

Four New Records of Ciliated Protists from Lakshadweep, India

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Abstract

The present study provides a brief description of four ciliated protists, namely *Rigidohymena quadrinucleata* (Dragesco and Njiné, 1971) Berger, 2011; *Oxytricha quadricirrata* Blatterer and Foissner, 1988; *Condylostoma curvum* Burkovsky, 1970 and *Spirostomum caudatum* (Müller, 1786) Delphy, 1939, that are new records for Indian fauna. The details of each species from live observation and after protargol impregnation have been presented.

Keywords: *Condylostoma*, Hypotrich Ciliate, India, Minicoy Island, *Spirostomum*

Introduction

Ciliates are a diverse group of protists and an important link in the micro-community because they consume a significant portion of bacterial productivity and thus play an important role in channelling minerals and nutrients for higher organism growth. About 700 species of free-living ciliates have been reported from India (Bharti and Kumar, 2021). However, the details on the morphology based on modern methods, i.e., the live observation, silver impregnation, and DNA sequence data, are available for less than 100 species of Indian free-living ciliates (Kamra *et al.*, 2008; Kamra and Kumar, 2010; Kumar *et al.*, 2010, 2015; Singh and Kamra, 2013, 2014; Bharti *et al.*, 2018; Abraham *et al.*, 2020).

Over 30 species of ciliated protists were identified from the soil samples collected from various islands (Minicoy Island, Agatti Island, Kavaratti Island, Kalpitti Island and Payapalli Island) of Lakshadweep, of which four were found to be new records for Indian fauna. The details on the live observations and protargol impregnation have been presented for all four species.

Materials and Methods

Soil samples were collected (about 50-100 gm each) from 08-18th December 2019 during the survey in Lakshadweep. The samples were air dried for two weeks before rewetting and were further processed employing the non-flooded Petri dish culture (Foissner *et al.*, 2002). The details on the sampling sites have been

provided in the description of individual species. Ciliate cultures were maintained at room temperature and by providing green algae *Chlorogonium elongatum* as food (Ammermann *et al.*, 1974) or by providing sterile rice kernels. Live observations and photomicrography were performed using a stereo microscope (SZ2-ILST, Olympus) and bright field microscope (CX 43, Olympus). The protargol impregnation method described by Kamra and Sapra (1990) was used with some modifications. *In vivo* measurements were performed at 100x-1000x and those of stained specimens at 1000x magnification. Classification and terminologies are according to Lynn (2008) and Berger (1999, 2011).

Results and Discussion

The present study is the first attempt to study the diversity of ciliates in the soils collected from the islands of Lakshadweep. Over 30 species of ciliated protists were recorded; four were identified as new to Indian fauna. It is believed that other habitats, such as marine waters, when sampled, may further increase the total number of ciliates identified using modern methodologies. Brief reports on four species with new records for Indian fauna are presented.

Taxonomic Account

Phylum CILIOPHORA Doflein, 1901
Class SPIROTRICHEA Bütschli, 1889
Order SPORADOTRICHIDA Fauré-Fremiet, 1961

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Family OXYTRICHIDAE Ehrenberg, 1830

Genus *Rigidohymena* (Dragesco and Njiné, 1971) Berger, 2011

1. *Rigidohymena quadrinucleata* (Dragesco and Njiné, 1971) Berger, 2011 (Figure 1 A-G)

Brief description of the Indian population (based on four specimens from live and seven from protargol impregnation): Size about $110 \times 55 \mu\text{m}$ in protargol preparations; shape elliptical with body ends rounded; dorsoventrally flattened. Nuclear apparatus with four macronuclear nodules in or slightly left of the body's midline. Contractile vacuole near the left cell margin. Cortex rigid; cytoplasmic crystals of usual shapes. Buccal cavity: deep and wide; undulating membranes in *Cyrtohymena*-pattern, optically intersecting at the posterior third near the buccal vertex. The adoral zone occupies about 50% of the body's length and is composed of 37 membranelles. On average, there are three frontal cirri, one buccal cirrus, four fronto-ventral cirri arranged in a hook-shaped pattern, three post-oral ventral cirri, two pretransverse ventral cirri, and five transverse cirri. One left and right marginal cirral row, each with 16 cirri. Six dorsal kineties, including two dorsomarginal rows. Invariably, three caudal cirri are at the posterior end of dorsal kineties, 1, 2, and 4.

