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Ciliates of the Silent Valley National Park, India: Urostyloid Hypotrichs of the Region with a Note on the Habitat

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Summary. The Silent Valley National Park in the state of Kerala, India, ranks high among the biodiversity hotspots of the world with 4.8 as the alpha diversity index. The Valley is surrounded by mountain ranges and has a diverse topography with a mosaic of varied habitats that have remained isolated from extraneous influences. The present report describes urostyloid ciliates from diverse ecozones within the core zone of the National Park. Six species of the urostyloids, including *Anteholosticha angida* n. sp. and *Bakuella nilgiri* n. sp., were found in soil samples. *Anteholosticha angida* n. sp. differs from its cogeners in having a unique combination of characters – presence of colourless cortical granules, ~ 53 macronuclear nodules, ~ 3 micronuclei, ciliature with 3–4 buccal cirri in a row and 4 dorsal kineties. *Bakuella nilgiri* n. sp. is characterized by the presence of colourless cortical granules, ~ 98 macronuclear nodules, 3–4 micronuclei, ciliature with 4–8 buccal cirri in a row and a mid-ventral complex comprising of ~ 21 cirral pairs and 2–10 cirri in 2–3 rows reaching up to the level of the 6–11 transverse cirri.

Key words: Ciliated Protozoa, Urostyloidea, Silent Valley National Park, biodiversity, systematics.

INTRODUCTION

The Silent Valley National Park (Fig. 1) in the state of Kerala, India (11°08′N, 76°28′E and 11°13′N, 76°47′E) is a known biodiversity hotspot (UNESCO 2007). The alpha diversity index of 4.8 calculated by the Zoological Survey of India based on diversity of flora is one of the highest in the world. Habitats in the Valley exhibit a high degree of complexity and diversity, with micro-habitat enclaves within them. Although the macro-fauna of the Valley has been documented (ZSI 1986, Ramchandran and Joseph 2001), there has been no such investigation about micro-organisms. The present study, first in a series on the ciliate fauna of this region, describes six urostyloids, including two hitherto unreported species of the group.

The Urostyloidea group of ciliates have several common characteristics: flexible body, ventral ciliature typically comprising frontal cirri, buccal cirri, fronto-terminal cirri, cirri of the mid ventral complex, pre-transverse cirri and transverse cirri, arising during morphogenesis from several (more than six) obliquely arranged frontal – mid ventral – transverse primordia, marginal ciliature in one or more left and right rows, and dorsal ciliature with no dorso-marginal rows and

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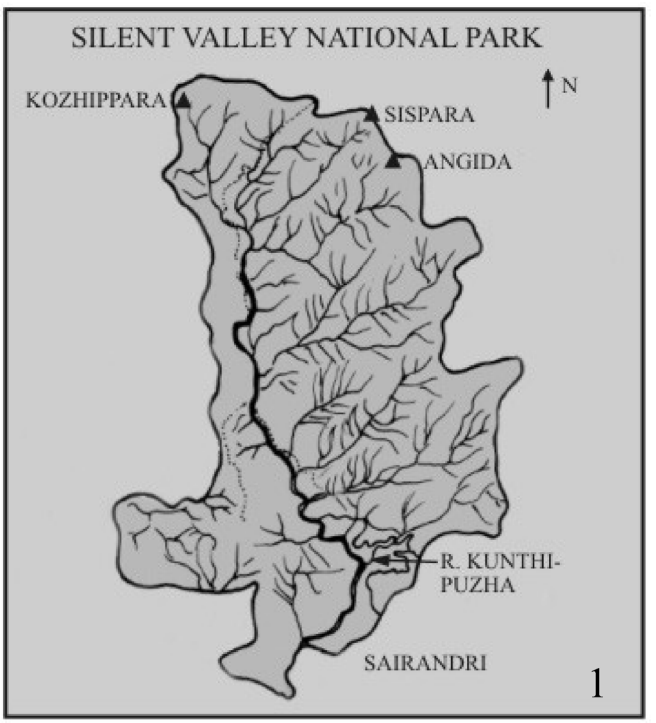


Fig. 1. Diagrammatic depiction of the salient features of the Silent Valley National Park. The three largest peaks (arrowheads) are located on the north eastern boundary, the river Kunthipuzha originates from various peaks of the Nilgiri hills and traverses the entire length of the Valley. Sairandri is the entry point of the National Park.

no fragmentation of kineties during morphogenesis. Berger (2006) assigned the name Urostyloidea to the group without resolving the taxonomic categorization. The classification in the present report has been adopted from Berger (2006).

MATERIAL, METHODS AND TERMINOLOGY

Soil samples were collected in January 2008 from various ecozones within the core zone of the Silent Valley National Park (see Discussion for details) from a depth of 0–10 cm. Ciliates were made to excyst and emerge from the soil samples employing the non- flooded petridish method (Foissner 1987a). Urostyloids were isolated and their clonal cultures were raised in the laboratory.

Most of the Urostyloid isolates thrived well in Pringsheim's medium with the green alga *Chlorogonium elongatum* as the food organism (Ammermann *et al*. 1974) at an optimum temperature of 18°C ± 2°C. Those species that preferred bacteria as food were grown in Pringsheim's medium with autoclaved whole wheat grains to support bacterial growth.

Observations on live cells were made by differential interference contrast microscopy. Surface structures, ciliature and infraciliature were visualized by the modified protargol staining technique (Kamra and Sapra 1990). Nuclear cytology was revealed by Feulgen staining. Biometric characterization of live and protargol-stained cells was conducted at a magnification of 1000 × using the Leica software IM50 image manager. A Leica camera DFC320 was employed for photomicrography. Line diagrams were prepared using Corel graphics.

Nomenclature and terminology were adopted from Borror (1972), Wiackowski (1985), Foissner (1995) and Berger (2006).

RESULTS AND DISCUSSION

Six species belonging to three families of the Urostyloidea group were obtained from the soil samples. A description of their morphology, morphogenesis and comparisons with related populations/species is as follows:

Family Holostichidae

***Anteholosticha angida* n. sp. (Figs 2a–c, 3a–c; Table 1)**

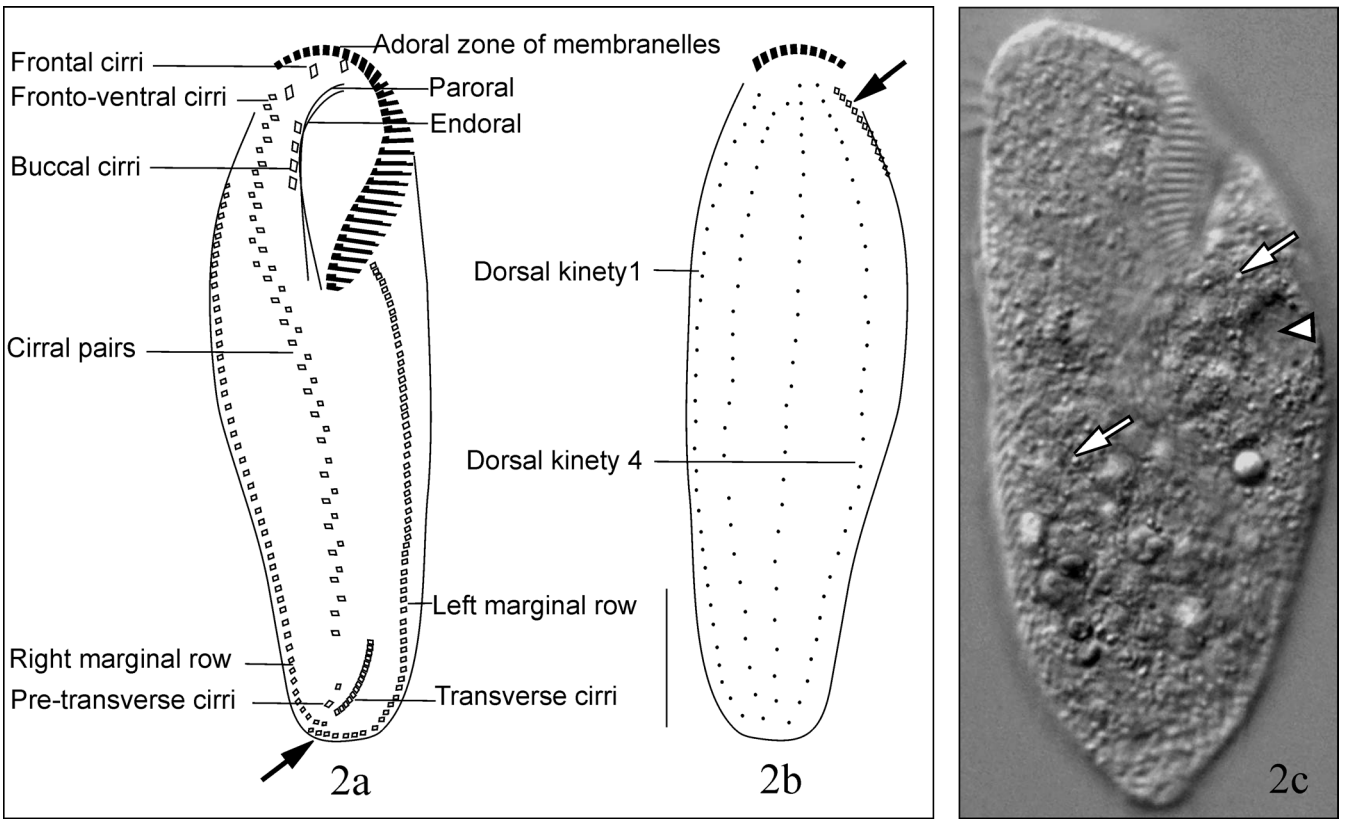
Diagnosis: Terrestrial *Anteholosticha*, average size of non-dividers *in vivo* 135 × 50 µm, that of protargol-stained cells 125 × 41 µm; colourless cortical granules, about 1.1 µm in diameter, present singly, uniformly distributed in medium density; about 53 macronuclear nodules, 3 micronuclei on an average; adoral zone of membranelles about 37% of body length with about 36 adoral membranelles; 3 or 4 buccal cirri in a row, about 13 transverse cirri, invariably 4 dorsal kineties.

Type locality: Light brown soil from the tropical rain forest close to the entry point (Sairandri) of the Silent Valley National Park, India (Fig. 1).

Type material: A holotype slide with protargol-stained cells has been deposited in the Natural History Museum, Cromwell Road, London SW7 5BD, UK (accession number 2010:10:18:2).

Etymology: The species has been named after one of the peaks, Mount Angida, on the north eastern boundary of the Silent Valley National Park.

Morphology: Body size on average 135 ×50 µm *in vivo* and 125 × 41 µm in protargol-stained preparations. Cells flexible, oblong, tapering slightly to a bluntly rounded posterior end. 42–62 macronuclear nodules, each about 6 × 2 µm in size; 2–4 micronuclei, each about 2.5 µm in diameter. A single contractile vacuole present in the left side of the body at the level of buccal

