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Two New Marine Pleurostomatid Ciliates from China, *Loxophyllum jini* and *L. qiuianum* (Ciliophora: Pleurostomatida)

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Summary. The morphology of two marine pleurostomatid ciliates, *Loxophyllum jini* sp. n. and *L. qiuianum* sp. n., collected from coastal waters near Qingdao (Tsingtao), China, were investigated using observations *in vivo* and following protargol impregnation. *Loxophyllum jini* is identified by its large body size (about 300-600 µm long *in vivo*), multi-macronuclear nodules (8-17), several (3-7) contractile vacuoles along the dorsal margin of cell, and the somatic kineties on left (9-14) and right (13-20) side. As a new species, *L. qiuianum* distinguished from its congeners by a combination of characters including the marine habitat and the distribution of extrusomes, the terminal position of contractile vacuole and the numbers of somatic kineties on both the right and left sides (19-30 and 8-13).

Keywords: *Loxophyllum jini* sp. n., *L. qiuianum* sp. n., marine ciliates, morphology and infraciliature.

INTRODUCTION

Bilaterally compressed pleurostomatid ciliates are commonly reported from a variety of geographical habitats all over the world (Kahl 1931, Dragesco 1960, Borror 1963, Agamaliev 1967, Hartwig 1973, Fryd-Versavel *et al.* 1975, Foissner 1987, Wilbert and Kahan 1981, Li 1990, Song 1994, Martin-Cereceda *et al.* 1995, Lin and Song 2004, Lin *et al.* 2005).

Although many taxa in this group have been described, studies carried out before the last quarter of the 20th century were based almost exclusively on live observations (Kahl 1931; Vuxanovici 1959, 1961; Dragesco 1954, 1965; Canella 1960), which has led to great difficulties in species identification and separation within the *Litonotus-Amphileptus-Loxophyllum* complex (Wilbert and Kahan 1981, Foissner 1984). Following the application of modern methods such as silver staining in the study of pleurostomatids, several new genera have been established in recent decades including: *Pseudoamphileptus* Foissner, 1983, *Kentrophyllum* Petz, Song *et* Wilbert, 1995, *Siroloxophyllum* Foissner *et* Leipe, 1995, *Amphileptiscus* Song *et* Bradbury, 1997, *Apoamphileptus* Lin *et* Song, 2004 and *Epiphyllum* Lin, Song *et* Warren, 2005.

The most conspicuous features of the species-rich genus *Loxophyllum* include: (i) the ciliary pattern on the right side, i.e. right somatic kineties, anteriorly shortened

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along the perioral kineties (*vs.* shortened in the median area, thus forming suture in *Amphileptus, Kentrophyllum, Amphileptiscus*, etc.); (ii) extrusomes distributed along both ventral and dorsal margins, and those on the dorsal margin usually clustered to form warts (*vs.* extrusomes absent on the dorsal margin in *Litonotus* and *Acineria* and never clustered to form warts) (Kahl 1931, Song 1993, Foissner and Leipe 1995, Foissner *et al.* 1995, Petz *et al.* 1995, Lynn and Small 2002).

During a recent survey of the marine ciliate fauna in northern China, two new members of *Loxophyllum* were isolated from coastal waters of the Yellow Sea near Qingdao, China. The results of these investigations are presented here.

MATERIALS AND METHODS

Samples were collected (14th October, 2002, and 4th June, 2004) from two different locations in coastal waters of the Yellow Sea near Qingdao (Tsingtao), China. Specimens were isolated from glass slides that had been immersed in the water for up to 10 days, after which time they were transferred to Petri dishes with sea water from the sampling site and transported to the laboratory. The slides were maintained at room temperature for two days as raw cultures together with small ciliates and flagellates in the original water which acted as a food source.

Living cells were isolated and observed using bright field and differential interference contrast microscopy. The infraciliature was revealed by the protargol impregnation method according to Wilbert (1975). Living individuals were examined at 100× to 1000× magnification; measurements were carried out with an ocular micrometer; drawings of stained specimens were performed at 1250× with the aid of a camera lucida. Terminology is mainly according to Corliss (1979) and Foissner (1984). The following term is here defined because of its importance in separating the new taxa from their marine congeners. **Warts (Wa)**: present in most *Loxophyllum* species as papillary protrusions along the dorsal margin of cell, each filled with a cluster of extrusomes.

RESULTS

Order: Pleurostomatida Schewiakoff, 1896
Family: Amphileptidae Bütschli, 1889
Genus: *Loxophyllum* Dujardin, 1841

Loxophyllum jini sp. n. (Figs 1-3, Table 1)

Diagnosis: Large marine *Loxophyllum* about 300-600 µm long *in vivo* with conspicuously slender body; approximately 11 macronuclear nodules and 3 micronuclei; about 9-14 left and 13-20 right somatic kineties; several (*ca* 3-7) contractile vacuoles along the dorsal margin of cell; extrusomes bar-shaped, uniformly distributed along the hyaline edges of both ventral and dorsal margins; without warts.

Type locality and ecological features: Collected (4 June 2004) from coastal waters of the Yellow Sea near Qingdao (Tsingtao), China, 36°08'N; 120°43'E. Water temperature *ca* 17°C, salinity 29‰, pH *ca* 7.9.