Material deposited: Five slides with protargol-impregnated specimens have been deposited at the National Zoological Collections of the Zoological Survey of India, Kolkata, India, with the following accession numbers: Pt. 5172, Pt 5236, Pt 5237, Pt 5238, and Pt 5243.

Occurrence and ecology: Thus far, reported from Yaounde, Cameroon; Salzburg, Austria; Namibia; Antarctica; Brazil; China, Slovakia (Dragesco and Njiné 1971; Njiné, 1977; Foissner 1984, 1997; Wang *et al.*, 2017; Benčáťová and Tirjaková 2017). The Indian population was isolated from soil sample collected from Minicoy Island, Lakshadweep, India ($8^{\circ}16'13.6''\text{N}$ $73^{\circ}01'59.3''\text{E}$). Typically feeds on algae and small ciliates.

Genus *Oxytricha* Bory de St. Vincent in Lamouroux, Bory de St. Vincent and Deslongchamps, 1824

2. *Oxytricha quadricirrata* Blatterer and Foissner, 1988 (Figure 2 A-D)

Brief description of the Indian population (based on three specimens from live and six from protargol impregnation): Size approximately $55 \times 25 \mu\text{m}$ after protargol

preparations; shape is elongate elliptical with a narrow anterior end and a rounded posterior end; dorsoventrally flattened. Contractile vacuole in the left cell margin. Two elliptical macronuclear nodules in or slightly left of the cell mid-line, each with one or two micronuclei attached at various positions. Cortex is flexible and contractile and contains colourless granules arranged in short rows. The buccal cavity is narrow, and the paroral membrane is slightly curved anteriorly. The adoral zone occupies about 37% of body length and is composed of 19 membranelles. On average, there are three frontal cirri, one buccal cirrus, four fronto-ventral cirri, three post-oral ventral cirri, two pretransverse ventral cirri, and invariably four transverse cirri. Marginal rows are non-confluent; left and right marginal rows have 16 cirri and 14 cirri, respectively. There are six dorsal kineties, including two dorsomarginal rows. Invariably three caudal cirri, one each at the posterior end of dorsal kineties 1, 2, and 4. Dorsal kinety 3 and 4 are partially separated.

Material deposited: Four slides with protargol-impregnated specimens have been deposited at the National Zoological Collections of the Zoological Survey of India, Kolkata, India, with the following accession numbers: Pt. 4940, Pt 5038, Pt 5242, and Pt 5243.

Occurrence and ecology: Thus far, reported from Australia, Brazil, Slovakia and Venezuela (Foissner, 1997, 2016; Berger, 1999; Bartosova and Tirjaková, 2005). The Indian population of *O. quadricirrata* was isolated from a soil sample collected from Minicoy Island, Lakshadweep, India ($08^{\circ}16'0.8''\text{N}$ $73^{\circ}02'38.6''\text{E}$). It feeds generally on algae and bacteria.

Class HETROTRICHEA Stein, 1859

Order HETEROTRICHIDA Stein, 1859

Family CONDYLOSTOMATIDAE Kahl in Doflein and Reichenow, 1929

Genus *Condylostoma* Bory de St. Vincent, 1824

3. *Condylostoma curvum* Burkovsky, 1970 (basonym: *Condylostoma curva* Burkovsky, 1970) (Figure 3 A-H)

Brief description of the Indian population (based on two specimens from live and five from protargol impregnation): Size about $60 \times 35 \mu\text{m}$ in protargol preparations; cells are wider, shorter and have a rounded posterior end. A large cavity defines the buccal area. The adoral zone of membranelles occupies approximately 39% of the body length and is composed of about 32 membranelles. Cortical granules present, scattered in