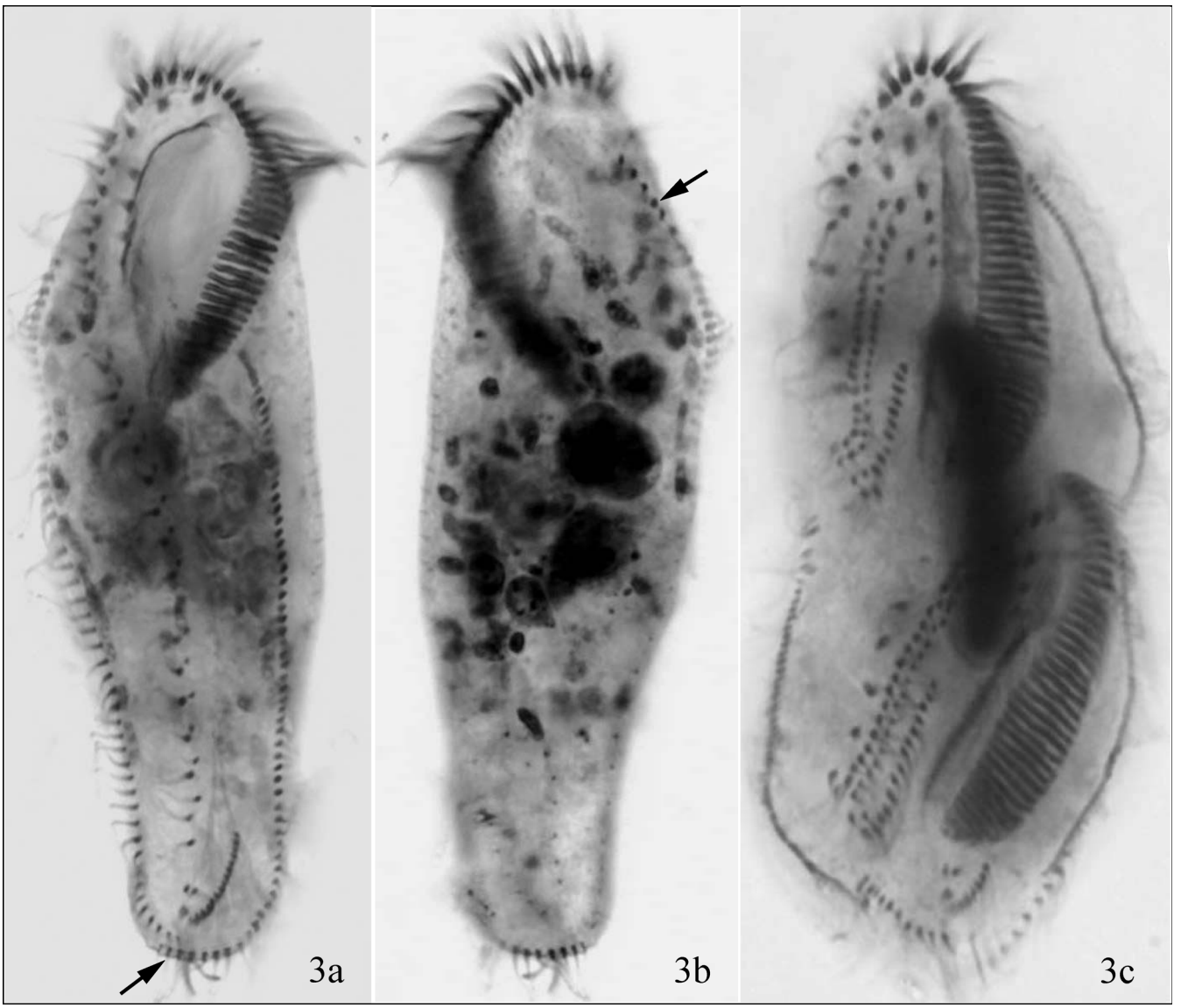


Figs 2a, b. Line diagrams of a protargol impregnated vegetative cell of *Anteholosticha angida* n. sp. **a** – ventral surface; **b** – dorsal surface; arrow in 2a marks the overlapping marginal rows at the posterior end of the cell, arrow in 2b points to the anterior segment of the right marginal row which appears on the dorsal surface. Bar represents 25 μm. **Fig. 2c.** Photomicrograph of a live cell of *Anteholosticha angida* n. sp. showing cortical granules (arrows) and the contractile vacuole (arrowhead).

vertex. Cortical granules colourless, about 1.1 μm in diameter, present singly, almost uniformly distributed in medium density throughout the cortex. Fat droplets each about 3 μm in diameter.

Ciliature: A conspicuous adoral zone occupying 31–40% of cell length with 32–40 membranelles, paroral and endoral curved and virtually intersecting; 3 hypertrophied frontal cirri, one row of 3 or 4 buccal cirri, 2 fronto-terminal cirri, mid-ventral complex with 16–21 cirral pairs, the last 2 or 3 cirri positioned at the level of the anterior end of the transverse cirral row, 2 pre-transverse cirri, 9–15 transverse cirri in a slightly curved row; one right marginal row with 47–56 cirri and one left marginal row with 40–52 cirri, the left marginal row curves along the posterior end slightly overlapping the posterior segment of the right marginal row, the anterior 12–16 cirri of the right marginal row extend on to the dorsal surface; 4 bipolar dorsal kineties; caudal cirri absent.

Morphogenesis during division: *Anteholosticha angida* n. sp. shows a typical urostyloid pattern of divisional morphogenesis. The parental adoral zone is retained unchanged for the proter. The first frontal cirrus is formed from the reorganizing paroral and endoral in the proter; in the opisthe, it is formed from the primordium for the paroral and endoral. Sixteen to 21 oblique cirral streaks are formed for each of the two daughter cells. The first oblique row gives rise to the second frontal cirrus and 3 or 4 buccal cirri. The cirri of the mid-ventral complex are formed strictly in pairs from the rest of the oblique cirral primordia; the anterior product of the second oblique row forms the third frontal cirrus. The posterior 10–15 cirral streaks additionally give rise to the pre-transverse cirri, transverse cirri and the two fronto-terminal cirri as is typical of urostyloids. The marginal rows and the dorsal kineties are formed intra-kinetally. No caudal cirri are formed.



Figs 3a–c. Photomicrographs of protargol impregnated cells of *Anteholosticha angida* n. sp. **a** – ventral surface; **b** – dorsal surface; **c** – late divider; arrow in 3a indicates the overlapping marginal rows, arrow in 3b points to the anterior segment of the right marginal row which appears on the dorsal surface.

Comparison with congeners: Four known species of the genus *Anteholosticha* possess multiple buccal cirri in a row; these are *A. adami* (Foissner 1982) Berger, 2003, *A. multistilata* (Kahl 1928) Berger, 2003, *A. antecirrata* Berger, 2006 and *A. intermedia* (Bergh 1889) Berger, 2006. *Anteholosticha angida* n. sp. shares this character with the above mentioned four species but has been designated as a new species due to the following differences: in *A. adami*, the marginal rows do not overlap posteriorly whereas they do in *A. angida* n. sp, the body length of *A. antecirrata* is twice to that of *A. angida* n. sp., *A. multistilata* has 8 or 9 hypertrophied frontal cirri vs. 3 in *A. angida* n. sp. *Anteholosticha intermedia* resembles *A. angida* n. sp. in some features, but in the former, the cirri of the mid-ventral complex do not reach the level of the transverse cirri. Other differences between *A. angida* n. sp and its congeners with multiple buccal cirri include its substantially larger number of transverse cirri (9–15) and in possessing 4 (vs. usually 3) dorsal kineties. One population of *A.*

Table 1. Biometric characterization* of *Anteholosticha angida* n. sp.

Character	Mean	Min	Max	SD	CV
Body length, µm	125.4	104.5	153.5	15.37	12.26
Body width, µm	40.7	29.6	48.6	5.25	12.90
Adoral membranelles, no.	35.8	32	40	2.14	5.97
Adoral Zone of Membranelles (AZM) length, µm	45.4	41.3	52.3	2.94	6.47
AZM / body length %	36.7	30.7	40.3	2.61	7.12
Macronuclear nodules, no.	52.6	42	62	6.50	12.35
Macronucleus length, µm	5.6	4.0	6.9	0.90	16.12
Macronucleus width, µm	2.3	1.8	2.9	0.29	12.83
Micronuclei, no.	3.0	2.0	4.0	0.82	27.3
Micronucleus diameter, µm	2.5	2.3	2.7	0.15	6.04
Buccal cirri, no.	3.8	3	4	0.42	11.05
Frontal cirri, no.	3	3	3	0	0
Fronto-terminal cirri, no.	2	2	2	0	0
Mid ventral complex, no. of cirri	36	32 (16 pairs)	42 (21 pairs)	2.67	7.41
Pre-transverse cirri, no.	2	2	2	0	0
Transverse cirri, no.	12.7	9	15	1.49	11.73
Right marginal row (s), no.	1.0	1	1	0	0
Right marginal row, no. of cirri	51.7	47	56	2.26	4.37
Left marginal row (s), no.	1.0	1	1	0	0
Left marginal row, no. of cirri	46.1	40	52	3.35	7.26
Dorsal kineties (DK), no.	4.0	4	4	0	0
DK_1, no. of bristles	30.9	26	35	2.88	9.32
DK_2, no. of bristles	25.8	22	29	2.09	8.10
DK_3, no. of bristles	25.7	22	28	1.70	6.61
DK_4, no. of bristles	33.2	30	37	1.87	5.63

* Data based on protargol stained non-dividers obtained from a non-flooded petridish culture. n – 20; Max – maximum; Min – minimum; SD – standard deviation; CV – coefficient of variation (%).

adami (Groliere 1975), and some populations of *A. intermedia* (Berger 2006) have 4 kineties.

***Caudiholosticha sylvatica* (Foissner 1982) Berger, 2003, Silent Valley population (Figs 4a–c, 5a–e; Table 2)**

Occurrence and ecology: *Caudiholosticha sylvatica*, Silent Valley population, was isolated from the dark brown soil collected near the roots of tall trees in the tropical rain forest tract.

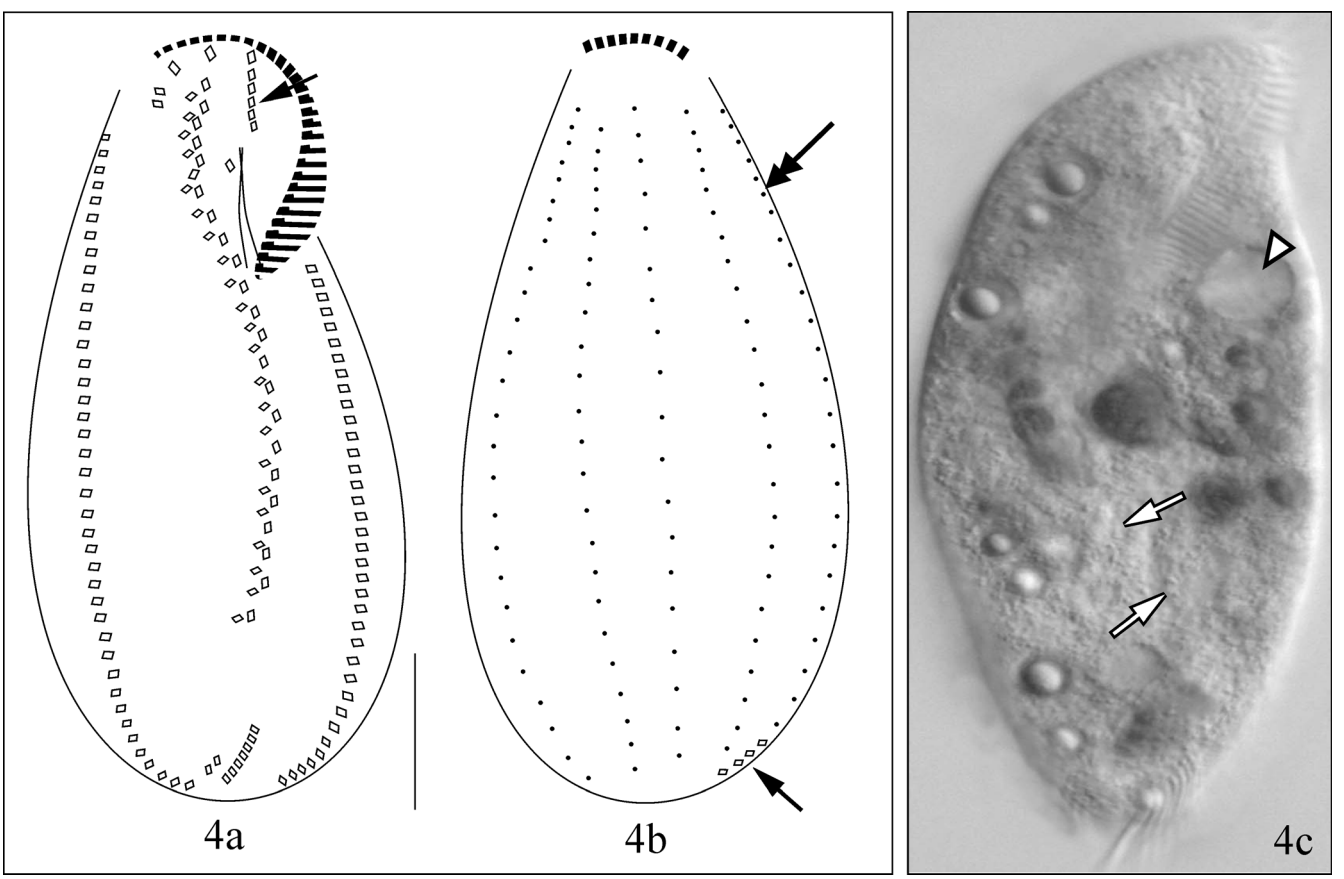
Morphology: Body size on average 130 × 55 µm *in vivo*, 123 × 52 µm in protargol-stained preparations. Body flexible, oblong with a rounded posterior end. Forty five to 64 macronuclear nodules, about 6 × 2.7 µm each in size; 2–4 micronuclei, each about 2.4 µm in diameter. Contractile vacuole on the left side of the body at the level of the buccal vertex. Spherical colourless cortical granules about 1.1 µm in diameter, present as single entities or in pairs, randomly distributed. Large fat globules present mostly on the right margin of the cell.

