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EDITED BY LT.-COL. R. B. S. SEWELL, C.I.E., Sc.D., F.R.S., I.M.S. (*ret.*)

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PROTOZOA:

CILIOPHORA.

BY

B. L. BHATIA, D.Sc., F.Z.S., F.R.M.S.

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AUTHOR'S PREFACE.

A SYSTEMATIC study of the microscopic forms of life is of comparatively recent data in India. Freshwater, as well as parasitic, Protozoa have been studied by a number of workers in different parts of India, Burma, and Ceylon. This volume deals with the Ciliophora, a group of animals which has always been a favourite study with microscopists on account of the complexity of their structure, the diversity of their habitats, and the interesting movements exhibited by them ; and the same general plan adopted in other volumes of the series has been followed. A systematic survey is likely to furnish a clear understanding of the group, and of the mutual relationships between the parasitic organisms and the free-living forms from which they must have been evolved ; as remarked by Wenyon " the student of the Protozoa which are pathogenic to man and domestic animals should have a sound knowledge of other parasitic Protozoa, and at least a good working knowledge of non-parasitic forms as well. Conversely, those who study free-living Protozoa should have a clear conception of the parasitic forms . . . " ; and it is hoped that this volume will thus be of interest to medical and veterinary workers as well as to workers in general Protozoology.

The most approved and up-to-date system of classification has been followed, and in the Identification Tables of Families I have included those families which are at present not known from India. Those who use this volume should bear in mind that the 310 species here described are but a small fraction of the total known from other parts of the world.

All species that are as yet known from India, Burma, and Ceylon have been brought together, but a large number still await discovery. The freshwater forms particularly are cosmopolitan, and future workers who discover forms different from those here described must not conclude that such forms represent new genera or species till they have carefully explored the vast literature on the subject, to which the Bibliography given at the end of the volume will furnish a guide.

The species of each genus have been arranged in alphabetical order, except where a number of groups of allied species have been recognized. In the synonymies, given under each species, references to all the records from India, Burma, and Ceylon have been included, and a † mark prefixed to all such references. A selection of other references, which are considered important or useful, is also given.

In the Introduction I have given lists of species found in different regions, and in the case of parasitic forms in particular hosts, in the hope that these may be of use to workers in particular areas and to those looking for the parasites in particular hosts. I have also included a short account of the principal methods employed in the study of the Ciliophora which may be of some use to those taking up the study of this interesting group.

A volume such as this is bound to incorporate very largely the work of others, and my grateful acknowledgements are due to all those whose works have been drawn upon. Where available, figures have been given for all species dealt with. A small number of these are original or taken from my own work, but a large number have been borrowed with the kind permission of the authors or publishers concerned. My special thanks are due to Prof. C. A. Kofoid and his colleagues, who have added so much to our knowledge of Indian Entodiniomorpha, for permission to reproduce certain figures and for the loan of the blocks of the plates that appear at the end of this volume. My thanks are also due to the editors

and publishers of journals and text-books from which illustrations have been reproduced with their kind permission, and for which due acknowledgement is made in every case by giving the name of the author from whom the figure has been copied, and also in several cases for the loan of blocks.

My special thanks are due to Dr. B. Prashad, Director of the Zoological Survey of India, for special facilities given to me on the occasion of several visits to Calcutta to consult the literature in the splendid library maintained by the Zoological Survey; and also to Dr. S. L. Hora for his help in getting some figures copied under his supervision by the artists working under him. Finally, I have to offer my most grateful thanks to the Editor, Lieut.-Colonel R. B. Seymour Sewell, C.I.E., F.R.S., for a thorough and critical revision of the text, and for generous help and guidance during the production of this work.

B. L. BHATIA.

Government College,
Hoshiarpur, Punjab.
June, 1936.

ZOOLOGICAL GARDEN
CALCUTTA.

GLOSSARY OF TECHNICAL TERMS.

Aboral.—Situated furthest away from the mouth.

Acetabuliform.—Having a cup- or sucker-shaped outline.

Adoral.—Conducting to the oral aperture.

Afferent.—Conveying from the surface towards the centre.

Amitotic division.—Direct division of the nucleus which is not accompanied by the formation of a spindle of threads.

Anisogamy.—Copulation between dissimilar gametes.

Anus, or *cytopyge.*—Opening or pore for defæcation of undigested remains of food.

Basal granules.—Kinetic elements embedded in the contractile zone of the cortex, and each giving origin to a single cilium.

Biconcave area.—A conspicuous biconcave area on each side of the body in the postero-dorsal region of certain Entodiniomorpha.

Binary fission.—A mode of reproduction in which the division of the nucleus or of each of the two differentiated nuclei is followed by a division of the cell.

Boundary layer.—Thin membrane separating the endoplasm from the ectoplasm. It is well marked in Entodiniomorpha, and is continuous anteriorly with the wall of the gullet and posteriorly with the wall of the rectum.

Brood chamber.—A cavity developed inside the body of a Suctorian within which ciliated embryos are produced.

Buccal.—Relating to the mouth or oral aperture.

Budding.—The process of unequal fission, resulting in the formation of daughter organisms, which show a simplified structure when first formed.

Campanulate.—Having the shape of a bell.

Carapace.—The indurated dorsal shield possessed by such ciliates as *Euplotes* and *Aspidisca*.