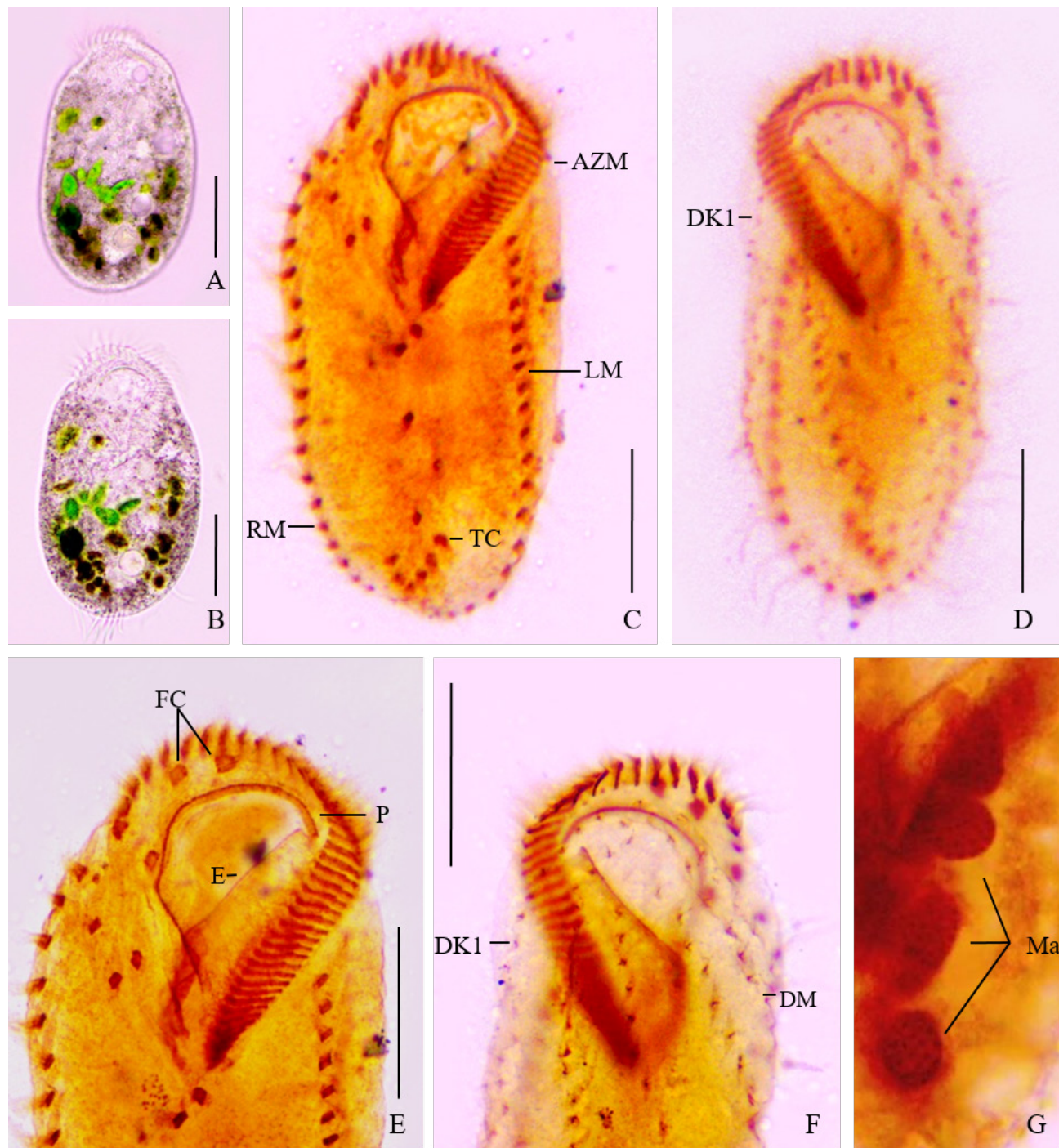


Figure 1. Photomicrographs of live (A, B) and protargol impregnated (C-G) specimens of *Rigidohymena quadrinucleata* Indian population. A, B. Specimens showing the body shape and position of contractile vacuole. C. Specimen showing ciliature on the ventral surface. D, F. Specimen showing dorsal kineties and caudal cirri (D). E. Details of the oral apparatus, showing distinct *Cyrtohymena*-like buccal field. G. Arrangement of four macronuclear nodules. AZM, adoral zone membranelles; DK1, dorsal kinety 1; DM, dorsomarginal kinety; E - Endoral; FC - Frontal Cirri; LM - Left Marginal cirral row; Ma - Macronuclear nodules; P - Paroral; RM - Right Marginal row; TC - Transverse Cirri. Scale bars: 50 μ m (A, B), 30 μ m (C-F).