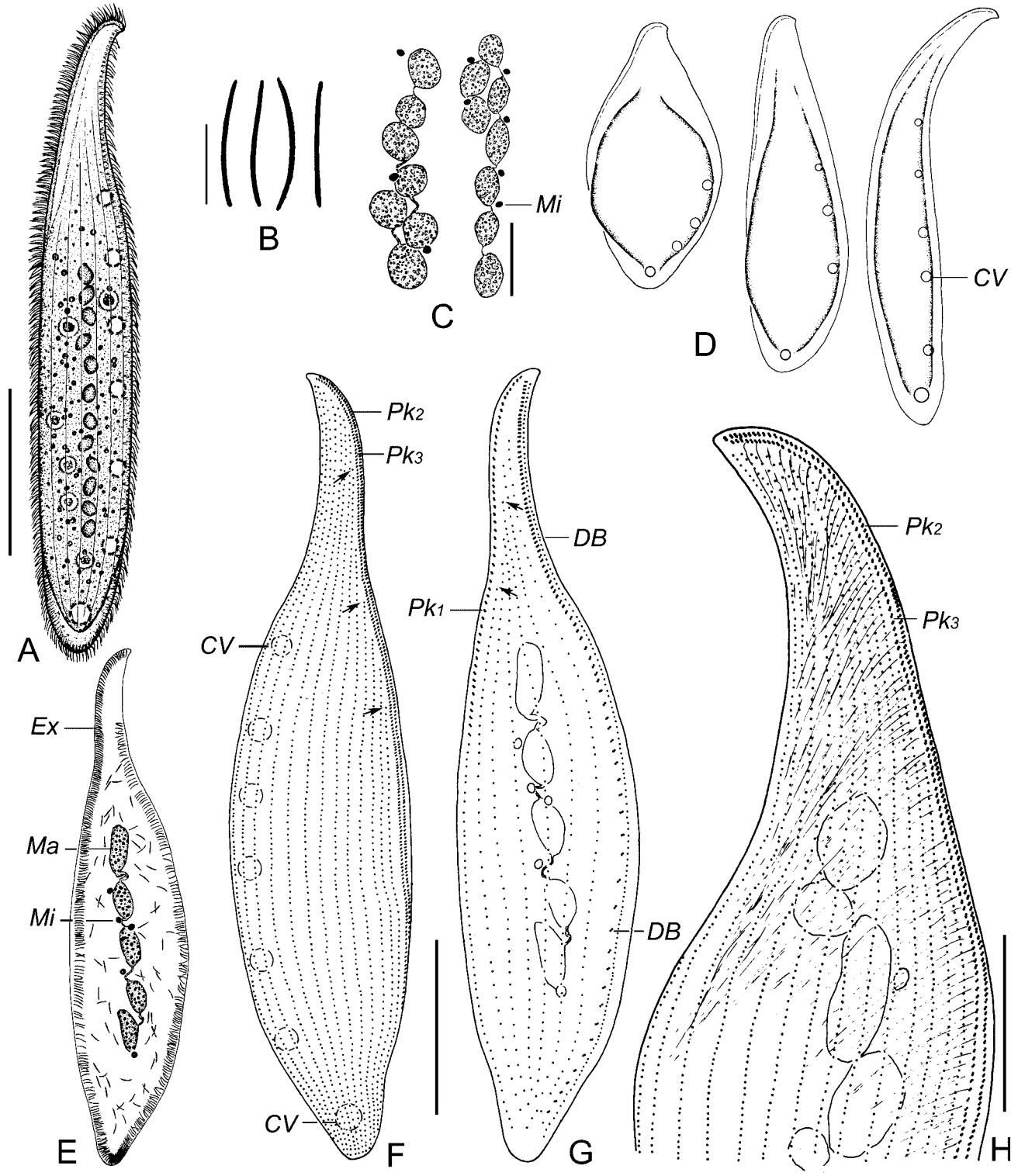
Type slides: One permanent slide of protargol impregnated specimens is deposited as a holotype in the Natural History Museum, London, UK with registration No. 2005:2:2:1. One paratype slide (No. Lin-04-6-4) is deposited in the Laboratory of Protozoology, OUC, China.

Dedication: We dedicate this new species to our distinguished colleague, Prof. Lipei Jin, Sun Yat-Sen University, Guangzhou, China, in recognition of his academic contributions to ciliatology.