Chitinous.—Corresponding in nature with chitin or the horny material which forms the protective covering of insects and other Arthropoda.

Chlorophyll.—The green colouring-matter of vegetable organisms.

Cilia.—The fine hair-like appendages that constitute the locomotive organs of a large group of Infusoria and many other animals.

Ciliated embryos.—Buds provided with cilia which are developed in a brood chamber in a Suctorian, and finally emerge through a birth-pore.

Cirri.—The elongate, flattened modifications of ordinary cilia, developed upon the peristomal region and other parts of the body of many ciliates.

Commensal.—An organism which does not live at the expense of the organism to which it is usually attached, but is associated with it simply as a messmate.

Concrement vacuole.—A vacuole which is interpreted as possessing a statolith function, found in certain types of parasitic ciliates.

Conjugation.—The temporary or permanent union of two organisms leading to reproduction by germs or spores or to the renewal of their capacity to multiply by simple fission.

Contractile vacuole.—One or more structures in the spongy layer of the ectoplasm which fill up by the excretory fluid draining into them and discharge the fluid on the surface of the body.

Convolute.—Rolled upon itself.

Cortical.—Relating to the external layer of an organism.

Crateriform.—Having the shape of a cup.

Crenulate.—Finely notched or serrated.

Cuirass.—An indurated defensive shield, synonymous with *Carapace.*

Cuticle.—The more indurated pellicle which forms the outer layer of the body of Infusoria.

Cyclosis.—The protoplasmic circulation observable in the cells of certain plants, and also in many Protozoa.

Cyst.—Impervious membrane surrounding an organism, formed as a protection against desiccation in free-living forms, or as an adaptation to a change of hosts in parasitic forms. In some cases cyst formation is related to the digestion of food, and in others to reproductive processes.

Cytomicrosomes.—Minute granules situated in the films between the alveoli in the ectoplasm as well as the endoplasm.

Cytopharynx.—Longer or shorter tube (popularly referred to as gullet) leading from the cytostome, and ending blindly in the endoplasm.

Cytoplasm.—The protoplasm of the cell-body as contrasted with that of the nucleus.

Cytopyge.—Anal aperture of unicellular animals.

Cytostome.—Oral aperture of unicellular animals.

Diastole.—Expansion of the contractile vacuole of Infusoria and other Protozoa.

Dichotomous.—Branching into pairs; furcate or forked.

Decurrent.—Running out or projecting beyond.

Dextrogyrous.—Circling towards the right.

Dextrotropous.—Turning to the right.

Dorsal disk.—A rounded ectoplasmic projection lying in the semi-circle bounded by dorsal membranelles.

Dorsal membranelles.—The membranelles forming the dorsal zone.

Dorsal zone.—A zone of membranelles arranged in a transverse furrow on the dorsal surface of the body, found in certain Entodiniomorpha.

Ectoparasitic.—Having the nature of an external parasite.

Ectoplasm.—The denser external substance of Infusoria and other unicellular organisms.

Efferent.—Conveying from the centre towards the periphery.

Emarginate.—Having a notched or excised margin.

Encuirassed.—Having an indurated dorsal shield or cuirass.

Encystment.—The phenomenon of becoming motionless and excreting a membranous investment or cyst, common to the majority of the Infusoria.

Endogenous or *internal budding.*—Formation of buds in the interior of the cytoplasm of the parent inside a brood-chamber.

Endomixis.—Periodic nuclear reorganization which occurs without conjugation or cell-fusion taking place.

Endoparasitic.—Having the nature of an internal parasite.

Endoplasm.—The inner, more fluid substance of the body of Infusoria and other unicellular organisms.

Endoplasmic sack.—The boundary layer with the enclosed endoplasm.

Endoplast.—The nucleus as developed in the Infusoria and other Protozoa.

Endoplastule.—The more solid particles developed singly or in varying number within, or in many cases external to, the endoplast of Protozoa.

Endoral.—Referring to the fringe of cilia developed between the adoral and preoral series of certain Oxytrichidæ.

Everted.—The condition of being turned out or backwards.

Excretory pore.—A small permanent opening in the cuticle through which the contractile vacuole passes out its contents.

Exogenous or *external budding.*—Formation of buds from the external surface of the body.

Fibrillæ.—The delicate, thread-like structures developed in the cortical layer of many Infusoria, as also in the stalk of *Vorticella*, possessing a rudimentary muscular function.

Fibrillar system.—The whole complex of structures which serve a correlating and conductile function.

Fimbriated.—Fringed at the margin.

Fission.—Division of the nucleus or of both the differentiated nuclei followed by a division of the body.

Food-vacuole.—A minute droplet of fluid in which a solid particle ingested as food is suspended and gradually digested.

Funiculus.—The slender, thread-like filament which connects the parts of the macronucleus in such infusorial types as *Loxodes* and *Loxophyllum*.

Gamete.—Sexual cell. Among the Protozoa the entire individual, being a single cell, takes part in the process of conjugation.

Gibbous.—Unsymmetrically distended or swollen at some part of the surface.

Glabrous.—Having a smooth surface.

Golgi apparatus.—A cytoplasmic inclusion which shows a tendency to clump together in masses or to form a network in the neighbourhood of the nucleus.