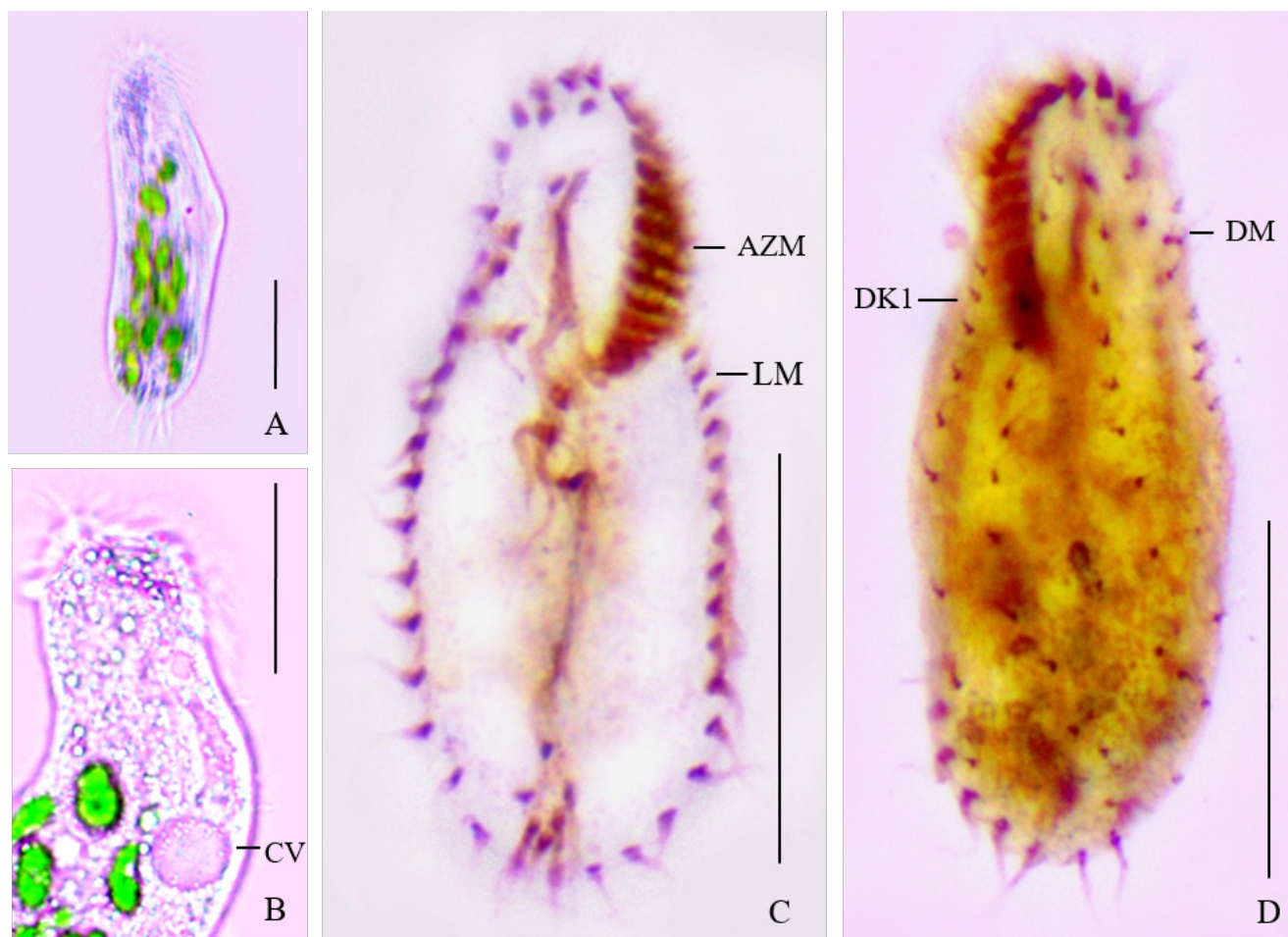


Figure 2. Photomicrograph of live (A, B) and protargol impregnated (C, D) specimens of *Oxytricha quadricirrata* Indian population. **A, B.** Specimen showing the body shape (A), cortical granules and position of contractile vacuole (B). **C, D.** Specimens showing ciliature on the ventral (C) and dorsal surface. **AZM** - Adoral Zone Membranelles; **DK1** - Dorsal Kinety 1; **DM** - Dorsomarginal row; **LM** - Left Marginal cirral row; **CV** - Contractile Vacuole. Scale bars: 25 μ m.

between the ciliary rows. Moniliform macronucleus with, on average, eight nodules. On average, there are 20 somatic kineties.

Material deposited: Four slides with protargol-impregnated specimens have been deposited at the National Zoological Collections of the Zoological Survey of India, Kolkata, India with the following accession numbers: Pt. 5228, Pt 5229, Pt 5230, and Pt 5231.

Occurrence and ecology: Originally collected from White Sea, Russia (Burkovsky, 1970); China and Korea (Song *et al.*, 2003; Chen *et al.*, 2011; Kim *et al.*, 2012; Yan *et al.*, 2015). The Indian population of *C. curvum* was isolated from a soil sample collected from Kavaratti Island, Lakshadweep, India (10°50'30.2"N 72°11'09.1"E).

Usually feeds on bacteria and algae.

Class HETROTRICHEA Stein, 1859
Order HETROTRICHIDA Stein, 1859
Family SPIROSTOMIDAE Stein, 1867
Genus *Spirostomum* Ehrenberg, 1834

4. *Spirostomum caudatum* (Müller, 1786) Delphy, 1939 (Figure 4 A-G)

Brief description of the Indian population (based on three specimens from live and six from protargol impregnation): Body size on average 95 \times 20 μ m in protargol preparations; shape is elongated cylindrical, slender, posterior end tail-like; anterior end slightly beak like, length to width ratio is about 5:1. A single