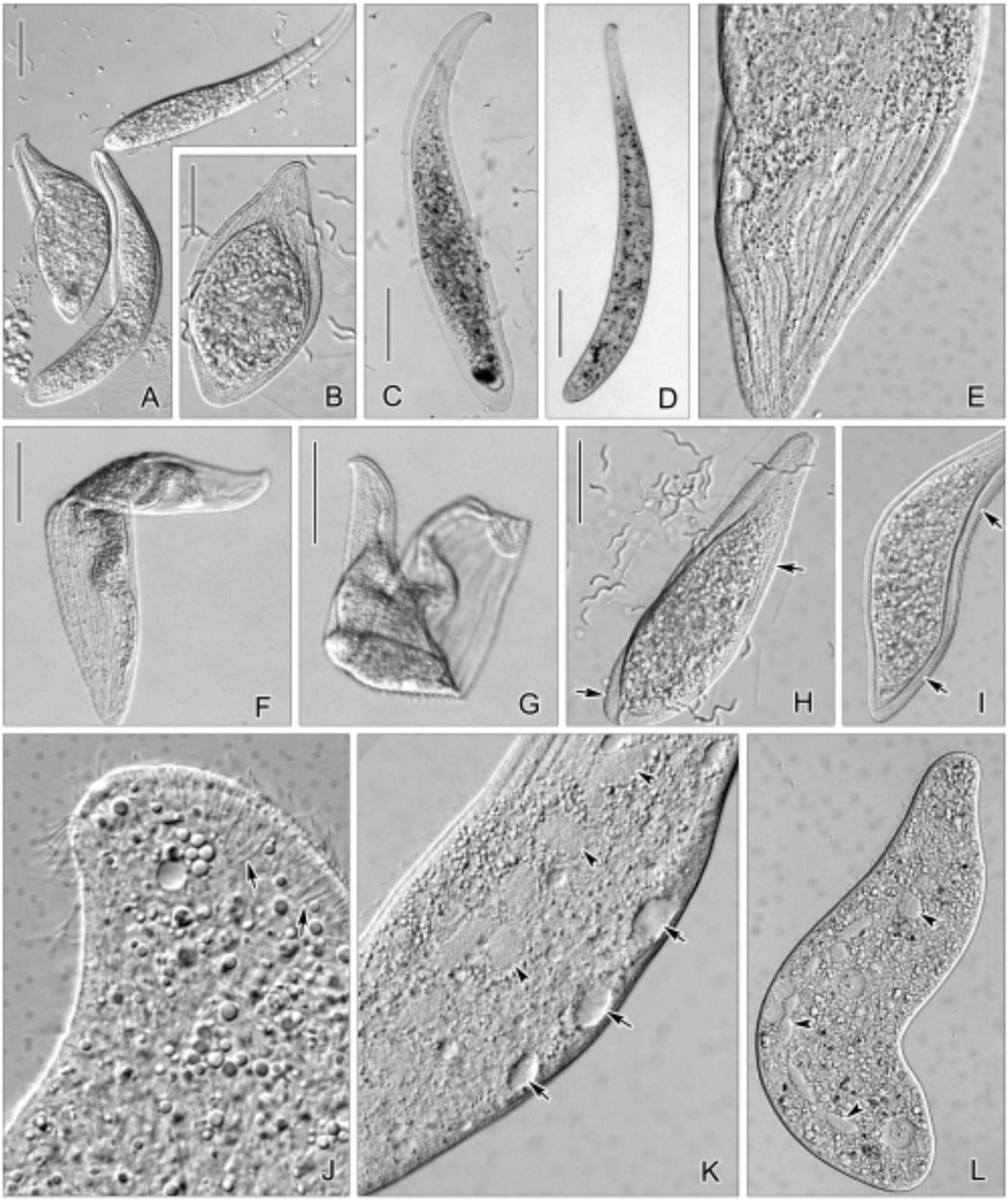
Morphology and infraciliature: Size highly variable, 300-600 × 50-150 µm *in vivo*, usually 400-500 µm in length (for morphometrics see Table 1). Cell very flexible, variable in shape from extremely slender rod-shaped when extended to broadly leaf-shaped when contracted (Figs 1A, D; 2A-D, F-I). Leaf-shaped body often with well-defined thin and hyaline fringe (Figs 2A-C, H, I). Laterally compressed about 3-1.5:1; right side flat; left slightly to distinctly vaulted, mostly due to the presence of ingested food material (Figs 2A-C). Pellicle with many inconspicuous longitudinal shallow grooves (Fig. 2E). Right side densely ciliated, cilia *ca* 6 µm long; cilia sparsely distributed on left side, difficult to detect in life.

Cytoplasm slightly grayish, often with numerous tiny (usually 3-4 µm across) greasily shining globules, which render the main part of the body opaque (Figs 2A-J). Extrusomes bar-shaped, slender, straight to slightly curved, 8-10 µm long *in vivo* (Fig. 1B), evenly distributed along entire ventral and dorsal margins with the exception of the anteriormost region of the dorsal margin, some scattered in cytoplasm (Figs 1B, E; 2J). Food vacuoles few in number, 10-15 µm across. Several (3-7) contractile vacuoles (CV) about 5-10 µm in diameter, pulsating infrequently, positioned along the posterior 3/4 of the dorsal margin; the largest CV usually terminally positioned (Figs 1A, D, F; 2K).

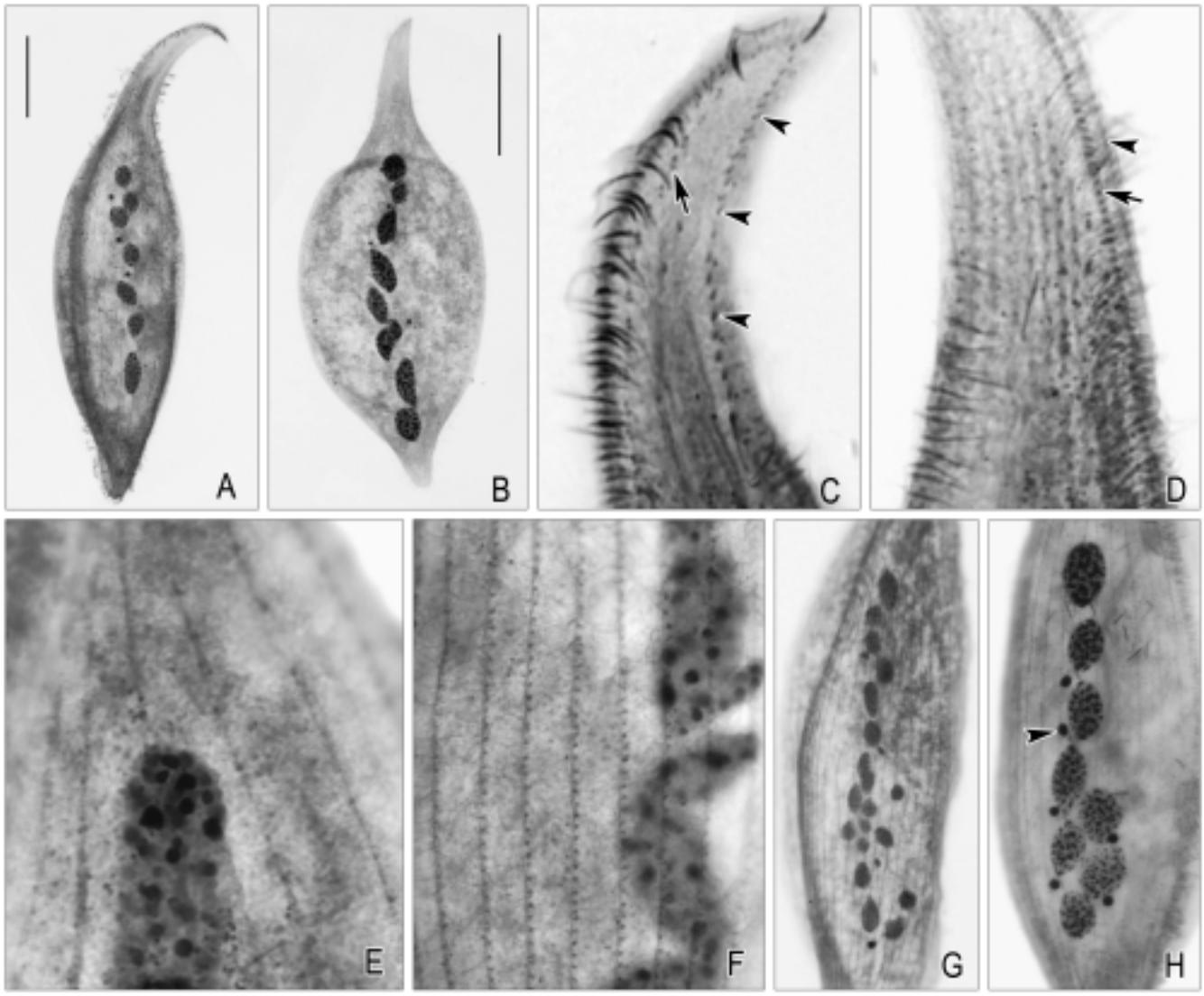
Many (8-17) macronuclear nodules, elongate to ellipsoid, 10-40 × 8-20 µm in size, interconnected by funiculus, located in central region of cell, usually detectable *in vivo* under differential interference contrast microscopy, and with 2-6 oval micronuclei (*ca* 5 µm long) between them (Figs 1C, E; 3A, B, G, H).