Holophytic.—Organisms which feed in a plant-like manner and, with the help of chlorophyll or similar pigment, in the presence of sunlight, build up simple organic substances from carbon dioxide and water.

Holozoic.—Animals which are entirely dependent for food on other organisms which they capture, devour, and digest.

Illoricate.—Devoid of a protective sheath or lorica.

Indurated.—Having a hardened consistence.

Infundibuliform.—Funnel-shaped.

Isogametes.—Gametes which are similar in shape and size.

Isogamy.—Copulation between similar gametes.

Karyogamy.—Sexual process or conjugation involving the union of micronuclear products.

Lævotropous.—Turning to the left.

Lorica.—The organically distinct protective sheath excreted and inhabited by many Infusoria such as *Vaginicola* and *Tintinnus.*

Loricate.—Possessing a protective sheath or lorica.

Macrochromatin.—In Protociliata, where the nuclei do not show dimorphism, each nucleus contains two types of chromatin, the macrochromatin being functional in vegetative life and the microchromatin during sexual phases.

Macrochromosomes.—Band-shaped pieces into which the macrochromatin divides during mitosis of the nuclei in the Opalinids.

Macrogamete.—In those cases in which there is marked difference in size between two conjugating individuals, the larger is referred to as macrogamete.

Macronucleus or *meganucleus.* The larger of the two nuclei into which the nuclear apparatus is differentiated in Euciliata, which functions during the vegetative life of the organism.

Membranellæ.—The relatively large flattened cilia that constitute the peristomial fringe in many Ciliate Infusoria, synonymous with *Cirri.*

Membranelle rootlets.—Short fibrils extending posteriorly from the bases of the membranellæ.

Membranulæ.—Very long, delicate, finely pointed aggregates of cilia which differ from cirri in movement and in composition. They are, for example, found in *Didinium.*

Metabolic.—Changeable in form ; polymorphic.

Metamorphic.—Changeable in form.

Microchromatin.—In Protociliata the nuclei do not show dimorphism, but each nucleus contains two types of chromatin, that which is functional in sexual phases being called microchromatin.

Microchromosomes.—Parts into which the microchromatin divides during mitosis of the nuclei in the Opalinids.

Microgamete.—The smaller of the two gametes in anisogamous conjugation.

Micronucleus.—The smaller of the two nuclei into which the nuclear apparatus is differentiated in Euciliata, which functions during the reproductive phases.

Microzooids.—Free-swimming zooids of abnormally minute size, which conjugate with the normal-sized sedentary animalcules of many Vorticellidæ.

Mitochondria.—Minute cytoplasmic inclusions of a lipoidal nature occurring in the form of spherical granules or rod-shaped or crescentic bodies.

Mitotic.—Indirect division of the nucleus which is accompanied by the formation of a spindle of threads.

Moniliform.—Jointed so as to resemble a string of beads.

Morphonemes.—Those fibres which maintain the body form.

Motorium.—A mass of differentiated protoplasm from which a number of fibres pass to different regions of contractile activity.

Multinucleate.—Possessing many nuclei, e. g. *Opalina.*

Multiple fission.—A mode of reproduction in which the division of the nucleus or of the two differentiated nuclei is not immediately followed by the division of the cell, but, after repeated nuclear division, the cell divides into as many parts as there are nuclei.

Myonemes.—Specialized muscle-like fibrils which cause the contraction of the whole or a part of the body. In a generalized condition they may be both coordinating and contractile in function.

Myophan.—Layer, developed in many Infusoria, that contains muscle-like fibrils.

Myophanes.—Specialized fibrils which perform a contractile function only.

Napiform.—Turnip-shaped.

Neuromotor system.—A system of connected fibrils emanating from the motorium and passing to different regions of contractile activity.

Neuromotorium.—A mass of differentiated material connected with the motor strand and other fibres performing conductile and contractile functions.

Neurophanes.—Specialized fibrils which perform a conducting function only.

Nuclear dimorphism.—The differentiation of the nuclear apparatus into a vegetative macronucleus and a reproductive micronucleus.

Nucleolus.—An exceedingly minute, more solid particle developed singly or in varying number within the substance of the nucleus of an animal or vegetable cell. Its homologue among the Protozoa is generally referred to as *Endoplastule* or *Karysome.*

Nucleus.—More densely granular body within the substance of most animal and vegetable cells. In Euciliata the nuclear apparatus is differentiated into a larger macronucleus and a smaller micronucleus.

Œsophageal.—Relating to or connected with the œsophagus.

Œsophageal fibrils.—Thin, closely spaced fibrils forming the wall of the œsophagus and running parallel to its long axis.

Œsophagus.—A distinct tubular gullet or œsophageal tube leading from the cytostome to the endoplasm.

Operculum.—The lid-like structure developed within the sheath or lorica, or attached to the body of certain Vorticellidæ. The term is also used for the ectoplasmic elevation separating the two membranelle zones in certain Entodiniomorpha.

Oral.—Relating to the mouth.

Oral disk.—The greatly thickened inner end of the adoral lip in Entodiniomorpha.

Oral trichites.—Armature of trichites or elongated rods of denser protoplasm embedded in the walls of the cytostome and the cytopharynx.

Parasite.—An organism living in or upon the body of another organism and dependent for its existence on that particular organism or a limited group of organisms.