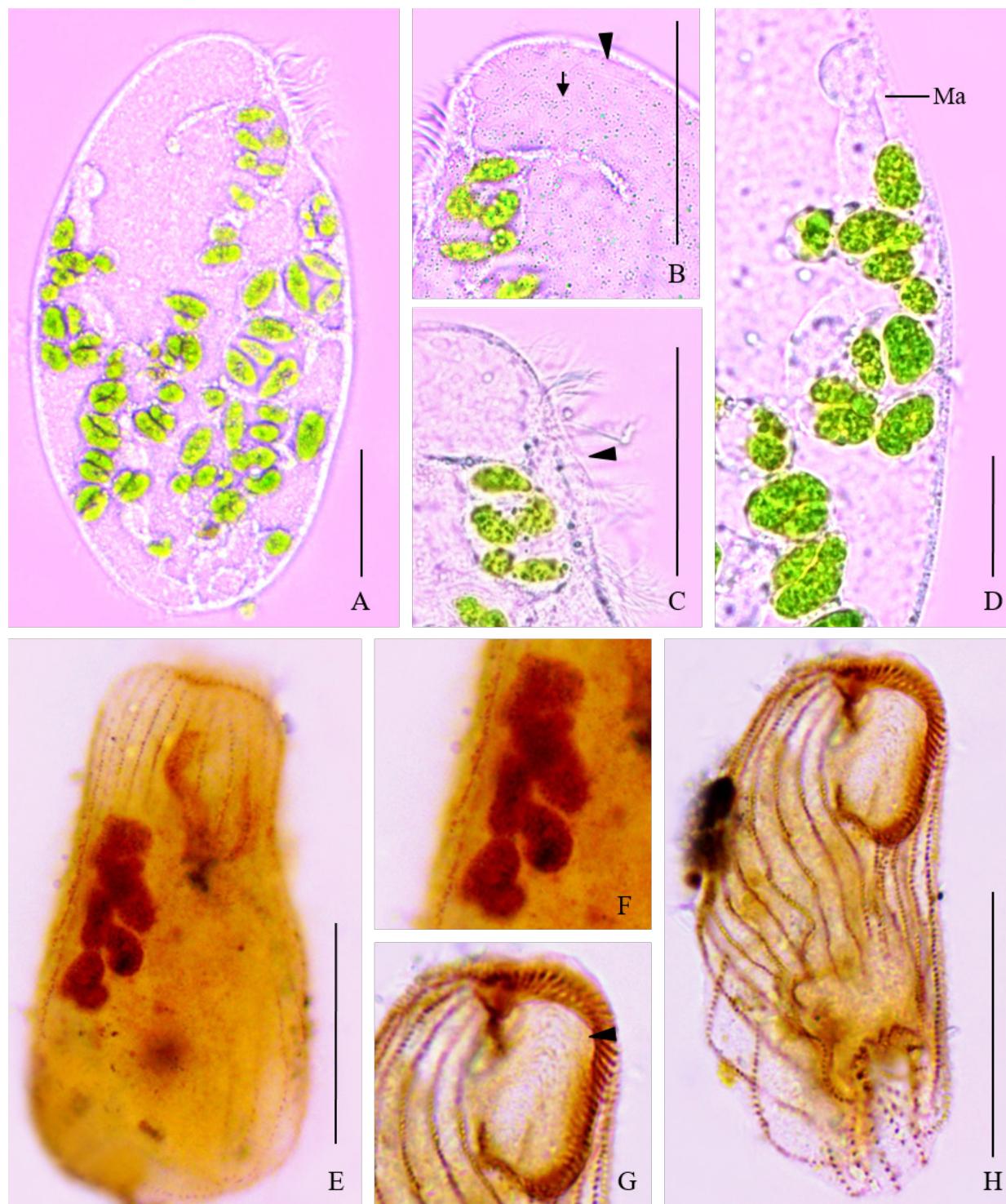


Figure 3. Photomicrographs of live (A-D) and protargol impregnated (E-H) specimens of *Condyllostoma curvum* Indian population. **A, B.** Specimen showing the body shape (A), cortical granules (small arrow) and somatic kineties (arrowhead) (B). **C.** Anterior end of specimen showing buccal lip (arrowhead). **D.** Position and shape of macronuclear nodules. **E, H.** Dorsal (E) and ventral (H) view of specimens showing body shape and somatic kinety rows. **F.** Enlarged view of macronuclear nodules, **G.** Buccal field with peristomial kineties (arrowhead). Ma - Macronuclear nodules. Scale bars: 40 μ m.

macronuclear nodule positioned near the mid-body. Contractile vacuole at the posterior end of the body. Cortical granules are arranged in short rows between somatic kineties. On average, there are 16 somatic kineties. The adoral membranelles account for about 43% of body length, with 27 membranelles on average. Circumoral kinety arranged densely in a single row on the right side of adoral zone.

Material deposited: Three slides with protargol-impregnated specimens have been deposited at the National Zoological Collections of the Zoological Survey

of India, Kolkata, India, with the following accession numbers: Pt. 5232, Pt 5233, and Pt 5246.

Occurrence and ecology: Found generally in brackish water and terrestrial habitats. It has been reported from Africa, China, Europe and Korea. The Indian population of *S. caudatum* was isolated from soil samples collected from Kavaratti Island (geographic position: 10°33'16.5"N 72°37'57"E) and Agatti Island (geographic position: 10°50'30.2"N 72°11'09.1"E), Lakshadweep. Usually feeds on bacteria.