Ciliature: A conspicuous adoral zone occupying about 40% of cell length with 40–45 membranelles, paroral and endoral short, curved and virtually intersecting; 3 hypertrophied frontal cirri, a single buccal cirrus, a frontal row (see discussion below) with 5 or 6 cirri present a little to the left or anterior to the paroral and endoral and aligned just behind the first frontal cirrus, 2 fronto-terminal cirri, mid-ventral complex with 16–21 cirral pairs arranged almost linearly terminating

far above the level of the transverse cirri, 2 pre-transverse cirri, 8–10 transverse cirri; one right marginal row with 36–49 cirri and one left marginal row with 33–45 cirri; usually 5 dorsal kineties rarely with an extra incomplete row, 3 or 4 caudal cirri.

Morphogenesis during division: A few of the posterior cirri of the parental frontal row disaggregate and merge with the disaggregating paroral and endoral to form streak I which gives rise to the new frontal cirrus 1, cirri of the frontal row, and the paroral and endoral of the proter. In the opisthe, these structures are formed from a common primordium arising on the right of the oral primordium. The rest of the morphogenesis on the ventral surface is typical of urostyloids. The five dorsal kineties ($DK_{1–5}$) originate intra-kinetally. The 3–4 caudal cirri are formed from the posterior end of DK_5 and remain aligned to it in the vegetative cell.

Comparison with described populations: Borror and Wicklow (1983) described several populations of *Caudiholosticha sylvatica* but did not provide sufficient



Figs 4a, b. Line diagrams of a protargol impregnated vegetative cell of *Caudiholosticha sylvatica* Silent Valley population. **a** – ventral surface; **b** – dorsal surface; arrow in 4a marks the frontal row typical of the species, arrow in 4b points to the caudal cirri and double arrow to the dorsal kinety 5. Bar represents 25 µm. **Fig. 4c.** Photomicrograph of a live cell of *Caudiholosticha sylvatica*, Silent Valley population; arrows point to cortical granules, arrowhead marks the contractile vacuole.

▸▸

Figs 5a–f. Photomicrographs of protargol impregnated cells of *Caudiholosticha sylvatica*, Silent Valley population. **a** – ventral; **b** – dorsal surface of a vegetative cell; **c–e** – division stages, ventral surface; **f** – division stage, dorsal surface; arrow in 5a marks the frontal row of cirri, arrow in 5b points to the caudal cirri on the right margin of the cell, arrows in 5c–e show the progressive stages of the formation of frontal cirrus 1, frontal row of cirri and the paroral and endoral from streak I, arrow in 5f points to the new caudal cirri formed at the posterior end of dorsal kinety 5.

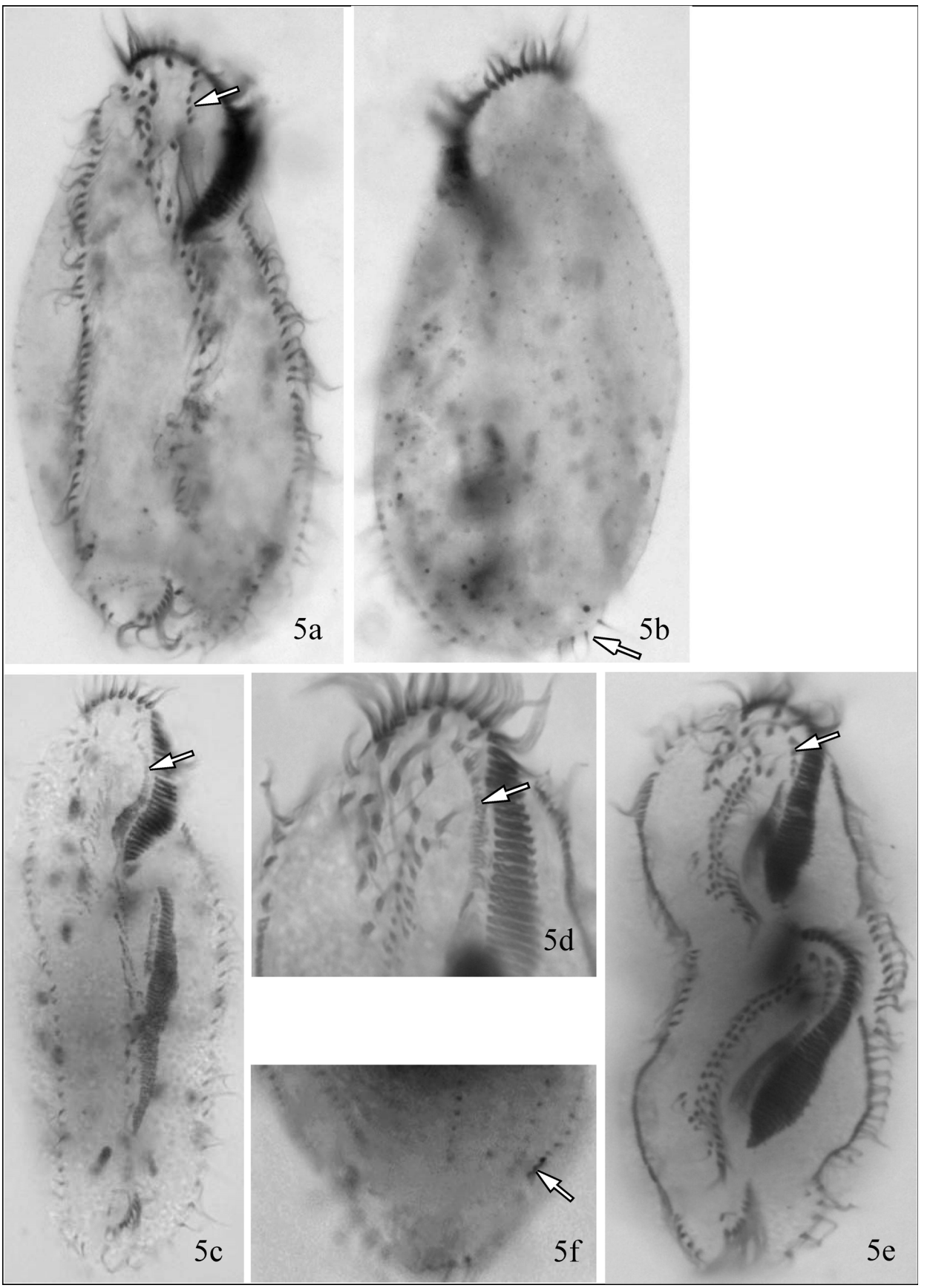

5a
5b
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Table 2. Biometric characterization* of *Caudiholosticha sylvatica* Silent Valley population.

Character	Mean	Min	Max	SD	CV
Body length, µm	123.2	100.3	142.7	16.11	13.07
Body width, µm	51.6	42.0	70.0	8.06	15.61
Adoral membranelles, no.	43.6	40	45	1.58	3.62
Adoral Zone of Membranelles (AZM) length, µm	47.0	40.4	59.4	5.58	11.87
AZM / body length %	39.6	31.8	47.5	4.19	10.59
Macronuclear nodules, no.	53.4	45	64	6.61	12.3
Macronucleus length, µm	6.0	5.3	6.39	0.34	5.65
Macronucleus width, µm	2.7	2.1	3.4	0.52	19.18
Micronuclei, no.	2.9	2	4	0.74	25.52
Micronucleus diameter, µm	2.4	2.1	2.6	0.18	7.60
Frontal row, no. of cirri	5.2	5	6	0.42	8.07
Buccal cirri, no.	1.0	1	1	0	0
Frontal cirri, no.	3.0	3	3	0	0
Fronto-terminal cirri, no.	2.0	2	2	0	0
Mid ventral complex, no. of cirri	36.0	32 (16 pairs)	42 (21 pairs)	3.40	9.44
Pre-transverse cirri, no.	2.0	2	2	0	0
Transverse cirri, no.	8.9	8	10	0.58	6.51
Right marginal row (s), no.	1.0	1	1	0	0
Right marginal row, no. of cirri	41.8	36	49	4.26	10.19
Left marginal row (s), no.	1.0	1	1	0	0
Left marginal row, no. of cirri	38.4	33	45	3.86	10.05
Dorsal kineties (DK), no.	5.0	5	5	0	0
DK_1, no. of bristles	23.7	21	26	1.64	6.62
DK_2, no. of bristles	27.3	22	34	3.59	13.15
DK_3, no. of bristles	16.8	10	22	3.91	23.27
DK_4, no. of bristles	18.2	15	21	1.81	9.94
DK_5, no. of bristles	19.3	17	21	1.57	8.13
Caudal cirri, no.	3.4	3	4	0.52	15.29

* Data based on protargol stained non-dividers obtained from a non-flooded petridish culture. n – 10; Max – maximum; Min – minimum; SD – standard deviation; CV – coefficient of variation (%).

data to enable any valuable comparison. However, comparison of morphometric data with other known populations is given in Table 3. The Silent Valley population resembles the Japanese population described by Berger and Foissner (1989). The row of cirri left of the buccal cirrus and lying just posterior to the first frontal cirri was termed 'frontal row' by Foissner (1995) for a similar row in *Bicoronella costaricana*. The term 'frontal row' is used here for a similarly positioned cirral row in *C. sylvatica*. The origin of this row is unknown in both these species although Berger (2006) supposed that they originate from cirral streak I. The present study on *C. sylvatica*, Silent Valley population, shows that it arises from the anterior segment of the primordium for paroral and endoral, just posterior to the first frontal cirrus.

Family Bakuellidae

Seven genera have been assigned to the family Bakuellidae Jankowski, 1979, including *Bakuella* and *Holostichides* (Berger 2006). The nine known species of the genus *Bakuella* possess transverse cirri but lack caudal cirri (Berger 2006). Members of the genus *Holostichides* lack transverse cirri but possess caudal

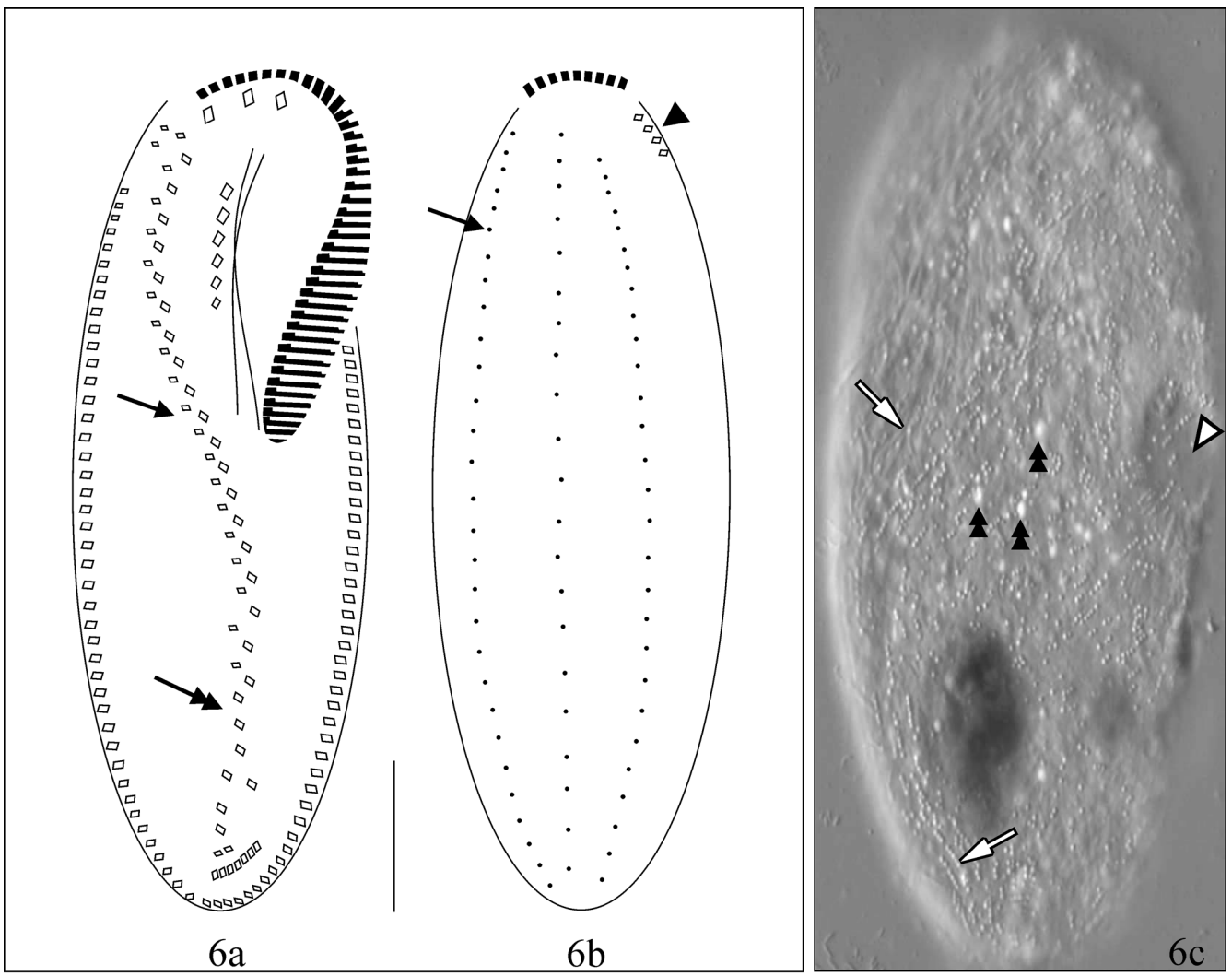
Table 3. Comparison between biometric data of *Caudiholosticha sylvatica* Silent Valley population and three described populations of the same species (mean values taken); (–) indicates data not available.