Paroral.—The fringe of cilia developed at the side of the adoral series in certain Oxytrichidæ.

Pectinate.—Divided into narrow segments like the teeth of a comb.

Pedicle.—Lateral branches of the stalk in colonial Vorticellid forms.

Pedunculate.—Provided with a stalk or peduncle.

Pellicle, or *periplast.*—The outermost layer of the cortex or ectoplasm, which is characterized by definite markings or sculpturings in many Ciliata.

Peristome.—The region, with its accompanying cilia, leading to the cytostome.

Peristomial.—Relating to the peristome.

Pharyngeal.—Pertaining to or connected with the cytopharynx.

Pharyngeal basket, or *pharyngeal armature.*—Trichites forming a tubular armature in the wall of the cytopharynx.

Plicate.—Disposed in pleats or folds.

Polymorphic.—Exhibiting a diversity of form.

Preoral zone.—The fringe of cilia developed in front of the mouth of certain Oxytrichidæ.

Protoplasm.—The physical basis of life, or elementary formative matter of all living organisms.

Protozoa.—Animals in which the body is not divided into cells.

Racemose.—Having a clustered form of growth, like a bunch of grapes.

Rectum.—A thin-walled tube arising ventrally from the endoplasmic sack, extending posteriorly through the ectoplasm and opening to the exterior by the anus.

Reniform.—Shaped like a kidney.

Revolute.—Rolled back upon itself.

Rhizoplasts.—Fine endoplasmic prolongations from the basal bodies of membranulæ to the vicinity of the nucleus.

Rhythmical.—Denoting the regular pulsations of an organ such as the contractile vacuole of a Ciliate.

Rod apparatus.—An armature of elongated rods or trichites embedded in the walls of the cytostome and the cytopharynx.

Saprozoic.—Organisms living upon organic substances in solution, which are products of the metabolism or decay of other organisms.

Setæ.—The stouter, bristle-like cilia possessed more abundantly by the Hypotricha.

Sigmoidal.—Having a shape resembling the letter S.

Siliceous.—Partaking of the nature and qualities of silica; composed of flint.

Silver-line system.—Collection of certain structures on which colloidal silver is deposited by the reduction of silver nitrate by reflected sunlight.

Skeletal plates.—Hard, chitinous structures lying beneath the cuticle and extending backwards from the oral area in certain genera in the family Ophryoscolecidæ.

"*Soie de Lachmann.*"—Oral seta of the Vorticellidæ; also known as the *Vestibular seta.*

Spasmoneme.—The excentrically placed myoneme running through the stalk of a Vorticellid, which is surrounded by a granular thecoplasm and a delicate outer sheath.

Spatulate.—Having a broad blade-shaped outline.

Spine.—A pointed tapering process.

Sporulation, or *multiple fission.*—Mode of reproduction in which the repeated division of the nucleus is followed by the splitting of the organism into as many parts as the nuclei.

Stolon.—The procumbent adherent basal region of the colony-stock of such a type as *Dendrosoma.*

Suctorial tentacles.—Stiff protoplasmic processes consisting of a parietal layer of ectoplasm in the form of a tube enclosing a canal containing a fluid, the apex of the tentacle usually terminating in a sucker-like knob.

Syngamy.—Sexual union or conjugation involving either a complete fusion of two organisms (gametes) or the temporary fusion of two organisms (conjugants) for the purpose of mutual exchange of micronuclear material.

Synkaryon.—The combination nucleus which results from the fusion of two micronuclear products derived from two individuals.

Systole.—Contraction of the contractile vacuoles.

Tentaculiferous.—Bearing or possessing tentacles.

Tentaculiform.—Having the form of a tentacle.

Thecoplasm.—The granular, fluid substance which surrounds the spasmoneme in the stalk of a Vorticellid.

Thecoplasmic granules.—Small granules contained in the thecoplasm alongside the spasmoneme, the number and arrangement of which vary in different species.

Trichites.—Stiff rod-like supporting structures usually found in the oral region.

Trichocysts.—Minute rod-like bodies developed in the cortical layer of many Ciliata, and composed of a sac within which is a long coiled-up thread that can be suddenly extruded.

Uncini.—The claw-like modification of ordinary cilia possessed by many Hypotricha.

Undulating membrane.—Aggregates of cilia formed by the fusion of one or more rows of cilia, ranging from delicate structures to large balloon-like expansions, usually found in the peristomial area inside the adoral zone.

Vacuolate.—Having a number of clear spaces or vacuoles.

Velum.—Delicate veil-like membrane bordering the oral orifice in such forms as *Cyclidium* and *Pleuronema.*

Vermicular.—Resembling a worm in shape.

Vestibular seta.—The bristle-like cilium or seta that projects from the vestibulum or oral fossa of many Vorticellidæ.

Vestibule.—The excavated chamber or fossa into which both the oral and anal apertures debouch, as developed in the Vorticellidæ.

Zoodendrium.—Dendritic or tree-like colony-stocks of such ciliates as *Dendromonas* and *Epistylis*.

Zooid.—An animal organism not independently developed from a fertilized egg or ovum, but derived from a preceding individual by the process of fission or gemmation. Specially applicable to the Ciliophora and other Protozoa, and to the component members of all colony-building communities, such as Polypes, Corals, and Polyzoa.