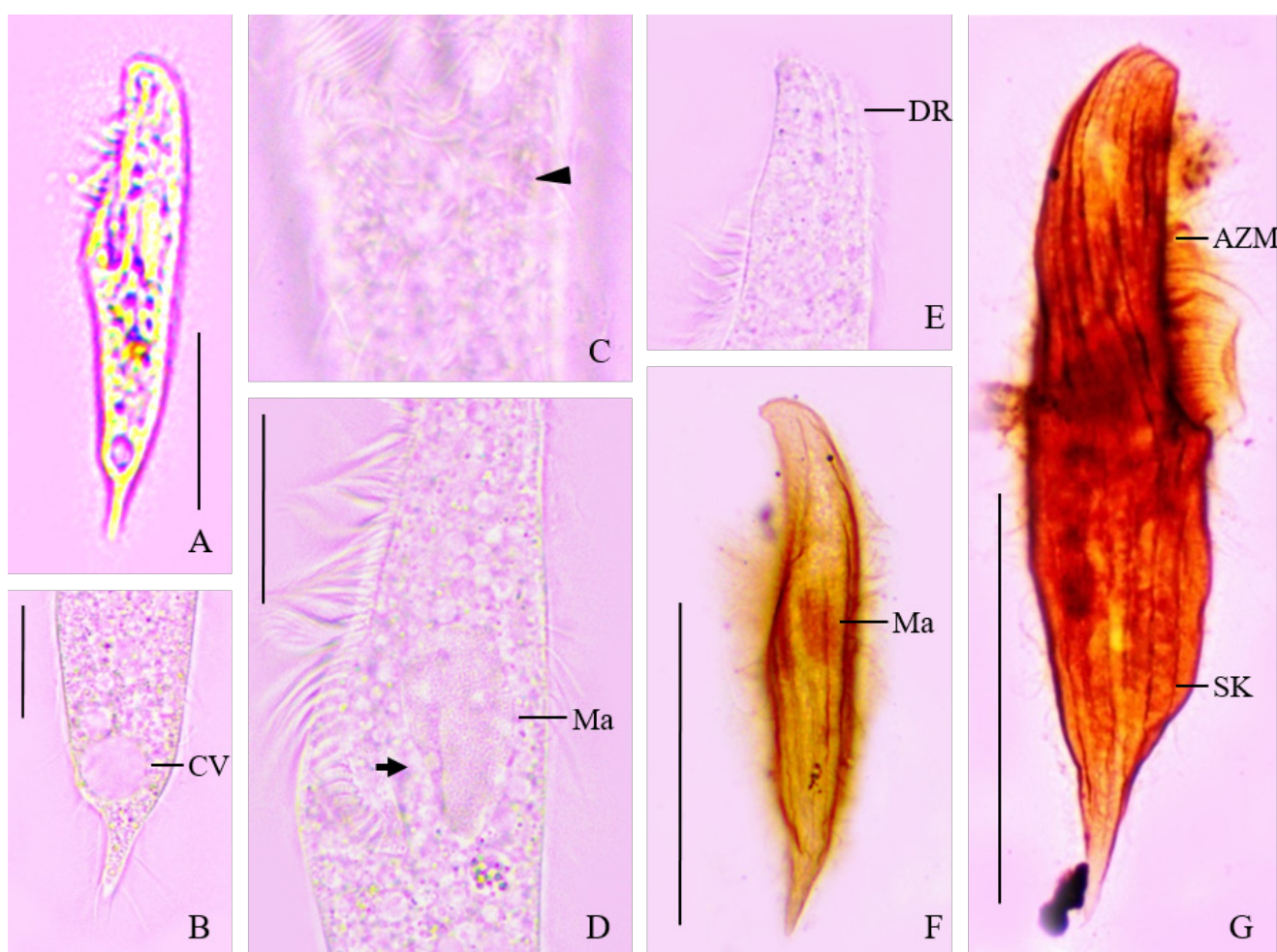


Figure 4. Photomicrographs of live (A-E) and protargol impregnated (F, G) specimens of *Spirostomum caudatum* Indian population. **A.** Specimen showing the body shape. **B.** Posterior end of specimen showing contractile vacuole. **C.** Specimen showing cortical granules (arrowhead). **D.** Position and shape of macronuclear nodule with single globular micronucleus (arrow). **E.** Dorsal view of anterior end of specimen showing dorsal ridges, **F.** Specimen showing elliptical macronuclear nodule, **G.** Specimen showing adoral zone of membranelles and somatic kineties. AZM, adoral zone membranelles; CV, contractile vacuole; DR, dorsal ridge; Ma - Macronuclear nodule; SK - Somatic Kinety. Scale bars: 50 μ m.

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