	SV population, present investigation	Austrian population, Foissner, 1982	Japanese population, Berger and Foissner, 1989	Korean population, Shin and Kim, 1993
Body length, µm	123.2	117.3	127.0	184.4
Body width, µm	51.6	44.0	52.0	79.3
Adoral membranelles, no.	43.6	34.8	44.1	46.7
Adoral Zone of Membranelles (AZM) length, µm	47.0	35.6	44.5	65.9
AZM / body length %	39.6	–	–	–
Body length: AZM length ratio	2.6	–	–	2.8
Macronuclear nodules, no.	53.4	32.3	56.0	61.6
Macronucleus length, µm	6.0	7.9	6.1	8.5
Macronucleus width, µm	2.7	3.9	4.1	3.9
Micronuclei, no.	2.9	–	2.2	3.3
Micronucleus diameter, µm	2.4	3.1 × 2.3	3.0 × 3.0	2.9
Frontal row (cirri between UM and AZM), no. of cirri	5.2	–	4.0	–
Buccal cirri, no.	1.0	1	1	1
Frontal cirri, no.	3.0	3	–	–
Fronto-terminal cirri, no.	2.0	–	2	2
Mid ventral complex, no. of cirri	36.0	–	33.4	–
Pre-transverse cirri, no.	2.0	2	2	2
Transverse cirri, no.	8.9	7.1	8.3	8.5
Right marginal row (s), no.	1.0	1	1	1
Right marginal row, no. of cirri	41.8	32.1	40.9	45.8
Left marginal row (s), no.	1.0	1	1	1
Left marginal row, no. of cirri	38.4	30.8	37.2	40.3
Dorsal kineties (DK), no.	5.0	5	5	5
DK_1, no. of bristles	23.7	–	–	–
DK_2, no. of bristles	27.3	–	–	–
DK_3, no. of bristles	16.8	–	–	–
DK_4, no. of bristles	18.2	–	–	–
DK_5, no. of bristles	19.3	–	–	–
Caudal cirri, no.	3.4	–	4.0	5.3

cirri (Foissner 1987b). Two species of the family isolated from the Silent Valley – *Bakuella nilgiri* n. sp. and *Holostichides chardezi* Foissner, 1987, are described below.

Bakuella nilgiri n. sp. (Figs 6a–c, 7a–e; Table 4)

Diagnosis: Soil ciliate, average size of non-dividers *in vivo* 158 × 68 µm, protargol-stained cells 141 × 54 µm; colourless granules distributed randomly throughout the cortex or in short linear rows; single contractile vacuole; about 98 macronuclear nodules, 3 or 4 micronuclei; adoral zone about 47% of body length, membranelles number about 48, paroral and endoral intersecting; 4–8 buccal cirri in a row, 2–4 fronto-terminal cirri, mid-ventral complex consisting of about 21 cirral pairs and 2–10 cirri in 2 or 3 rows that extend to the level of the transverse cirri, 2 (rarely 3) pre-transverse cirri, 6–11 transverse cirri in a curved row; left marginal row curves around the posterior end of the cell but does not overlap the posterior end of the right marginal row.



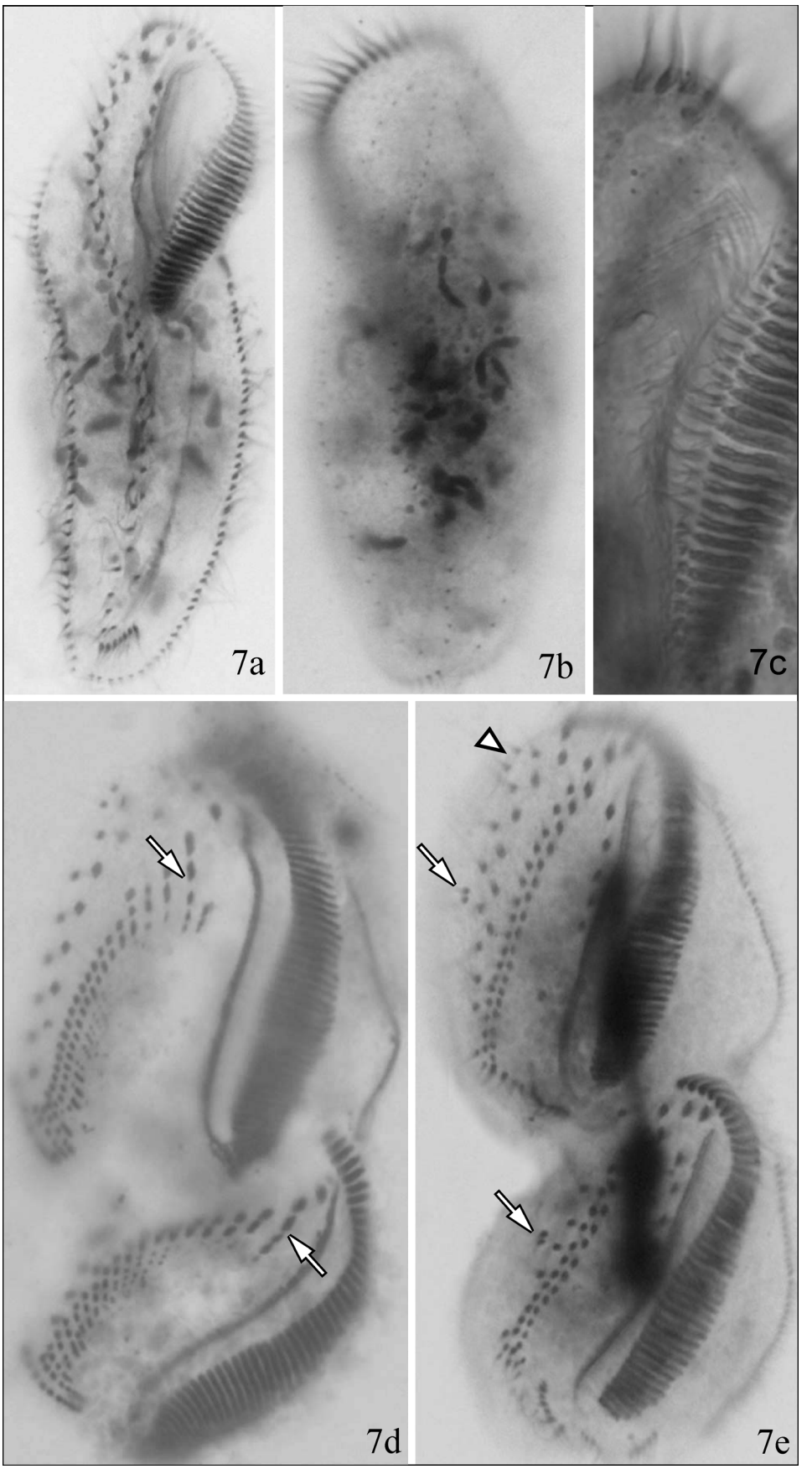
Figs 6a, b. Line diagrams of a protargol impregnated vegetative cell of *Bakuella nilgiri* n. sp. **a** – ventral surface; **b** – dorsal surface; arrow in 6a points to cirral pairs and double arrow in 6a to cirral rows, arrowhead in 6b marks the anterior cirri of the right marginal row which appear on the dorsal surface, arrow in 6b points to dorsal kinety 1. Bar represents 25 µm. **Fig. 6c.** Photomicrograph of a live cell of *Bakuella nilgiri* n. sp., arrowhead marks the contractile vacuole, arrows point to linearly arranged cortical granules, double arrowheads indicate fat droplets.

Type locality: Light brown fine texture soil from the grasslands in between tracts of the tropical rain forests, about a kilometre into the park from the entry point in the vicinity of the trekking trail.

Type material: A holotype slide with protargol-stained cells is being deposited in the Natural History Museum, Cromwell Road, London SW7 5BD, UK (accession number 2010:10:18:1).

Etymology: The species has been named after the Nilgiri Hills which form the northern boundary of the Silent Valley National Park.

Morphology: Average cell size *in vivo* 158 × 46 µm and 141 × 54 µm in protargol-stained preparations. Body flexible, elliptical with both ends broadly rounded. Seventy eight to 125 macronuclear nodules, 4.7 × 2.7 µm each on an average, scattered throughout the cytoplasm; 3–4 micronuclei, each about 2 µm in diameter. Contractile vacuole on the left side of the body at the level of the buccal vertex. Cortical granules colourless, about 0.7 µm in diameter, present singly or in short linear rows of 2–8 granules arranged roughly antero-posteriorly. Fat droplets about 2.6 µm diameter present throughout the body.



Figs 7a–e. Photomicrographs of protargol impregnated cells of *Bakuella nilgiri* n. sp. **a** – ventral surface; **b** – dorsal surface; **c** – pharyngeal fibres of the oral groove; **d** – a mid-divider; **e** – a late divider; arrows in 7d mark the formation of frontal cirrus 2 and cirri of the buccal row from streak II, arrows in 7e point to the newly formed fronto-terminal cirri, arrowhead marks the parental fronto-terminal cirri.

Table 4. Biometric characterization* of *Bakuella nilgiri* n. sp.

Character		Mean	Min	Max	SD	CV
Body length, µm		141.2	124.1	157.7	8.94	6.33
Body width, µm		53.9	44.1	77.0	5.88	10.90
Adoral membranelles, no.		47.6	42	54	3.25	6.82
Adoral Zone of Membranelles (AZM) length, µm		66.1	55.6	80.2	4.92	7.50
AZM / body length %		46.7	42.2	53	3.27	7.01
Macronuclear nodules, no.		97.5	78	125	14.41	14.78
Macronucleus length, µm		4.7	3.8	5.2	0.42	09.03
Macronucleus width, µm		2.7	2.1	3.0	0.29	10.94
Micronuclei, no.		3.7	3	4	0.47	12.55
Micronucleus diameter, µm		2.1	1.9	2.4	0.17	8.17
Buccal cirri, no.		6.2	4	8	1.09	17.72
Frontal cirri, no.		3.0	3	3	0	0
Fronto-terminal cirri, no.		2.4	2	4	0.59	25.10
Mid ventral complex	Cirral pairs, no.	20.9	18	23	1.93	9.26
	Cirri in rows, no.	5.5	2	10	2.03	37.25
Pre-transverse cirri, no.		2.1	2	3	0.22	10.73
Transverse cirri, no.		8.6	6	11	1.28	14.88
Right marginal row, no. of cirri		59.8	49	65	4.21	7.04
Left marginal row, no. of cirri		48.0	38	56	4.11	8.56
Dorsal kineties (DK), no.		3.0	3	3	0	0
DK_1, no. of bristles		31.5	26	41	4.25	13.49
DK_2, no. of bristles		39.5	31	47	5.26	13.33
DK_3, no. of bristles		37.0	31	47	3.62	9.78

* Data based on protargol stained non-dividers obtained from a non-flooded petridish culture. n – 20; Max – maximum; Min – minimum; SD – standard deviation; CV – coefficient of variation (%).

Ciliature: A conspicuous adoral zone occupying about 47% of cell length with 42–54 membranelles, paroral and endoral long and virtually intersecting; 3 hypertrophied frontal cirri, four to 8 buccal cirri in a row, two to 4 fronto-terminal cirri in a row, mid-ventral complex with 18–23 cirral pairs and 2–10 cirri in 2 or 3 rows, 2 (rarely 3) pre-transverse cirri, 6–11 transverse cirri arranged in a curved row that may sometimes be tick-mark shaped; one right marginal row with 49–65 cirri and one left marginal row with 38–56 cirri, left marginal row J-shaped, right marginal row ends terminates above the posterior end of the cell; 3 dorsal kineties, caudal cirri absent.