Zygote.—The cell resulting from the complete fusion of two gametes.

SYMBOLS.

† prefixed to a reference indicates that the record of certain species from India, Burma or Ceylon is based on this work.

* placed after the name of a family indicates that representatives of that family have not yet been found in India, Burma or Ceylon.

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2. Gen. Sphærophrya *Cl. & L.* 433
1. pusilla *Cl. & L.* 433

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CILIOPHORA.

INTRODUCTION.

Position of Ciliophora in the Animal Kingdom.

PROTOZOA are generally defined as unicellular animals. All the functions of animal life are performed by a small undivided mass of protoplasm. The body of the organism, unlike the body of a higher animal, is not differentiated into organs consisting of tissues or cell-aggregates set apart for the performance of different functions. Although a Protozoon, when seen under a microscope, is comparable in its structure with a single cell of a Metazoan body, it cannot be regarded as strictly homologous with it. Some authors consequently prefer to regard PROTOZOA as non-cellular—that is, representing a primitive type of body in which the cellular type of structure had not been evolved. Although many of these organisms present a fairly simple structure, the majority of them exhibit a complexity of structure to which there is no parallel among the cells forming the body of a higher animal. The reason is obvious. The various parts of the cell-body of a Protozoon are differentiated into structures for the performance of different functions of animal life, such as locomotion, food capture, sensation, reproduction, etc., but all this is within the limits of a single mass of protoplasm. Hence the organization of the PROTOZOA is actually by no means simple. It is not the object of this work to give a comprehensive account of the organization and structure of the PROTOZOA: for this the reader should refer to the numerous excellent text-books on the subject.

The PROTOZOA are microscopic organisms, and have been favourite objects of study under the microscope ever since the latter was invented. Leeuwenhoek, the father of Protozoology, first described (1677) a free-living Protozoan, a species of *Vorticella*, which he had seen in standing rain-water in 1675. He was also the first to publish an account of a parasitic Protozoan (1682), which he found in his own fæces, and which was the flagellate *Lamblia* (*Giardia*) *intestinalis*. In 1683 he found *Opalina* in the fæces of a frog, and possibly *Nyctotherus*

also. In 1703 he figured both *Vorticella* and *Carchesium*. *Paramecium* was discovered in 1703 and *Amœba* in 1755. Ledermüller, in 1763, was the first to introduce the popular term INFUSORIA, to include all the various microscopic animalcules which make their appearance in infusions exposed to the air. The first comprehensive work on INFUSORIA was the monograph by O. F. Müller, published posthumously in 1786, and "included, besides the Protozoa, Bacteria, Diatoms, Vinegar Worms, Planarian worms, Cercaria larvæ, Rotifers and other odds and ends of animals, provided that they were sufficiently small." Müller described 378 species in his monograph, of which about 150 are valid. The term PROTOZOA was first used by Goldfuss in 1817, but he included in the group the POLYPES and MEDUSÆ also. It was first restricted and employed in the modern sense by von Siebold in 1845. Ehrenberg published a large work in 1838 in which 350 species are described from his own observations. About one-third of this work was devoted to Rotifers. Dujardin (1841) was the first to divide the "Infusoires" into rhizopods, flagellates, and ciliates, according as pseudopodia, flagella, or cilia serve as their organs of locomotion. This division is still the basis of all the schemes of classification of the PROTOZOA. Bütschli (1889) limited the use of INFUSORIA to PROTOZOA that bear cilia at some period of their life-history. As these latter came to be regarded as constituting two classes, viz., the CILIATA, with cilia throughout life, and SUCTORIA, with cilia in the embryonic phases only, Doflein (1901) introduced the term CILIOPHORA to designate a sub-phyllum to include these two classes.

Besides the classes enumerated above, there is the class SPOROZOA, including organisms which are exclusively parasitic and which possess no special organs of locomotion and food capture. The earliest observations on a Coccidian and a Gregarine were published in 1839. The HÆMOSPORIDIA were discovered as late as the eighties of the last century.

The phylum PROTOZOA may thus be divided as follows :—

A. Subphylum PLASMODROMA Doflein, 1901.
Movement is effected by pseudopodia or flagella, and syngamy takes place in all known cases by the complete fusion of gametes.

I. Class MASTIGOPHORA Diesing, 1865.
The predominating phase is flagellate, locomotion being effected by filamentous whip-like structures called flagella. The body may be corticate or non-corticate.

II. Class RHIZOPODA von Siebold, 1845 (=SARCODINA Hertwig & Lesser, 1874).
The predominating phase is amœboid, locomotion being effected by temporary extensions of the body called pseudopodia. The body is non-corticate, *i. e.*, has no tough limiting membrane or cuticle.

III. Class SPOROZOA Leuckart, 1879.
Exclusively parasitic forms which lack definite organs of locomotion. Reproduction takes place by spore-formation.

B. Subphylum CILIOPHORA Doflein, 1901.
Movement is effected by cilia.

IV. Class CILIATA Perty, 1852.
Organisms bear cilia throughout life.

I. Subclass PROTOCILIATA Metcalf, 1918.
Organisms provided with two or more nuclei, which are all of one type. Syngamy is effected by the complete fusion of uninucleated stages.