Figs 1 A-H. Morphology and infraciliature of *Loxophyllum jini* sp. n., from life (A, B, D) and after protargol impregnation (C, E-H). **A -** left view of a typical individual; **B -** extrusomes; **C -** nuclear apparatus; **D -** shape variations of the same individual, note the contractile vacuoles and the hyaline edge; **E -** nuclear apparatus and distribution of extrusomes; **F**, **G** - infraciliature of right (F) and left (G) sides of the same specimen, arrows mark the somatic kineties terminating along the perioral kineties; **H -** right view showing the detailed structure around the cytostome, note the developed nematodesmata. Abbreviations: CV - contractile vacuole, DB - dorsal brush kinety, Ex - extrusome, Ma - macronucleus, Mi - micronucleus, PK_1 - perioral kinety 1, PK_2 - perioral kinety 2, PK_3 - perioral kinety 3. Scale bars 5 µm (B); 40 µm (C); 50 µm (H); 100 µm (A, F).



Figs 2 A-L. Photomicrographs of *Loxophyllum jini* sp. n. from life. **A, B -** views of normal body shape when extended and contracted; **C, D** - two typical body shapes when the cell is fully extended; **E** - left view of the posterior region of the cell showing the shallow grooves; **F, G** - showing typical cell contortions; **H, I** - noting the grayish central body and the hyaline edge (arrows); **J** - right view of the anterior region of the cell, showing the fine and densely spaced extrusomes (arrows) ; **K, L** - differential interference contrast microscopy, showing the nuclear apparatus (arrowheads), arrows mark the contractile vacuoles. Scale bars 100 μm.



Figs 3 A-H. Photomicrographs showing the infraciliature of *Loxophyllum jini* sp. n. after protargol impregnation. **A, B**- specimens showing the typical nuclear apparatus; **C** - anterior left side, arrows mark the dorsal brush, arrowheads indicate the perioral kinety 1, note the distribution of the extrusomes along the dorsal margin; **D** - view of right side, showing perioral kineties 2 (arrow) and 3 (arrowhead); **E, F** - somatic kineties on the left (E) and right (F) sides; **G, H** - nuclear apparatus, arrowhead depicts one of the micronuclei. Scale bars 100 µm.

Generally insensitive to disturbance. Movement by slowly gliding on substrate, rarely swimming.

Somatic kineties as shown in Figs 1F-H, 3A-H. Perioral kineties 2 and 3 ($PK_{2, 3}$) to right of oral slit, both consisting of closely spaced kinetosome pairs, i.e. dikinetids (Figs 1F, 3D), and both terminating near posterior end of cell (Fig. 1H). Perioral kinety 1 (PK_1) to left of oral slit, with widely spaced basal body pairs in anterior half and continues posteriorly as a row of monokinetids (Figs 1G, 3C). Right side with 13-20 kineties (mean 18, including $PK_{2, 3}$), somatic kineties densely arranged and terminate anteriorly along PK_3 (Fig. 1F, arrows). Left side more sparsely ciliated, with 9-14 kineties (including PK_1), somatic kineties terminating anteriorly along PK_1 (Fig. 1G, arrows). Dorsal brush kinety (DB) composed of basal body pairs and extends to posterior end of cell (Figs 1G, 3C). Nematodesmata well developed, all originating from the kinetosomes of the right perioral kineties and extending along the cytopharynx into the cytoplasm (Fig. 1H).