Morphogenesis during division: *Bakuella nilgiri* n. sp. shows a typical urostyloid pattern of divisional morphogenesis. The parental adoral zone of membranelles is retained unchanged in the proter. The first frontal cirrus is formed from the reorganizing paroral and endoral in the proter; in the opisthe, it is formed from the primordium for paroral and endoral. Twenty five to 30 cirral streaks are formed for each of the two daughter cells. The anterior-most cirral streak produces the second frontal cirrus and 4–8 buccal cirri. The anterior 18–23 cirral streaks, except the first one, each generate two cirri to form the cirral pairs of the mid-ventral complex. The rest produce successively more cirri to form cirral rows, pre-transverse and transverse cirri, and the fronto-terminal cirri.

Comparison with congeners: *Bakuella nilgiri* n. sp. from Silent Valley National Park differs from the other described species of the genus by virtue of its new combination of characters (Table 5). It resembles *B. pampinaria* Eigner and Foissner, 1992, a terrestrial *Bakuella* species, in size and ciliature but differs from it in the adoral zone length, adoral membranelle number, and the cirral composition of the mid ventral complex – *B. pampinaria* has more mid ventral cirri present in staggered rows while *B. nilgiri* n. sp. has most of the

Table 5. Comparison between biometric data of *Bakuella nilgiri* n. sp. and nine other species of the genus (mean values taken); (–) indicates data not available.

	B. crenata	*B. agamalievi*	*B. marina*	*B. salinarium*	*B. walibonensis*	*B. pampinaria*	*B. granulifera*	*B. edaphoni*	*B. pulchra*	*B. nilgiri*
Authors	Agamaliev & Alekperov, 1976	Borror & Wicklow, 1983	Agamaliev & Alekperov, 1976	Mihailowitsch & Wilbert, 1990	Song, Wilbert & Berger,1992	Eigner & Foissner, 1992, Foissner, 2004	Foissner, Agatha & Berger, 2002	Song, Wilbert & Berger, 1992	Buitkamp, 1977	Present investigation
Occurrence	fresh water	marine	marine	marine	marine	soil	soil	soil	soil	soil
Cortical granules	present	present (colourless/ green)	not known	present	present	present (yellow)	present (yellow)	absent	absent	present (colourless)
Body length	210	100–150/90–100	~ 200	281–352	180–230	90–180, 80–150	270–400	190–300	150–170	128–158
Body width	–	48–70/40/51	45–70/70–110	87–145	62–83	25–43, 28–48	70–120	59–82	–	47–57
Macronuclear nodules, no.	2	~ 50/80–120	–	~ 100	~ 100	58–125	250–400	–	–	~ 98
Micronuclei, no.	–	–	–	2	–	4-8	–	2–7	–	3 (rarely 4)
AM, no.	28–30	30/26–37	28–51	47–63	33–47	22–34, 22–39	44–62	34–45	–	45–54
AZM/body length %	35	33–40	30	38	38	24–37	30–42	29	–	42–53
FC, no.	3	3/4	3	3	3	3	3	3	3	3
BC, no.	3–4	1	2–5	6–8	5–6	2–5, 3–6	7–10	5–9	–	4–8
MVC (CP/CR)	5/10–12 rows	~ 11/4 rows with 3–5 cirri each	4–12, 4–10 rows	26/16 rows	14/2 rows with 3 cirri each	4,9/4 rows	18/3–5 rows	9,7 rows/3–5, 7–14 cirri	–	18–23/2–10 cirri in 2–3 rows
FT, no.	~ 9	4–7	5–11	2	2	1–7, 5–8	3–5	2–5	–	2–4 (mostly 2)
TC, no.	6–9	4–7, 5–7	7, 10	17–12	4–6	3–7, 2–5	9–15	6–11	–	7–11, + 2–3 PT
RMC row, no., shape	1	1	1	1	1	1	1	1, linear	–	1, linear
LMC row, no., shape	1	1	1	1	1	1	1	1, J-shaped	–	1, J-shaped
DKs, no.	3(2/5)	3	3, rarely 4	–	3	3	3	3	–	3

mid ventral cirri in pairs. It also resembles *B. edaphoni* but the latter lacks cortical granules.

***Holostichides chardezi* Foissner 1987, Silent Valley population (Figs 8a–c, 9a–e; Table 6)**

Occurrence and ecology: Soils of the tropical rain forest close to the entry point (Sairandri) of the Silent Valley National Park, India (Fig. 1).

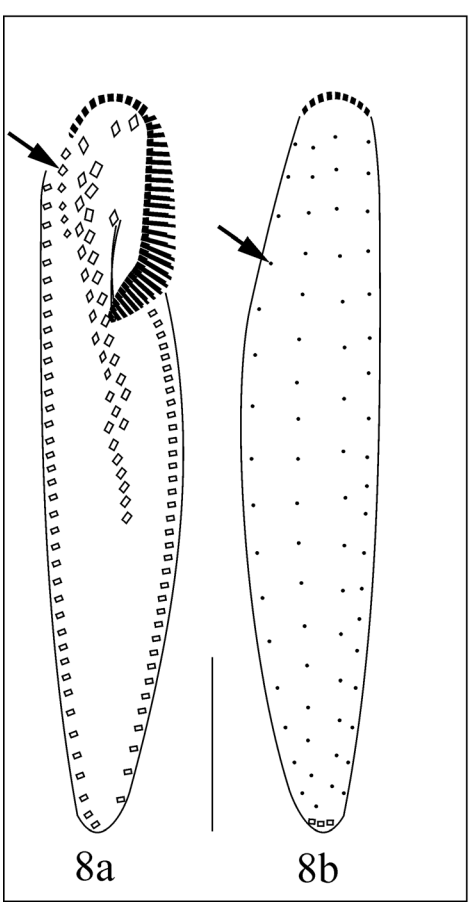
Morphology: Average cell size *in vivo* 126 × 30 µm, 107 × 25 µm in protargol-stained preparations. Body slender and elongate with a tapering posterior end. Thirty to 34 macronuclear nodules, each 5.2 × 3.3 µm in size, scattered throughout the cytoplasm; 2 micronuclei, about 2.6 µm in diameter. Contractile vacuole on the left side of the body at the level of the buccal vertex.

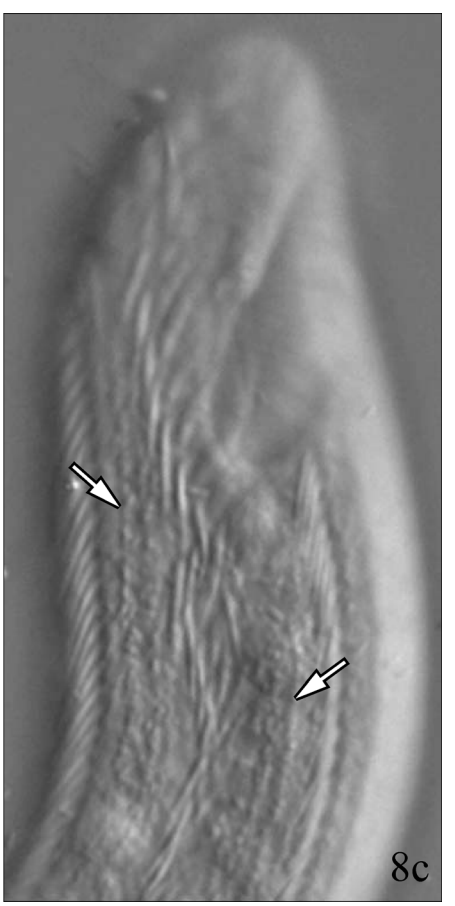
Cortical granules yellowish, 1.2 µm in diameter, present in about 10–15 rows distributed on both the ventral and the dorsal surfaces of the cell, each row with granules arranged singly or in linear groups of 3–8 granules.

Ciliature: A conspicuous adoral zone occupies about 31% of cell length with 32–35 membranelles, paroral and endoral short and virtually intersecting; 3 frontal cirri, a single buccal cirrus positioned almost at the anterior end of the paroral and endoral, fronto-terminal cirri in a row with 6 or 7 cirri, mid-ventral complex with 9–12 cirral pairs and 7–8 cirri in a single row posterior to the cirral pairs, transverse cirri absent; one right marginal row with 37–43 cirri and one left marginal row with 34–46 cirri, left marginal row terminates above the posterior end of the cell; 4 dorsal kineties, 3 inconspicuous caudal cirri.

Morphogenesis during division: Division morphogenesis in typical Urostyloid pattern. No transverse cirri are formed. The 4 dorsal kineties are formed intrakinetally. Dividers show caudal cirri forming at the posterior ends of dorsal kineties 1, 2, and 4.

Comparison with described populations: *Holostichides chardezi* isolated from Cape Verde in Senegal was first described by Foissner (1987b). Subsequently it has been found from several other locations (for review, see Berger 2006). According to Foissner (1998) it occurs in the Holarctis, the Palaeotropis and Australis with strong soil autochthonism. Shin (1994) reported its occurrence from South Korea (Table 7). The Silent Valley population resembles the Cape Verde population.





Figs 8a, b. Line diagrams of a protargol impregnated vegetative cell of *Holostichides chardezi* Silent Valley population. **a** – ventral surface; **b** – dorsal surface; arrow in 8a marks the row of fronto-terminal cirri, arrow in 8b points to dorsal kinety 1. Bar represents 25 µm. **Fig. 8c.** Photomicrograph of a live cell of *Holostichides chardezi*, Silent Valley population; arrows point to the rows of cortical granules.

▸▸

Figs 9a–e. Photomicrographs of protargol impregnated cells of *Holostichides chardezi*, Silent Valley population. **a** – ventral surface; **b** – dorsal surface; **c** – ventral surface of a late divider; **d** – dorsal surface of a late divider; **e** – ciliature in the anterior segment of the ventral surface; arrow in 9d show the inconspicuous caudal cirrus formed at the end of dorsal primordium 4 of a proter, arrow in 9e points to the fronto-terminal row.

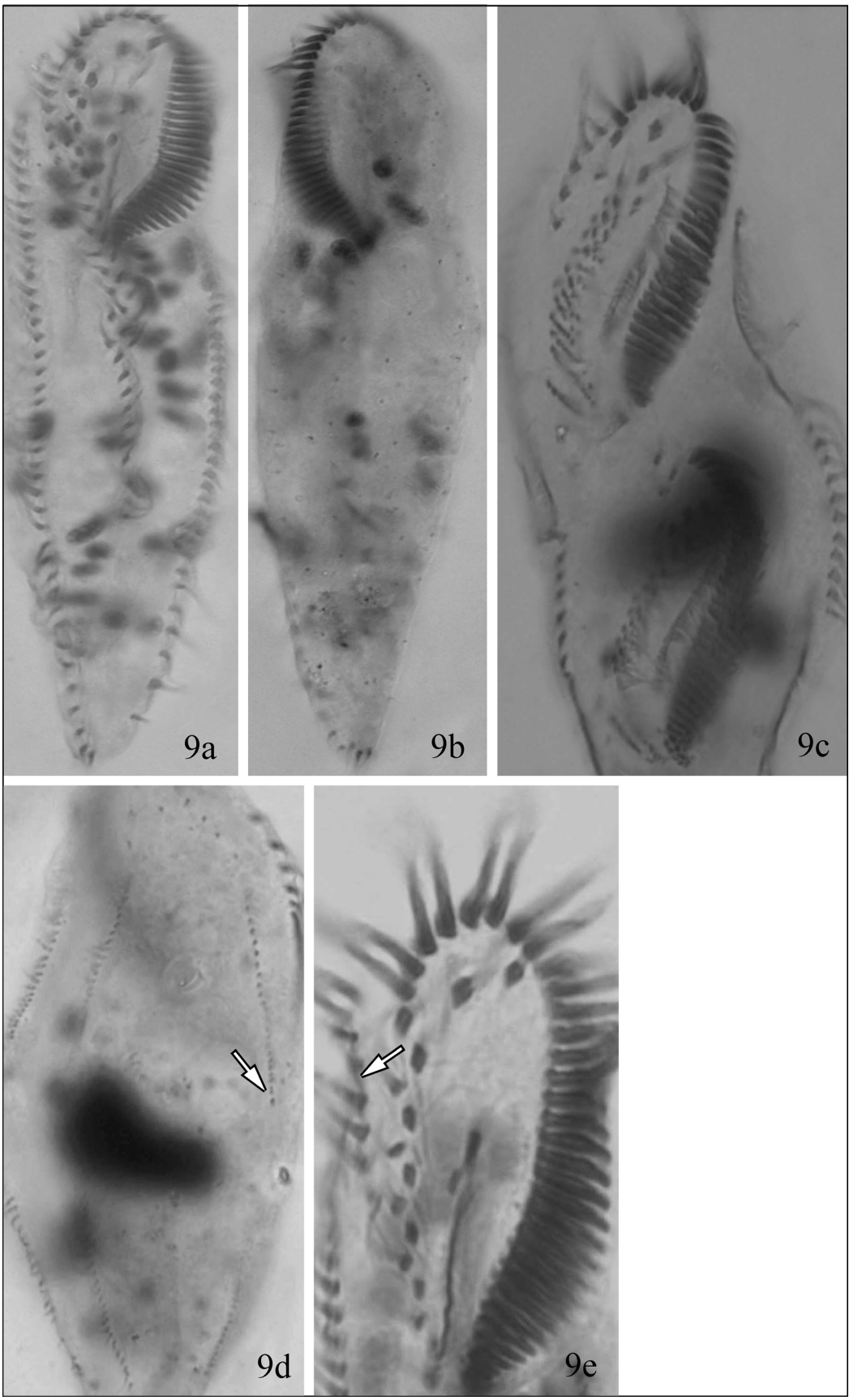

9a
9b
9c
9d
9e

Table 6. Biometric characterization* of *Holostichides chardezi* Silent Valley population.