II. Subclass EUCILIATA Metcalf, 1918.
Organisms show a definite nuclear dimorphism, there being two types of nuclei (macronuclei and micronuclei). During syngamy the macronuclei disintegrate, the micronuclei divide, and an interchange of micronuclear products takes place between the associating individuals, new macronuclei and micronuclei being reconstituted from the combination nucleus or synkaryon.

V. Class SUCTORIA Claparède & Lachmann, 1858 (=TENTACULIFERA Huxley, ACINETARIA Lankester).
Ciliated in the young stages, but later usually attach themselves to other objects, lose their cilia, and develop knobbed tentacles which serve as sucking-tubes.

General Organization and Structure.

The present volume deals only with the subphylum CILIOPHORA, and I give below a brief survey of the general organization and structure of the organisms included in this group, so as to afford the reader a general idea of the group and to introduce him to the principal technical terms employed in the description of the forms.

Modes of Life.—The great majority of CILIOPHORA are free-living aquatic forms, either marine or freshwater. Some groups of the CILIATA and practically all SUCTORIA are attached. They may be attached temporarily or permanently to some object, which may be the body of some other animal. A considerable number of forms are parasitic and show various degrees of dependence on the host.

Form.—The free-swimming Ciliates show a great variety of forms. The primitive type may be considered to be a spherical or ovoid organism, with the mouth or cytostome at the anterior end and the contractile vacuole near the posterior end. Cilia of equal length clothe the whole body evenly, being disposed in meridional rows extending from the anterior to the posterior pole. Such an ideally simple type is actually met with among species of *Holophrya* and *Prorodon* (see figs. 22, 25). Modifications from this type occur as the result of (1) shifting of the cytostome from the anterior pole to one side of the body and a consequent oblique arrangement of the ciliary

rows; (2) differentiation of the cilia into those covering the general surface of the body, which are locomotor in function, and special cilia near or around the mouth, which are variously modified for the purpose of food capture; (3) development of a special area, called peristome, leading to the cytostome; (4) the flattening of the body in creeping forms, in which a ventral surface, bearing cytostome and peristome, is distinguishable from the dorsal surface; and (5) restriction of the locomotor cilia to the ventral surface, and the complete or partial disappearance of those on the dorsal surface or their retention to serve a purely tactile function. This last and extreme modification is realized in such flattened and creeping hypotrichous forms as *Stylonichia* and *Aspidisca* (figs. 180, 184), in which the ventral cilia are restricted to tufts which fuse to form cirri or bristles on which the animal creeps.

Organisms may be temporarily or permanently attached. For this purpose there are developed special cilia or adhesive organs, or the surface of the body on the side opposite to the mouth (aboral) may be specially drawn out for the purpose into a stalk. In *Vorticella* and other related organisms the stalk contains a contractile thread, by means of which the organism can retract itself close to the point of attachment or extend itself further away from it. In this group the general covering of cilia disappears and only peristomial cilia are retained. Such organisms may, however, detach themselves from their stalks, develop temporary cilia for locomotion, swim off, and attach themselves again elsewhere.

Structure.—The protoplasm forming the body of a Ciliate is differentiated into two layers, ectoplasm and endoplasm. The *ectoplasm* consists of four or five layers, viz. (a) a thin delicate membrane called the *pellicle*; (b) *alveolar layer*; (c) protoplasmic layer containing small spindle-shaped bodies known as the *trichocysts*; (d) *contractile layer*, containing *myonemes* which run beneath and parallel to the ciliary rows at the surface; and (e) *spongy layer*, traversed by irregular spaces and channels containing fluid which drains into more conspicuous feeder-canals which open into a *contractile vacuole*. These layers or zones cannot be clearly distinguished in all cases as they grade into one another, and some of them are better developed in some organisms than in others. The *cytostome* or mouth, the *cytopyge* or anal aperture and the openings of the contractile vacuoles all perforate the pellicle, and the cilia also pass through it.

The *cilia* arise from basal granules placed externally to or between the myonemes, and pass to the exterior through the outer layers. The cilia may be restricted to certain regions (as in *Didinium nasutum*, *Urocentrum turbo*, etc., figs. 31, 89), or may by their fusion form locomotor organs

of a complex nature, such as *undulating membranes, membranelles, cirri and membranulæ.* Undulating membranes are usually formed by the adhesion or fusion of a single row of cilia, and may occur in the cytopharynx, margin of the cytostome, or in the peristome ; they are represented in all orders of the CILIATA. They are usually narrow and inconspicuous, but in some genera (e. g., *Cyclidium*, *Pleuronema*, figs. 85, 86) form large balloon-like expansions used for trapping the food. Membranelles are formed by the fusion of the cilia in the region of the mouth. They are grouped as a rule in a curved row, the "adoral zone," along the margin of the peristome in all orders of the CILIATA except the HOLOTRICHA (fig. 117). A dorsal ring of membranelles is also present in some parasitic forms, e. g., *Diplodinium* (fig. 158). In the Vorticellidæ (fig. 187) there are two rows of membranelles, forming a double adoral zone that winds about the peristome in a direction opposite to that in SPIROTRICHA (which includes HETEROTRICHA, HYPOTRICHA, etc.). Cirri are formed by the fusion of tufts of cilia, and are broader at the base and taper to a fine point. They are found typically on the ventral surface of HYPOTRICHA, and form groups named, according to their position, frontal, ventral, anal, caudal and marginal cirri. These cirri confer extreme variety of movements on the HYPOTRICHA. Some of them run on the tips of the frontal and ventral cirri (*Stylonichia*), others swim with a jerky movement (*Aspidisca*), while yet others combine swimming by means of the adoral zone of membranelles with sudden jumps effected by anal or caudal cirri (*Euplotes*). In a few cases dorsal cirri also occur and serve a tactile function (*Uronychia*). Membranulæ are long, delicate, finely pointed structures, each formed by the fusion of a small number of cilia, as in the case of the two circlets of *Didinium* or the posterior ciliary ring of Vorticellids.