Comparison: It is generally agreed that the shape and distribution of the extrusomes, the number and position of the contractile vacuoles, the pattern of the ciliature and the nuclear apparatus have great diagnostic

Table 1. Morphological characterization of *Loxophyllum jini* sp. n. (1st line) and *L. qiuianum* sp. n. (2nd line). Data based on protargol impregnated specimens. All measurements in µm. Abbreviations: M - median, Max - maximum, Mean - arithmetic mean, Min - minimum, n - number of specimens, SD - standard deviation.

Characters	Min	Max	Mean	M	SD	n
Body length	344	480	408.5	400	46.32	16
	168	320	252.0	248	39.72	25
Body width	64	160	82.8	80	23.49	16
	80	144	112.9	120	17.91	25
Number of right somatic kineties*	13	20	17.5	18	1.55	16
	19	30	23.2	23	2.93	25
Number of left somatic kineties**	9	14	11.9	11	1.71	13
	8	13	10.2	10	1.52	25
Number of macronuclear nodules	8	17	11.2	11	3.17	16
	1	3	2.1	2	0.40	25
Length of macronuclear nodules	11	43	26.3	22	9.39	16
	28	72	44.6	44	9.33	25
Width of macronuclear nodules	8	18	14	16	2.94	16
	18	32	25.2	24	4.10	25
Number of micronuclei	2	6	3.6	3	1.03	16
	1	1	1	1	0	25
Length of micronucleus	4	10	5	4	1.71	16
	5	13	7.5	6	2.33	25
Length of extrusomes	7	10	8.1	8	1	12
	5	7	5.6	6	0.58	25

* Perioral kineties 2, 3 included; ** Perioral kinety 1 included.

value in separating species of the genus *Loxophyllum* (Dragesco 1960, 1965, 1966; Foissner 1984; Song and Wilbert 1989). Up to now, over 40 *Loxophyllum*-like morphotypes have been reported, most of which (>30) were found in marine biotopes (Kahl 1931; Dragesco 1960, 1965; Carey 1991).

Based on the general body shape and the number of macronuclear nodules, at least 8 nominal marine *Loxophyllum* spp. should be compared with *L. jini*. Because none of these have been investigated using modern methods, our comparison is mainly based on their morphological characters in life (Sauerbrey 1928; Kahl 1931; Shigematsu 1953; Dragesco 1960, 1965) (Table 2).

Like *Loxophyllum jini*, *L. acutum* Dragesco, 1965 possesses many contractile vacuoles. However, *L. jini* can be distinguished from the latter by: (i) its larger body size (300-600 *vs. ca* 260 µm long); (ii) the broadly rounded posterior end of the body (*vs.* pointed tail-like posterior end in *L. acutum*); (iii) the absence of warts (*vs.* warts present along the dorsal margin in *L. acutum*).

The smaller sized *Loxophyllum compressum* Dragesco, 1965 differs from *L. jini* mainly in the distribution of contractile vacuoles (along both margins *vs.* along dorsal margin only in *L. jini*).

At least five congeners posses multiple macronuclear nodules like *Loxophyllum jini*, namely: *L. vermiforme* Sauerbrey, 1928, *L. meleagris* Dujardin, 1841, *L. multinucleatum* Kahl, 1928, *L. ozakii* Shigematsu, 1953 and *L. levigatum* Sauerbrey, 1928. All of these can easily be distinguished from *L. jini* by the number and positions of the contractile vacuoles (Table 2).

It is noteworthy that *Loxophyllum levigatum* was originally described as having a single contractile vacuole and the extrusomes are arranged along the ventral margin only (Sauerbrey 1928). Dragesco (1960), however, described another population (incorrectly spelt as *L. laevigatum*) with two CVs and extrusomes distributed along both the ventral and dorsal margins (Table 2). A re-investigation of both morphotypes is required in order to determine whether they are conspecific.

Loxophyllum qiuianum sp. n. (Figs 4, 5; Table 1)

Diagnosis: Medium-sized marine *Loxophyllum*, about 150-350 µm long *in vivo* with leaf-shaped body; mostly with 2 macronuclear nodules and 1 micronucleus;

Table 2. Morphological comparison of *Loxophyllum jini* sp. n. with some marine *Loxophyllum* spp. that contain multiple macronuclear nodules. All measurements in µm. CV - contractile vacuoles, Ex - extrusomes, Ma - macronuclear nodules, No. - number, RK/LK - right/left kineties.

	Body length	No. and position of CV	No. of Ma	No. of RK/LK	Distribution of Ex	Warts	Data source
L. jini	300-600	3-7; along dorsal margin	8-17	13-20 / 9-14	along both margins	absent	present work
L. acutum	*ca* 260	many; along dorsal margin	10-14	11-12 / -	along both margins	present	Dragesco (1965)
L. compressum	280	4-5; along both margins	6-7	14-16 / *ca* 10	along both margins	absent	Dragesco (1965)
L. meleagris	300-700	1; subterminal, dorsally	many	-	along both margins	present	Kahl (1931)
L. multinucleatum	140-160	3; along ventral margin	many	10 / -	along both margins	absent	Kahl (1931)
L. vermiforme	*ca* 1600	1; subterminal	many	60 / -	along both margins	absent	Sauerbrey (1928)
L. ozakii	170-230	1-3; along dorsal margin	170-200	-	along both margins	absent	Shigematsu (1953)
L. levigatum	*ca* 270	1; subterminal	7-15	40 / -	along ventral margin	absent	Sauerbrey (1928)
L. laevigatum	*ca* 270	2; along dorsal margin	many	-	along both margins	absent	Dragesco (1960)

- data not available.

Table 3. Morphological comparison of *Loxophyllum qiuianum* sp. n. with some marine *Loxophyllum* spp. that possess two macronuclear nodules. All measurements in µm. CV - contractile vacuoles, Ex - extrusomes, No. - number, RK/LK - right/left kineties.