Character		Mean	Min	Max	SD	CV
Body length, µm		106.8	98.6	118.9	5.57	5.21
Body width, µm		24.7	22.1	26.6	1.33	5.37
Adoral membranelles, no.		34.1	32	35	0.88	2.58
Adoral Zone of Membranelles (AZM) length, µm		32.6	31.1	35.3	1.05	3.22
AZM / body length %		30.6	29.6	32.4	0.85	2.77
Macronuclear nodules, no.		31.4	30	34	1.26	4.01
Macronucleus length, µm		5.2	4.3	6.3	0.49	9.40
Macronucleus width, µm		3.3	2.8	3.8	0.27	8.18
Micronuclei, no.		2.0	2	2	0	0
Micronucleus diameter, µm		2.6	1.8	3.3	0.43	16.28
Buccal cirri, no.		1.0	1	1	0	0
Frontal cirri, no.		3.0	3	3	0	0
Fronto terminal cirri, no.		6.5	6	7	0.53	8.15
Mid ventral complex	Cirral pairs, no.	21.5	18 (9 pairs)	24 (12 pairs)	1.90	8.84
	Cirri, no., in single row	7.4	7	8	0.52	7.02
Right marginal row, no. of cirri		39.4	37	43	1.95	4.95
Left marginal row, no. of cirri		38	34	46	3.16	8.32
Dorsal kineties (DK), no.		4.0	4	4	0	0
DK_1, no. of bristles		13.7	12	15	0.95	6.93
DK_2, no. of bristles		18.5	14	21	1.90	10.27
DK_3, no. of bristles		15.7	13	17	1.06	6.75
DK_4, no. of bristles		21.0	19	22	0.94	4.48
Caudal cirri, no.		3.0	3	3	0	0

* Data based on protargol stained non-dividers obtained from a non-flooded petridish culture. n –10; Max – maximum; Min – minimum; SD – standard deviation; CV – coefficient of variation (%).

Family Urostylidae

The multiple marginal rows in some members of the family arise from a common ventral primordium (term used by Wicklow 1981 for *Thigmokeronopsis jahodai*) on either side of the frontal ciliature. Two species of the genus *Pseudourostyla*, namely *P. franzi* and *P. levis*, were isolated from soil samples of the Silent Valley.

Pseudourostyla franzi Foissner 1987, Silent Valley population (Figs 10a–c, 11a–e; Table 8)

Occurrence and ecology: Sandy soils of riverine forest at the end of the trek route, close to the river Kunthipuzha, Silent Valley National Park, India (Fig. 1).

Morphology: Average cell size *in vivo* 270 × 97 µm, 260 × 94 µm in protargol-stained preparations. Body very flexible, elongate, elliptical in outline with both ends broadly rounded, slightly narrowing at the anterior end, a small hump on the right margin at the level of the last collar adoral membranelle; 340–480 macronuclear nodules, average size 6.3 × 3.0 µm, scattered throughout the cytoplasm; 8–13 micronuclei each about 2.9 µm in diameter; contractile vacuole in the left side of the body at the level of the buccal vertex; cortical granules colourless, about 0.6 µm in diameter, densely packed throughout the cortex present singly in no particular arrangement.

Ciliature: A conspicuous adoral zone occupying about 37% of cell length with 70–79 membranelles, paroral and endoral long and virtually intersecting; one row of 4–6 buccal cirri, a total of 21–26 pairs of frontal cirri form the mid-ventral complex, frontal cirri in the form of a bicorona that extends posteriorly as the mid ventral complex with successively decreasing levels of hypertrophy terminating in the mid-body region, 2 or 3 fronto-terminal cirri, 10–14 transverse cirri arranged in a slightly curved row; 11–13 right marginal rows and

Table 7. Comparison between biometric data of *Holostichides chardezi* Silent Valley population and two described populations of the same species (mean values taken); (–) indicates data not available.

	SV population, present investigation	Kenya (Africa) population, Foissner, 1987b	S Korea population, Shin, 1994
Body length, µm	106.8	111.6	148.1
Body width, µm	24.7	27.1	37.4
Adoral membranelles, no.	34.1	30.8	29.1
Adoral Zone of Membranelles (AZM) length, µm	32.6	30.6	40.6
AZM / body length %	30.6	–	–
Body length: length of AZM, ratio	3.26	–	3.7
Macronuclear nodules, no.	31.4	35.8	31.9
Macronucleus length, µm	5.2	6.7	7.3
Macronucleus width, µm	3.3	3.4	3.6
Micronuclei, no.	2.0	4.0	3.7
Micronucleus diameter, µm	2.6	3.7 × 2.5	2.8
Buccal cirri, no.	1.0	1.0	1.0
Frontal cirri, no.	3.0	3.0	3.0
Fronto-terminal cirri, no.	6.5	4.6	4.7
Cirral pairs, no.	11.8	7.0	5.8
Cirri, no., in single row	7.4	11.2	8.7
Right marginal row (s), no.	1.0	1.0	1.0
Right marginal row, no. of cirri	39.4	38.5	38.4
Left marginal row (s), no.	1.0	1.0	1.0
Left marginal row, no. of cirri	38.0	34.2	33.7
Dorsal kineties, no.	4.0	4.0	4.0
Caudal cirri, no.	3.0	3.7	3.0

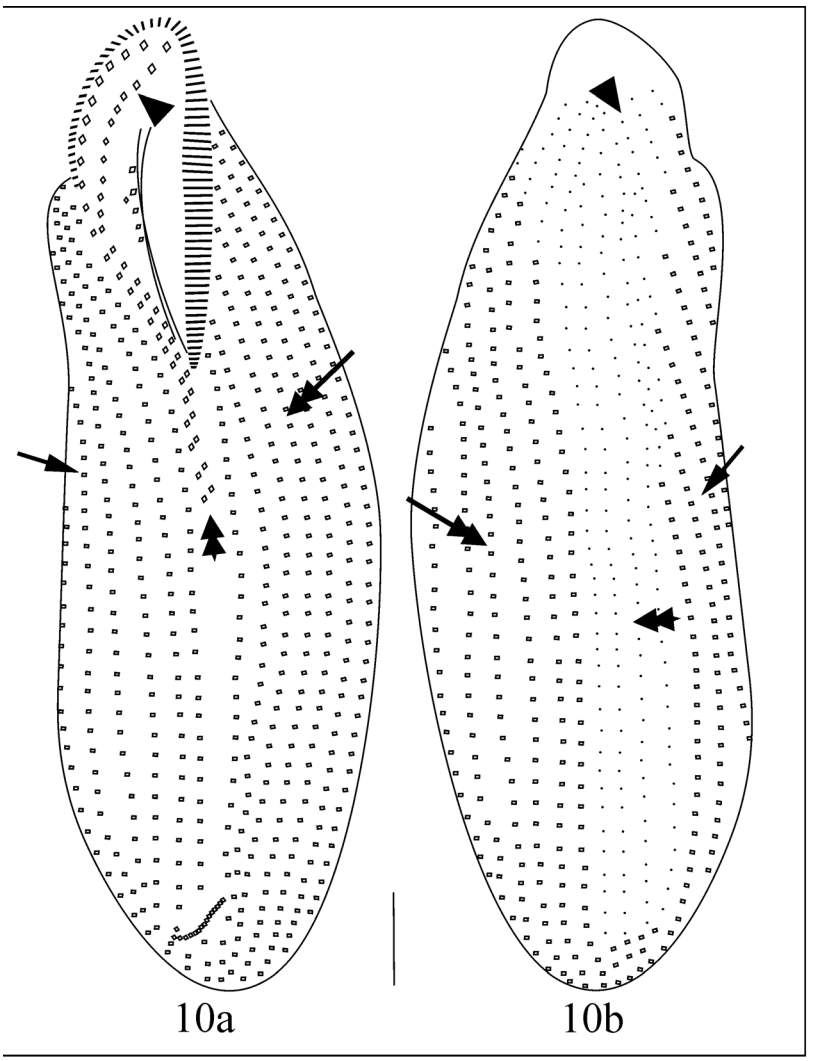
14–16 left marginal rows occupying nearly 90% of the ventral surface and 70% of the dorsal surface; 4 complete dorsal kineties each with about 28 bristles, 6–8 incomplete dorsal kineties present in the anterior segment of the cell aligned along the marginal rows on the dorsal surface; caudal cirri absent.

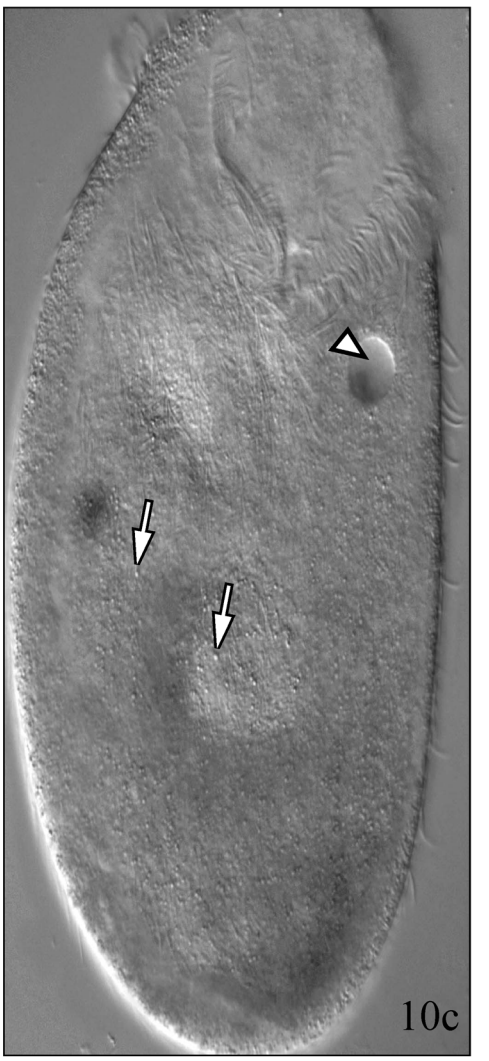
Morphogenesis: Development of new marginal rows occurs intra-kinetally as seen in a reorganizer.

Comparison with described population: *Pseudourostyla franzi* from the Silent Valley National Park resembles *P. franzi* Foissner, 1987b in the unique distribution of multiple marginal rows both on the ventral and on the dorsal surfaces (Table 9). The cirri of the mid-ventral complex and the dorsal kineties in *Pseudourostyla franzi*, Silent Valley population, occupy only 20% of the cell surface, the marginal rows occupying the rest of the cell exterior, i.e. 80%.

There are, however, significant differences between the two populations (highlighted figures in table 9). The cell length is the same in both cases but the length of the adoral zone in the Silent Valley population is about 40% greater than that of the African population. Similarly, the body width and the numbers of left and right marginal rows are also greater in the Silent Valley population. Since division morphogenesis is unknown in both cases, the species name *P. franzi* is retained for the Silent Valley population.

One protargol-stained reorganizer of the Silent Valley population showed intrakinetal primordia formation for the marginal rows; it appears that formation of all the marginal rows from a single ventral primordium on either side of the frontal ciliature as seen in *P. levis* (see below) may not be a generic character of *Pseudourostyla*.





Figs 10a, b. Line diagrams of a protargol impregnated vegetative cell of *Pseudourostyla franzi* Silent Valley population. **a** – ventral surface; **b** – dorsal surface; arrows and double arrows in 10a and 10b mark the multiple right marginal and left marginal rows respectively, arrowhead in 10a points to the bicorona typical of the genus, double arrowhead in 10a points to the mid ventral complex that terminates at the mid body line, double arrowhead in 10b points to the four complete dorsal kineties, arrowhead in 10b shows the additional incomplete dorsal kineties in the anterior segment of the cell each of which aligns to one of the marginal rows on the dorsal surface. Bar represents 25 μm. **Fig. 10c.** Photomicrograph of a live cell of *Pseudourostyla franzi*, Silent Valley population; arrowhead marks the contractile vacuole and the arrows point to cortical granules.