A striking feature of many Ciliates is their power of contraction. A *Spirostomum* or a *Trachelocerca* will suddenly contract to a fraction of its length in the expanded state. A *Folliculina* or a *Vorticella* will fold itself up, and an entire colony of Vorticellids may contract itself into a small mass. These movements are brought about by long, delicate, contractile threads, called *myonemes*, which may run straight (*Stentor*) or spirally (*Spirostomum*) throughout the entire length of the body. A second set of myonemes may run transversely about the body, as in the peristomial region of the Vorticellids or *Stentor*.

In Ciliates with a uniform covering of cilia the latter do not all beat simultaneously, but a wave of contraction passes from the anterior to the posterior end. Cilia in the same transverse row beat synchronously, but those in a longitudinal

row beat in a regular succession and are metachronous in their contraction. This also accounts for the wave-like movement of undulating membranes which are formed by the fusion of longitudinal rows of cilia. Distinct fibres connecting the basal granules of cilia were described by Entz, Maier, Schuberg and others, but were interpreted as myonemes. As, however, the rhythmic action of the cilia is independent of the contractility of the organism, it is probable that such fibres are not myonemes but co-ordinating fibres of a conductile nature. Sharp, Yocom, and Taylor have given convincing evidence of the occurrence of specific conducting or co-ordinating system of fibrils. Sharp (1914) was the first to describe in *Epidinium ecaudatum* (fig. 164) a *neuromotor system* of fibrils connecting the basal fibrils coming from the cilia or groups of cilia with a co-ordinating centre called the *motorium*. The motorium is situated in the ectoplasm near the anterior end of the organism, and a number of fibres pass to different regions of activity. Yocom (1918) described a similar but more complex system in *Euplotes patella*. A definitely staining bilobed mass situated in the ectoplasm near the right anterior angle of the triangular peristome was identified as a motorium (fig. 183, *m*). From one of its lobes a set of five longitudinal fibrils (*a–c*) run to the bases of the five anal cirri near the posterior end, and from the other lobe a single fibril passes along the inner margin of the anterior lip and down the left side of the peristome connecting the bases of the adoral zone of membranelles (*m.f.*). Taylor (1920), as the result of micro-dissection experiments with the same form, furnished direct evidence of the part played by the neuromotor apparatus. Macdonald (1922) described a similar system in *Balantidium coli* and *B. suis*, and since that date several other workers have demonstrated the neuromotor apparatus in other forms.

Klein (1926) introduced a modification of a silver impregnation method, by which the organisms are fixed by drying, and the reduction of silver nitrate by reflected sunlight deposits colloidal silver on certain structures, which are referred to collectively as the "silver-line system." This system is composed of two rather distinct parts. One of these, described as "indirectly connected" with the contractile system, is composed largely of closely set polygons and the trichocyst granules which lie in the centres of the anterior and posterior sides of the polygons. The other portion consists chiefly of the basal granules, which are located at or near the centres of the polygons of the first part, and the longitudinal body fibrils, which connect the basal granules in the same longitudinal row of polygons. Lund (1933) has correlated the "silver-line" system with the "neuromotor" system, and comes to the

conclusion that the " silver-line " system is not solely composed of conductile elements, but comprises parts of at least two, and possibly three, quite different aggregations of structures, namely, the pellicle, the trichocysts, and the peripheral portion of the neuromotor system. Klein's technique fails to demonstrate the great pharyngeal complex, which is at least in part conductile. The term " fibrillar system " may be employed to include the whole complex of structures which serve a correlating and conductile function.

Embedded in the ectoplasm are small spindle-shaped bodies known as *trichocysts*, each of which on being stimulated can discharge a long stiff thread. They may be distributed all over the surface (*Paramecium*, fig. 63) or be confined to certain regions (proboscis of *Dileptus*, fig. 45). Oral *trichites* are similar structures surrounding the mouth in various GYMNOSTOMATA, and may form a tube extending into the endoplasm (as in some species of *Nassula*, *Orthodon* etc.). In other cases much larger rods are met with, and form *pharyngeal baskets* (as in the families Nassulidæ and Chlamydodontidæ). A constant number of rods may be found in a species, and they may be united to form a tube at the posterior end of the basket (fig. 56).

The number and arrangement of the contractile vacuoles varies considerably. In *Paramecium* there are two contractile vacuoles, each surrounded by six to eight feeder-canals in a star-like manner. In *Stentor* and *Spirostomum* there is a single contractile vacuole, with a long feeder-canal running along the length of the body.