	Body length	No. and position of CV	No. of RK/LK	Furrows	Distribution of Ex	Warts	Data source
L. qiuianum	150-350	1, terminal	19-30 / 8-13	absent	no Ex along oral slit	present	present work
L. rostratum	150-250	1, subterminal	16-18 / 6-7	present	along both margins	present	Song (1993)
L. chaetonotum	70-120	1, subterminal	7 / -	present	along both margins	present	Borror (1965)
L. perihoplophorum	*ca* 400	several, dorsal margin	20 / -	-	along both margins	present	Buddenbrock (1920)
L. multiverrucosum	400	several, dorsal margin	- / -	-	along both margins	present	Kahl (1933)
L. elegans	*ca* 170	1, terminal	18 / -	absent	mainly along oral slit	absent	Kattar (1970)
L. vitraeum	80-100	1, subterminal	8 / -	-	mainly along oral slit	absent	Dragesco (1965)
L. fasciolatus	*ca* 130	1, terminal	12 / -	present	along ventral margin	absent	Dragesco (1966)
L. multiplicatum	250	1, terminal	*ca* 15 / -	-	only along oral slit	absent	Kahl (1931)

- data not available.

about 8-13 left and 19-30 right kineties; 1 terminally located contractile vacuole; extrusomes bar-shaped, evenly spaced along ventral margin but clustered along dorsal margin to form about 6-12 inconspicuous warts.

Type locality and ecological features: Found in a shrimp-farming pond (14 October 2002) in coastal waters of the Yellow Sea near Qingdao (Tsingtao), China, 36°08'N; 120°43'E. Water temperature *ca* 23°C, salinity *ca* 22‰, pH *ca* 8.1.

Type slides: One permanent slide of protargol impregnated specimens is deposited as a holotype in the Natural History Museum, London, UK with registration No. 2005:2:2:2. One paratype slide (No. Lin-02-10-14) is deposited in the Laboratory of Protozoology, OUC, China.

Dedication: We dedicate this new species to our distinguished colleague, Prof. Zijian Qiu, Harbin Normal University, Harbin, China, in recognition of his academic contributions to protozoology.

Morphology and infraciliature: Size highly variable among individuals, 150-350 × 70-120 μm *in vivo* (for morphometrics see Table 1). Cell very flexible, from slender leaf-shaped when fully extended to broadly rounded when contracted (Figs 4C, 5A-C); with short (about 20-25% of cell length) neck region at anterior end of cell and a short tail-like region at posterior end (arrows in Figs 4C; 5A-C, F). Laterally compressed about 3:1, right side flat, left slightly to distinctly vaulted, mostly due to the presence of ingested food material (Figs 5A-C). Right side densely ciliated, cilia about 5 μm long; left side sparsely ciliated, cilia difficult to detect in life; the ciliary rows on both sides are marked by the presence of conspicuous, longitudinal, shallow grooves that appear as white lines on the cell surface (Figs 4B, 5D).

Cytoplasm grayish, often with numerous tiny (3-8 μm across) greasily shining globules and short (*ca* 1 μm long) rod-like greenish crystals (Fig. 4E), that render the main part of the body opaque (Figs 5A-C). Extrusomes bar-shaped, slender, straight to slightly curved, 5-7 μm long (Fig. 4D); evenly arranged along the ventral margin with the exception of the buccal area, and clustered together to form 6-12 inconspicuous warts (Wa) along the dorsal margin although absent from the anterior neck-like region; some extrusomes scattered in cytoplasm (Figs 4F, 5H). Food vacuoles few in number, each 10-15 μm across. One small contractile vacuole (CV), 5-10 μm in diameter, terminally located, pulsating infrequently (Fig. 4A, arrow).

