 2, 3, 5; Table 1)

Since Bullington reported this species from Tortugas with no information about either the ciliature or the nuclear apparatus (Bullington 1940), no further studies have been carried out and hence its definition remains unclear. We identified our Qingdao-population basically because, compared with the original descriptions, our form possesses extremely similar size, body shape, general living appearances, as well as the number of frontoventral and transverse cirri. Based on the Qingdao population, we give here an improved diagnosis for this poorly studied species:

Diagnosis for *Gastrocirrhus stentoreus*: *in vivo* about 80-130 μm in length with long and ribbon-like macronucleus, 2 micronuclei; *ca* 80 membranelles; 5-6 frontoventral cirri in left fronto-ventral row and 8-10 in right one; 7-8 transverse cirri; 5 dorsal kineties.

Morphology and infraciliature: Cell likes the species described above, cup-shaped, *in vivo ca* 80-130 μm long (Figs 2A, 5A). A well developed adoral zone of membranelles (AZM) borders anterior cell edge and winds clockwise down the left of the peristome, cilia of membranelles about 25 μm long; two oblique frontoventral rows, located right to peristome (Figs 2D; 3A; 5C, E), of which frontal cirrus (FC - Fig. 2D, arrow) is evidently thick and distributed anterior-most, near the distal end of AZM, about 35 μm long. Transverse cirri situated posterior to cytostome, arranged in J-shape; and several ridges occur between transverse cirri. Dorsal kineties densely ciliated, cilia about 4 μm long. Trichocysts arranged in patches (Figs 2E, F; 5B). Endoplasm colorless to grayish, containing numerous granular inclusions and several large food vacuoles, which render cell opaque. Macronucleus ribbon-like, constantly two micronuclei attached to macronucleus (Figs 2C; 3B, arrows; 5D, L, arrows).

Movement modestly fast, by crawling on substrate or jumping back and forth; sometimes recognized with adoral membranelles sticking to substrate or surface of other substance when feeding (Fig. 2B).

Infraciliature as shown in Figs 2C, D; 3A-F and 5C-N: AZM composed of 73-91 membranelles; undulating membrane like in *Gastrocirrhus monilifer*, composed of rows of kinetosomes (Figs 3A, arrowhead; 5M, arrow). On average 5 cirri in left and 9 in right frontoventral row, in which the posterior 2-3 cirri of the right row are always far away from the others; 7-8 transverse cirri. Consistently 5 dorsal kineties aligned spirally and converged at posterior extremity (Figs 3A, B; 5G, arrows).

Several morphogenetic stages have been observed, which indicate the following features (Figs 3C-F; 5F, H-L, N): (1) Oral primordium appears on the surface of the cortex posterior to cytostome in the opisthe, which then develops into new membranelles posteriad and finally makes new adoral zone of membranelles (Figs 3C, D; 5I, arrow); (2) Fronto-ventral transverse cirral anlagen in both dividers are derived from the breaking of 7 streaks of primary primordia, which occur as a ladder-like structure in the middle part of the cell (Fig. 3D). Each anlage subsequently fragments and evolves into new cirri (Figs 3C, E); (3) The old AZM is possibly inherited by the proter; (4) The undulating membrane comes from the newly-formed anlage in both dividers, from which single frontal cirrus is also derived at the anterior end (Figs 3C, E, arrow and arrowheads; 5K, N, arrows); (5) The renewal of dorsal kineties occurs within the old structures (Fig. 5H, arrow).

Comparison and discussion: in terms of the body size, shape, the number of transverse cirri and dorsal kineties, *Gastrocirrhus stentoreus* is very similar to *G. smalli* (Lei Y., Choi J. K. et Xu K., 2002). However, both organisms can be separated by the feature of the macronuclear apparatus (single and ribbon-like in *G. stentoreus vs.* two segments in the latter) (Lei *et al.* 2002).

Different from other nominal congeners, *Gastrocirrhus stentoreus* can be recognized by combined features of number of frontoventral and transverse cirri and the number of macronuclear segments (Table 2) (Ozaki and Yagiu 1942, Fauré-Fremiet 1954, Curds and Wu 1983, Lei *et al.* 2002).

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