Figs 11a–e. Photomicrographs of protargol impregnated cells of *Pseudourostyla franzi*, Silent Valley population. **a** – ventral surface; **b** – dorsal surface; **c** – middle segment of the cell (ventral surface); **d** – anterior segment of the cell (dorsal surface); **e** – middle segment of the cell (dorsal surface); arrowhead in 11a marks the 'hump' seen in most cells, double arrows in 11c–e indicate the multiple right and left marginal rows which occupy a major portion of the ventral and dorsal surfaces, arrow in 11c show the paired fronto-ventral cirri, arrow in 11e mark the four bipolar dorsal kineties, arrow in 11d shows the multiple dorsal kineties in the anterior segment of the dorsal surface which align along the anterior ends of the marginal rows.

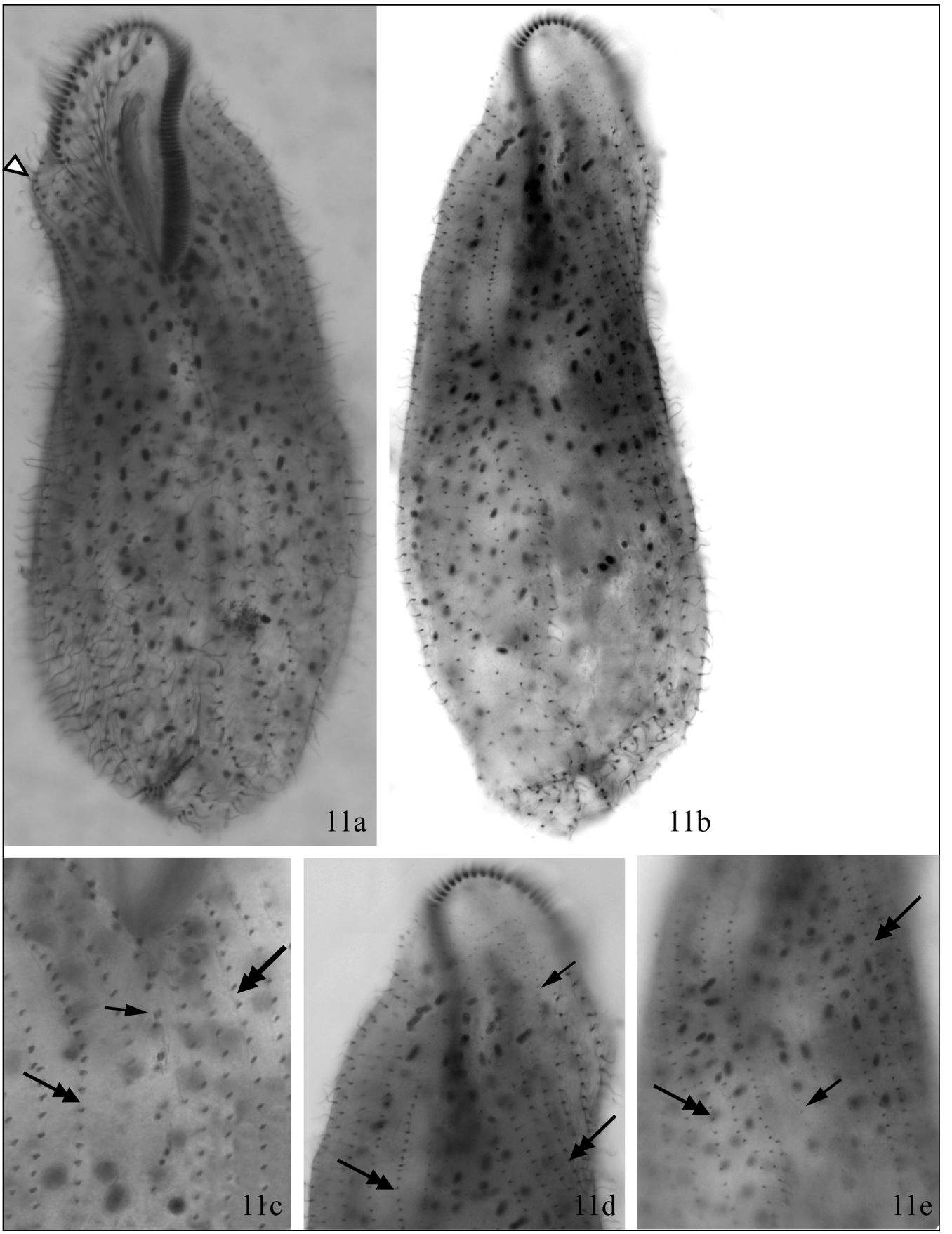

11a
11b
11c
11d
11e

Table 8. Biometric characterization* of *Pseudourostyla franzi* Silent Valley population.

Character	Mean	Min	Max	SD	CV
Body length, µm	259.8	227.8	281.6	13.67	5.26
Body width, µm	93.9	84.4	104.9	5.96	6.34
Adoral membranelles, no.	75.2	70	79	2.64	3.51
Adoral Zone of Membranelles (AZM) length, µm	102.5	84.4	113.4	7.91	7.72
AZM / body length %	37.1	31.3	44.2	3.52	9.48
Macronuclear nodules, no.	390	340	480	40.82	10.47
Macronucleus length, µm	6.3	6.1	6.7	0.17	2.65
Macronucleus width, µm	3.0	2.4	3.5	0.32	10.52
Micronuclei, no.	10	8	13	1.63	16.3
Micronucleus diameter, µm	2.9	2.5	3.6	0.28	9.93
Buccal cirri, no.	4.6	4	6	0.70	15.19
Frontal and mid ventral cirri, no.**	46.3	42 (21 pairs)	52 (26 pairs)	2.36	5.10
Fronto-terminal cirri, no.	2.2	2	3	0.42	19.09
Transverse cirri, no.	11.9	10	14	1.29	10.84
Right marginal row (s), no.	12.3	11	13	0.67	5.45
Left marginal row (s), no.	15.0	14	16	0.67	4.47
Dorsal kineties, no.	4.0	4	4	0	0

* Data based on protargol stained non-dividers obtained from a non-flooded petridish culture. n – 10; Max – maximum; Min – minimum; SD – standard deviation; CV – coefficient of variation (%).
** These include the cirri present as pairs in the form of a bicorona and continued further posteriad as ventral pairs; the cirri become successively less hypertrophied.

Table 9. Comparison between available biometric data of *Pseudourostyla franzi* Silent Valley population and *Pseudourostyla franzi* Foissner, 1987a (mean values taken); (–) indicates data not available.

	SV population, present investigation	African population, Foissner, 1987
Body length, µm	259.8	257.2
Body width, µm	**93.9**	**56.0**
Adoral membranelles, no.	**75.2**	**67.1**
Adoral Zone of Membranelles (AZM) length, µm	**102.5**	**76.8**
AZM / body length %	**39.4**	**30**
Macronuclear nodules, no.	390	218.0
Macronucleus length, µm	6.3	4.8
Macronucleus width, µm	3.0	3.0
Micronuclei, no.	10	~ 10
Micronucleus diameter, µm	2.9	2.9
Buccal cirri, no.	4.6	2.1
Frontal and mid ventral cirri, no.*	46.3	–
Fronto-terminal cirri, no.	2.2	2.0
Transverse cirri, no.	**11.9**	**7.7**
Right marginal row (s), no.	**12.3**	**7.8**
Left marginal row (s), no.	**15.0**	**8.4**
Dorsal kineties, no.	4.0	4.0

* These include the cirri present as pairs in the form of a bicorona and continued further posteriad as ventral pairs; the cirri become successively less hypertrophied. Figures in bold highlight the biometric differences between the two populations.

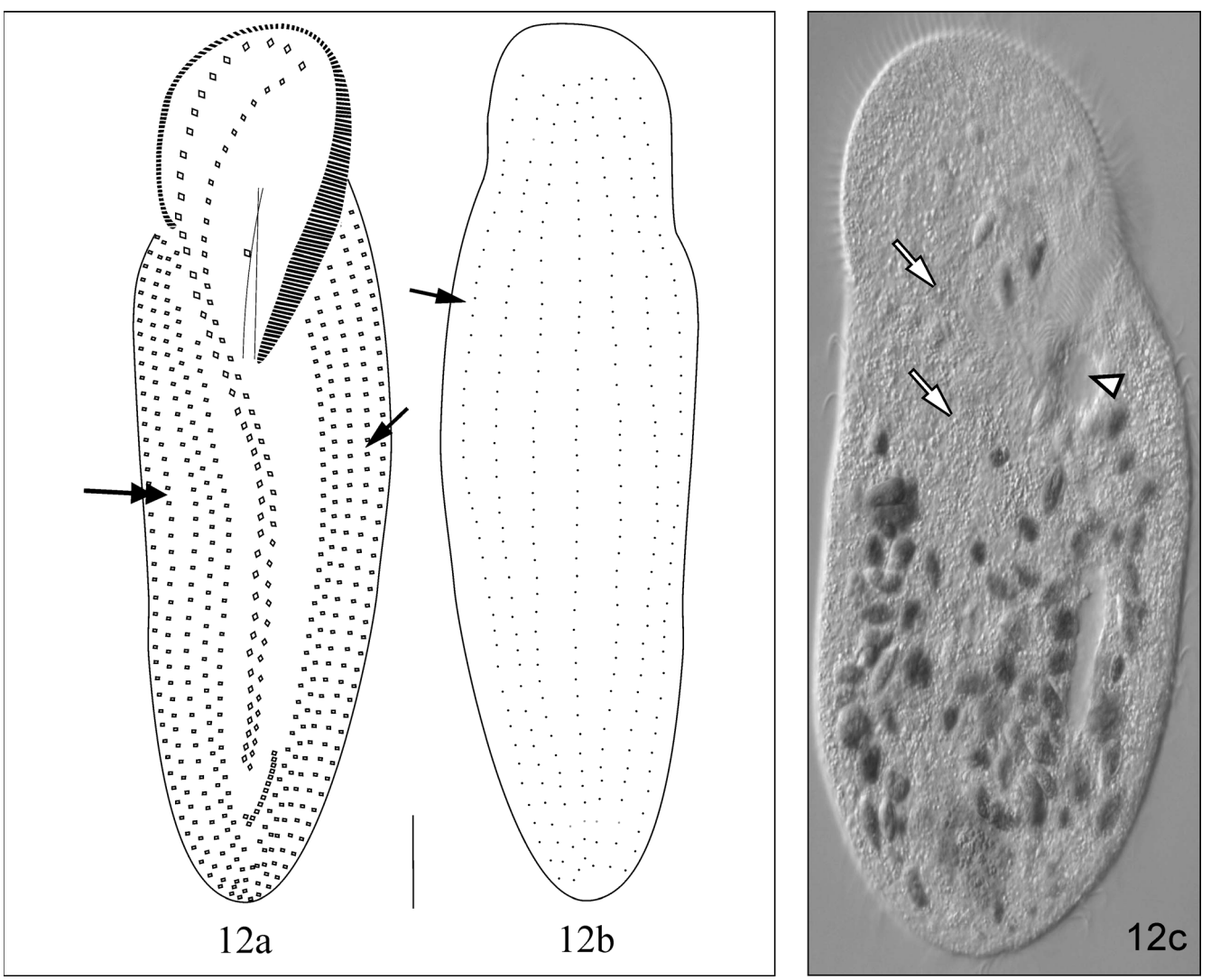
Pseudourostyla franzi has also been reported from several sites in Europe, South America, Australia, Asia (China) and Africa (Foissner 1987b; Shen *et al.* 1992; Foissner 1995, 1998; Foissner *et al*. 2002; Berger 2006).

It is proposed that *Pseudourostyla franzi,* Silent Valley population, should be assigned a separate genus status as it possesses three autapomorphies, viz. the terrestrial abode, marginal rows occupying a large part of the dorsal surface and intra-kinetal formation of all marginal rows. This however would need a complete description of the morphogenesis of *P. franzi*.