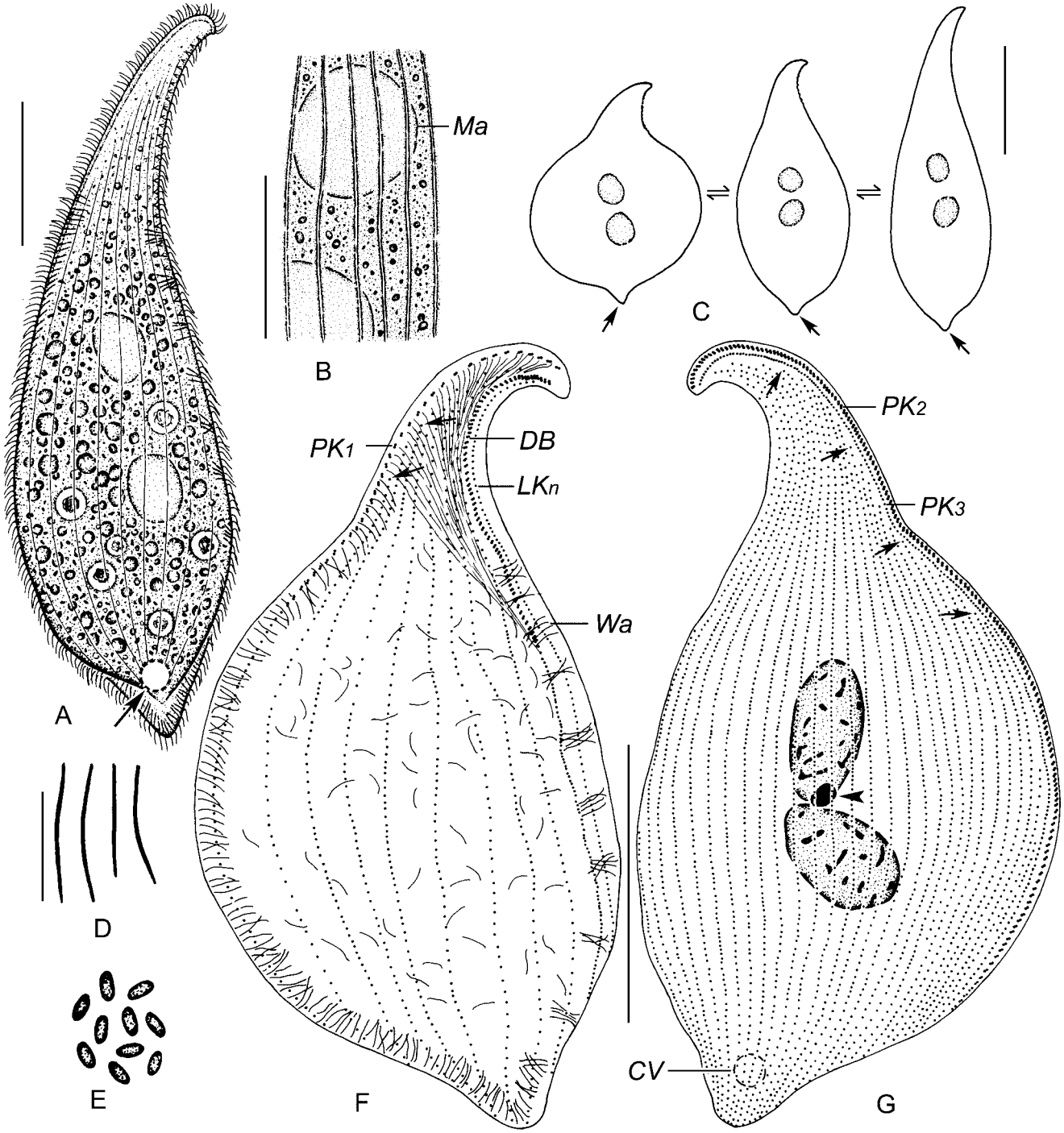
Usually with two macronuclear nodules, 28-72 × 18-32 μm in size after fixation, ovoid to ellipsoid, located in mid-body region, and appear as two large transparent areas *in vivo* (Figs 5A-C). Single micronucleus, 5-13 μm in length, located between macronuclear nodules (Fig. 4G, arrowhead).

Generally insensitive to disturbance. Usually gliding extremely slowly on substrate, rarely swimming through the water.

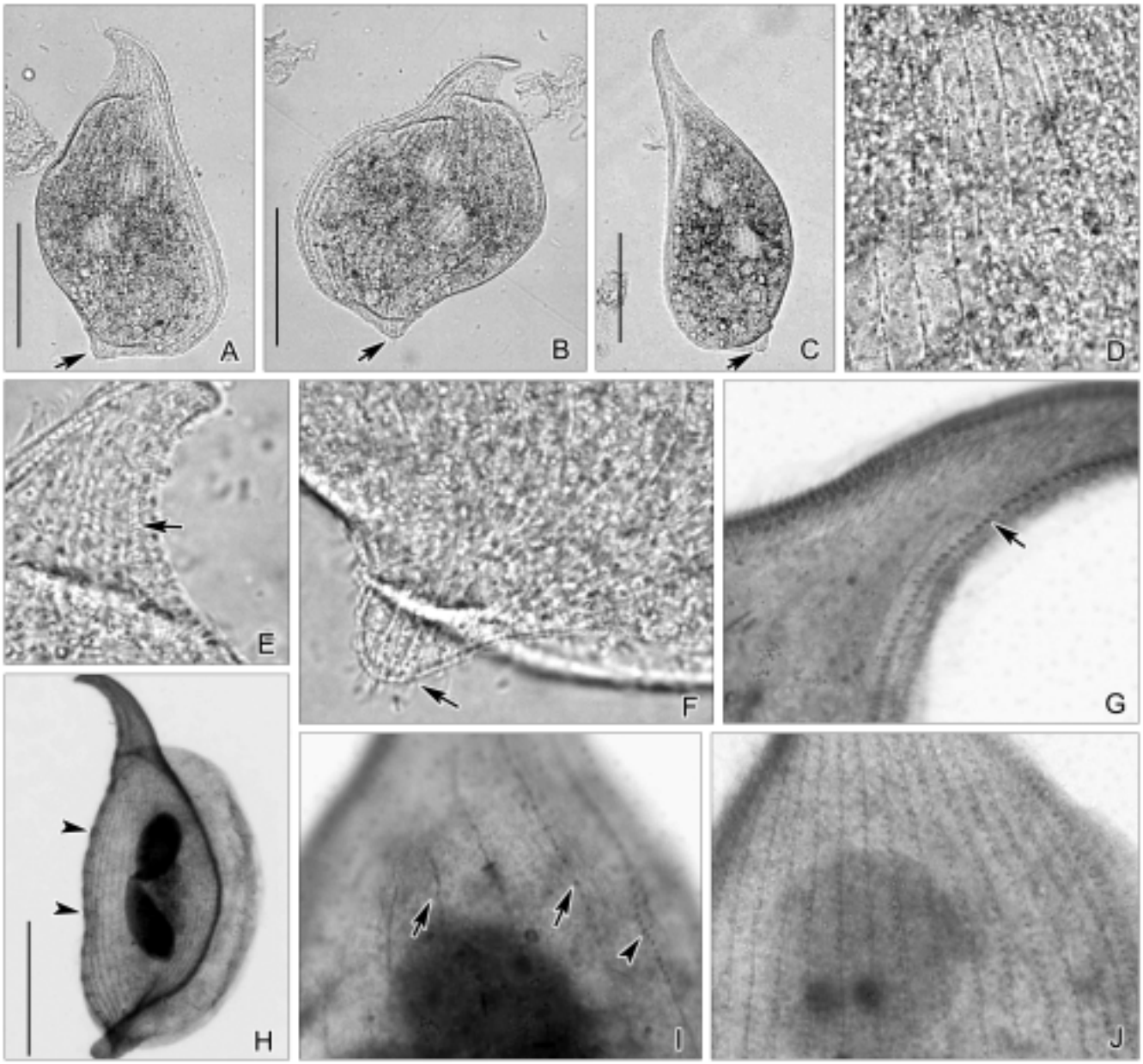
Infraciliature as shown in Figs 4F, G; 5G-J. Perioral kineties 2 and 3 ($PK_{2,3}$) right of cytostome and extend 80% of cell length, terminating in posterior 1/5 of body; PK_2 consists of closely spaced kinetosome pairs (i.e. dikinetids), PK_3 comprises a row of close-set monokinetids (Fig. 4G). Perioral kinety 1 (PK_1) left of oral slit, with loosely spaced basal body pairs in anterior 1/3 and continues posteriorly as a row of monokinetids (Fig. 4F). Right side with 19-30 (mean 23, including $PK_{2,3}$) closely spaced kineties (Fig. 5J), somatic kineties terminating anteriorly along PK_3 (arrows in Fig. 4G). Left side loosely ciliated with 8-13 kineties (including PK_1 and the dorsal brush kinety) (Fig. 5I); somatic kineties terminating anteriorly along PK_1 (Fig. 4F, arrows). Dorsal brush kinety (DB) composed of densely spaced basal body pairs in anterior 1/3 and continues posteriorly as a row of densely spaced monokinetids (Figs 4F; 5E, G, I). Nematodesmata well developed (Fig. 4F).

Comparison: Among the known marine *Loxophyllum* species, our new form is most similar to *L. rostratum* Cohn, 1866, which was investigated by Song (1993) using modern methods (Table 3). Compared with *L. rostratum*, *L. qiuianum* is identified by: (i) the absence of extrusomes along the oral slit (*vs.* extrusomes present along the entire ventral margin in *L. rostratum*); (ii) the terminal position of the contractile vacuole (*vs.* subterminally located); (iii) the absence of furrows on the left side (*vs.* with 5 distinct furrows); (iv) the shape of the posterior end (constantly with a short tail-like region *vs.* shape highly variable in *L. rostratum*); (v) the possession of greater numbers of somatic kineties on both the right and left sides (19-30 and 8-13 *vs.* 16-18 and 6-7 in *L. rostratum*).

Among other related morphotypes, *Loxophyllum qiuianum* is most similar to *L. chaetonotum* Borror, 1965 (Table 3). Apart from its smaller body size (70-120 *vs.* 150-350 μm long for *L. qiuianum*) and its large subterminal contractile vacuole (*vs.* small, terminal CV in *L. qiuianum*), *L. chaetonotum* also differs from



Figs 4 A-G. Morphology and infraciliature of *Loxophyllum qiuianum* sp. n., from life (A-E) and after protargol impregnation (F, G). **A -** left view of a typical individual, arrow depicts the contractile vacuole; **B -** right side view, showing the ciliary rows marked by the position of shallow grooves that typically appear as longitudinal white lines; **C -** shape variations of the same individual, noting the short tail-like posterior end (arrows); **D -** extrusomes; **E -** greenish crystals in the cytoplasm; **F, G -** infraciliature of right (F) and left (G) sides of the same specimen, arrows mark the somatic kineties terminating along the perioral kineties, arrowhead marks the micronucleus in (G), note the warts (Wa) along the dorsal margin in (F). CV - contractile vacuole, DB - dorsal brush kinety, LKn - the right-most kinety on the left side, Ma - macronucleus, PK_1 - perioral kinety 1, PK_2 - perioral kinety 2, PK_3 - perioral kinety 3, Wa - wart. Scale bars 5 μm (D); 50 μm (A, B); 80 μm (F); 100 μm (C).



Figs 5 A-J. Photomicrographs of *Loxophyllum qiuianum* sp. n. from life (A-F) and after protargol impregnation (G-J). **A-C -** different body shapes when the cell contracts and extends, noting the constant tail-like posterior end (arrows); **D -** right side view, showing the shallow grooves that appear as longitudinal white line marking the positions of the ciliary rows; **E -** anterior part of left side, arrow marks the dorsal brush; **F -** posterior region, showing the short tail-like end (arrow); **G -** left side view, arrow indicates the dorsal brush kinety; **H -** infraciliature of right side, arrowheads mark the warts; **I, J -** somatic kineties on left (I, arrows) and right (J) sides, arrowhead in (I) marks the dorsal brush kinety. Scale bars 100 μm.

L. qiuianum in having fewer kineties on the right side (7 *vs.* 19-30) and the presence of extrusomes along the oral slit (*vs.* extrusomes absent along oral slit in *L. qiuianum*).

Loxophyllum perihoplophorum Buddenbrock, 1920 and *L. multiverrucosum* (Kahl, 1933) Carey, 1991 are two similar forms that can be separated from *L. qiuianum* by the presence of warts in the anterior dorsal region (*vs.* warts absent from this region in *L. qiuianum*) and the possession of several contractile vacuoles distributed along the dorsal margin (*vs.* a single, terminal CV in *L. qiuianum*) (Table 3) (Buddenbrock 1920, Kahl 1933).

Other *Loxophyllum* spp. that possess two macronuclear nodules and a single CV include: *L. elegans*

Wenzel, 1961, *L. fasciolatus* Dragesco, 1966 and *L. vitraeum* Dragesco, 1965. *Loxophyllum qiuianum* can be separated from these by its possession of warts (*vs.* warts absent in each of these three) (Table 3).

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