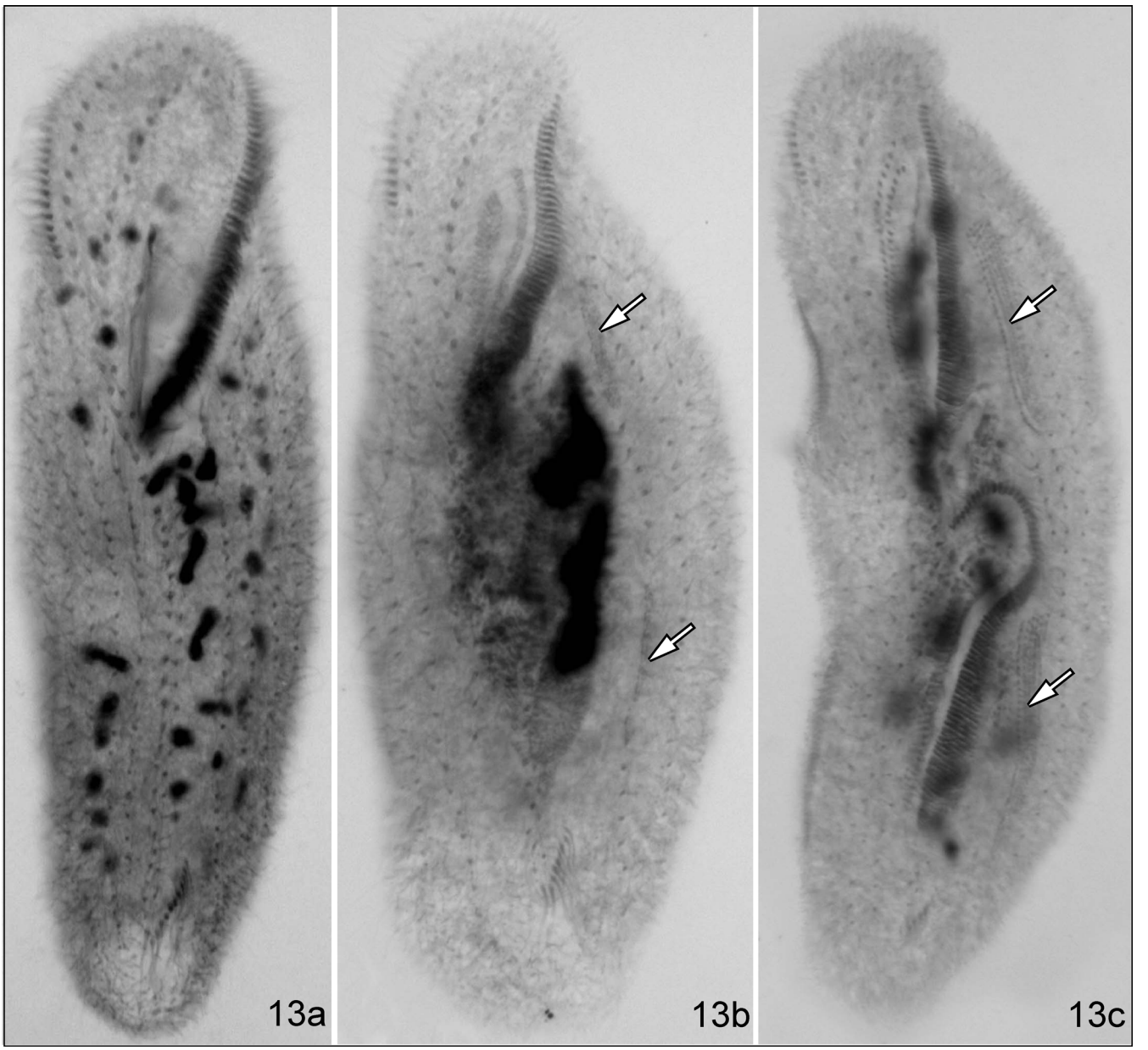
***Pseudourostyla levis* Silent Valley population (Figs 12a–c, 13a–c; Table 10)**

Occurrence and ecology: Sandy soils of riverine forest at the end of the trek route, close to the river Kunthipuzha, Silent Valley National Park, India (Fig. 1).

Morphology: Average body size 246 × 76 µm *in vivo*, 234 × 69 µm in protargol-stained preparations; Body elongate, elliptical in outline with both ends broadly rounded, dorso-ventrally flattened, very flexible; about 50 macronuclear nodules, each about 8 × 4 µm, scattered throughout the cytoplasm; 4–9 micronu-



Figs 12a, b. Line diagrams of a protargol impregnated vegetative cell of *Pseudourostyla levis*, Silent Valley population. **a** – ventral surface; **b** – dorsal surface; arrow and double arrow in 12a point to the multiple left and right marginal rows respectively, arrow in 12b points to dorsal kinety 1. Bar represents 25 µm. **Fig. 12c.** Photomicrograph of a live cell of *Pseudourostyla levis*, Silent Valley population; arrows point to cortical granules, arrowhead shows the contractile vacuole.



Figs 13a–c. Photomicrographs of protargol impregnated cells of *Pseudourostyla levis*, Silent Valley population. **a** – ventral surface; **b** – an early divider, ventral view and **c** – a late divider, ventral view; arrows in 13b show the ventral primordia formed from the inner row of left marginal cirri, arrows in 13c show all new left marginal rows forming from ventral primordia.

clei, each about 2.9 µm in diameter; contractile vacuole on the left side of the body at the level of the buccal vertex fed by long canals which run the entire length of the cell; colourless granules of two distinct types, one of small size about 0.76 µm in diameter and the other of a larger size about 1 µm in diameter interspersed and uniformly distributed throughout the cortex; trichocysts evenly distributed all over the body.

Ciliature: A conspicuous adoral zone occupying about 40% of cell length with 79–100 membranelles, paroral and endoral short and virtually intersecting; one buccal cirrus, 34–42 pairs of frontal cirri in the form of a bicorona continuing posteriorly as a row of cirral pairs that extends to the level of the transverse cirri with successively decreasing levels of hypertrophy, 2 fronto-terminal cirri, 7–13 transverse cirri arranged in

Table 10. Biometric characterization* of *Pseudourostyla levis* Silent Valley population.

Character	Mean	Min	Max	SD	CV
Body length, µm	234.1	189.2	265.8	26.81	11.45
Body width, µm	68.9	57.6	83.1	8.62	12.51
Adoral membranelles, no.	87.4	79	100	7.515	8.59
Adoral Zone of Membranelles (AZM) length, µm	92.6	87.4	101.2	3.52	3.80
AZM / body length %	40.0	35.2	48.2	4.32	10.79
Macronuclear nodules, no.	73.6	58	92	11.68	15.86
Macronucleus length, µm	8.2	6.0	10.8	1.46	17.73
Macronucleus width, µm	4.4	3.3	5.6	0.58	13.15
Micronuclei, no.	6.0	4	9	1.69	28.16
Micronucleus diameter, µm	2.9	2.5	3.5	0.29	10.17
Buccal cirri, no.	1.0	1	1	0	0
Frontal and mid ventral cirri, no.**	75.0	68 (34 pairs)	84 (42 pairs)	5.01	6.68
Fronto-terminal cirri, no.	2.0	2	2	0	0
Transverse cirri, no.	9.2	7	13	1.75	19.02
Right marginal row (s), no.	5.0	5	5	0	0
Left marginal row (s), no.	5.0	5	5	0	0
Dorsal kineties, no.	7.0	7	7	0	0

* Data based on protargol stained non-dividers obtained from a non-flooded petridish culture.
** Data combining the bicorona and the rest of the two fronto-ventral rows. n – 10; Max – maximum; Min – minimum; SD – standard deviation; CV – coefficient of variation (%).

a slightly curved row; 5 rows of right marginal cirri and 5 rows of left marginal cirri; 7 dorsal kineties, caudal cirri absent.

Morphogenesis: Division morphogenesis of *Pseudourostyla levis* Silent Valley population is typical of the species (Takahashi 1973, 1988; Gupta 1990). A distinct feature of the species is the formation of the right and left marginal rows from ventral primordia on either side of the frontal primordia, one set each for the two daughter cells. There is, however, intra-kinetal formation of the dorsal kineties.

Comparison with described population: The confusion between *Pseudourostyla cristata* and *P. levis* has been discussed by Berger (2006) who described the neotype of the latter and proposes that *P. cristata* and *P. levis* as sibling species and designated them the *P. cristata*-group.

The previously described populations of the species (Table 11) have been isolated from fresh water and soils from paddy fields. The Silent Valley population was isolated from sandy soils of riverine forests. Thus one could say that the species is terrestrial with a strong limnetic connection.

A NOTE ON THE BIOTOPE

The Silent Valley National Park (Fig. 1) in the state of Kerala, India, lies between 11°08′N, 76°28′E and 11°13′N, 76°47′E, and is a part of The Western Ghats World Heritage Site, Nilgiri Sub-Cluster (UNESCO 2007). The core zone is 12 km (north-south) by 7 km (east-west) and extends over an area of 89.5 km^2. Its topography is undulating with high, continuous ridges along its north-eastern boundary; the three highest peaks are Angida (2383 m), Sispara (2206 m) and Kozhippara (1904 m). The park being a cliff plateau is surrounded on all sides by the high mountains or faults of The Western Ghats and has remained inaccessible to all types of extraneous factors including human agencies. It has also remained insulated from extremes of climate, which, in turn, facilitated the setting of micro-climatic conditions within the park. The perennial river Kunthipuzha originates from the Nilgiri hills in the north and flows in the north-south direction, tracing the Valley right up to its southern boundary. The amount of rainfall received at any place in the park is determined by the presence of

Table 11. Comparison between available biometric data of *Pseudourostyla levis* Silent Valley population and three described populations of the same species (mean values taken); (–) indicates data not available.

	SV population, present investigation*	FW population 1, Hiroshima, Takahashi, 1973	FW population 2, Hiroshima, Takahashi, 1988	FW population 3, Hiroshima, Takahashi, and Suhama, 1991	Delhi FW population, Gupta, 1990
Body length, µm	234.1	–	213.1	–	274.3
Body width, µm	68.9	–	–	–	80.0
Adoral membranelles, no.	87.4	–	82.6	–	95.6
Adoral Zone of Membranelles (AZM) length, µm	92.6	–	–	–	105.0
AZM / body length %	40.0	–	–	–	–
Macronuclear nodules, no.	73.6	~ 60	–	~ 40	37.4
Macronucleus length, µm	8.2	–	–	–	–
Macronucleus width, µm	4.4	–	–	–	–
Micronuclei, no.	6.0	6.0	–	3–12	5.9
Micronucleus diameter, µm	2.9	–	–	–	–
Buccal cirri, no.	1.0	1.0	–	–	1.0
Frontal and mid ventral cirri, no.**	75.0	–	60.0	–	60.1
Fronto-terminal cirri, no.	2.0	–	–	–	–
Transverse cirri, no.	9.2	8.0	8.0	–	7.6
Right marginal row (s), no.	5.0	4.0	4.1	–	4.0
Left marginal row (s), no.	5.0	5.0	5.5	–	5.0
Dorsal kineties, no.	6.0	–	7–8	–	7.0

*Data based on protargol stained non-dividers obtained from a non-flooded petridish culture.
**Data combining the bicorona and the rest of the two fronto-ventral rows.

hills and the wind direction, and varies between 3200–7500 mm; the eastern regions are characterized by a rain shadow. The park has a moderate climate, with temperatures varying from 8° to 27°C.

The valley has distinctly differentiated patches of tropical rain forests, montane sub-tropical forests and montane temperate forests. The tropical rain forests have tall trees with broad leaves making a thick canopy with practically no light reaching the ground; as a result, the ground below is barren. The humidity, however, supports plenty of climbers, ferns and fungi on the tree trunks. The evergreen forests are interspersed with open grasslands.

The National Bureau of Plant Genetic Resources, ICAR, India, refer to The Silent Valley National Park as an important gene pool resource for recombinant DNA innovations; the official website cites the use of the germplasm from the native *Oryza pittambi* for introducing traits of broad-spectrum disease-resistance into high yielding hybrid rice varieties which has contributed substantially to the green revolution in Asia.

There are as many as 2,000 species of plants including more than a thousand species of flowering plants (Manilal 1988). The fauna is comparatively less documented; only group-wise data is available for some faunal groups including vertebrates and insects (Mathew and Rahamathulla 1993, Ramchandran and Joseph 2001, Mathew, Rugmini and Binoy 2003, Bird Life International 2005). While the archaic antiquity of the Indian peninsula is reflected in the autochthonous floral and faunal derivatives, influence of intrusive elements from the Indo-Chinese, Malayan, Palaearctic, Ethiopian and Australian regions, have also been found in the Park. These affinities to far-flung bio-geographic elements obviously indicate that the Valley has evolved from its primordial state some 50 million years ago to the present climax of evolution (Gopi and Radhakrishnan 2002).

The present report is a part of a research project that has been undertaken by our laboratory to catalogue ciliate diversity from various ecozones of the Silent Valley National Park.

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