A mouth or cytostome is normally present (except in PROTOCILIATA, ASTOMATA and SUCTORIA). In GYMNOSTOMATA the cytostome is closed except during the ingestion of solid food; it is opened or closed by a system of rods contained in the cytopharynx, and there is no undulating membrane. In all other CILIATA which possess a cytostome it is permanently open, and the cytopharynx may possess one or more undulating membranes, but no rod-apparatus. Frequently there is a funnel-like structure called the *peristome* for collecting the food and conveying it to the cytostome. Cilia on the floor of the peristome are often longer than over the rest of the body. In SPIROTRICHA an adoral zone of membranelles is always present along the left margin of the peristome. In the PERITRICHA the adoral zone consists of two parallel undulating membranes, which, after describing a number of spiral turns, pass into a funnel-shaped depression or vestibule, at the bottom of which the cytostome, followed by a short cytopharynx, is situated. The contractile vacuole and the anus also open into the vestibule. In SUCTORIA there is no cytostome, but food is taken in by the numerous sucking

tentacles, the protoplasm of the body of the prey passing in a stream through the tubular cavity of the tentacle. The majority of CILIOPHORA are holozoic, but some of the parasitic forms may be saprozoic (*Opalina*).

The endoplasm is finely alveolar and more fluid than the ectoplasm, and exhibits a streaming movement (*cyclosis*). The endoplasm contains food-vacuoles enclosing food-particles in process of digestion, the nuclei, and other refringent granules, some of which may be excretory granules, others mitochondria, and still others belonging to the Golgi apparatus.

The nuclear apparatus in most CILIOPHORA shows dimorphism —there being a large, deeply staining macronucleus and a small, often inconspicuous, micronucleus which is difficult to stain. In PROTOCILIATA there are two or more similar nuclei, but in each nucleus there are believed to be two kinds of chromatin, distinguished as macrochromatin and microchromatin. The former is functional during vegetative life and the latter during the reproductive phases. Among the EUCILIATA the macronucleus is typically a compact body, and the micronucleus a small refringent body close to it or actually lodged in a depression of the surface of the macronucleus. In other forms the macronucleus may be rod-shaped or sausage-shaped (*Diplodinium*), or in the form of a horseshoe (*Vorticella*) or a beaded string (*Stentor* and *Spirostomum*), or there may be two macronuclei connected by a delicate filament (*Stylonichia*), or the macronucleus may be broken up into a large number of small nuclei. The macronucleus in some of the SUCTORIA (*Dendrosoma, Ephelota*, etc.) is much branched. The micronucleus does not vary much in form, but the number of micronuclei may be one, two, or many in different species.

Reproduction.—Macronuclei are vegetative in function and control the general metabolism: during reproduction they disappear by absorption and fresh macronuclei arise from products of micronuclear division. The micronucleus is reproductive in function and plays an important part during conjugation, as also in periodical reorganization without conjugation, known as endomixis.

Reproduction takes place by binary fission which is generally transverse to the long axis of the body. During this process the macronucleus divides amitotically and the micronucleus mitotically. The nuclear division is followed by transverse fission of the organism, and the parts lacking in each daughter organism are reconstituted. In fixed forms, as in Vorticellidæ, the fission is generally in a vertical plane and leads to unequal fission or budding. Repeated fission accompanied by imperfect separation of daughter zooids leads to the formation of large branching colonies in many PERITRICHA. Multiple

fission or sporulation also occurs inside temporary cysts in some parasitic forms. In SUCTORIA either external or internal budding takes place. In internal budding a certain part of the organism becomes invaginated, the margins close over, and a brood-chamber is formed, inside which the ciliated embryos are developed.

The details of conjugation or syngamy also vary a good deal in the group. Among the PROTOCILIATA ordinary individuals divide repeatedly, and thus give rise to a number of small-sized forms with one, two or more nuclei; these then encyst and pass out with the fæces of the host. These cysts are ingested by tadpoles and the organisms are set free in their rectum. The organisms multiply and give rise to larger and smaller individuals (gametes) which fuse in pairs to form a zygote. Each resulting zygote has at first a single nucleus, and later gives rise to the binucleated or multinucleated condition characteristic of the species. In most of the EUCILIATA temporary fusion takes place between similar zooids, the macronucleus degenerates and disappears in each conjugant, and the micronucleus in each divides two or three times. Only one of the resulting products of micronuclear division takes further part in the process, the others being absorbed. This remaining micronucleus again divides into two pronuclei, one migratory and the other stationary. The migratory pronucleus of each passes into the body of the other conjugant and fuses with its stationary pronucleus, forming a synkaryon in each. The conjugants now separate, the synkaryon in each divides a number of times, resulting in the formation of new macronuclei and micronuclei, and each ex-conjugant divides into a number of zooids, each zooid containing a single macronucleus and one or more micronuclei according to the species. In the majority of the PERITRICHA sexual dimorphism is the rule, and a small zooid fuses permanently with a large zooid, and only a single zygote with one synkaryon results.

A periodic nuclear reorganization also takes place apart from conjugation, and was described by Erdmann and Woodruff (1914) in *Paramecium aurelia* and by the same authors (1917) in *P. caudatum* under the name endomixis. In the former species it takes place at intervals of about thirty days; the old macronucleus breaks up and is absorbed, and each of the two micronuclei divides twice, forming eight products, some of which become new macronuclei and some new micronuclei. In the latter it occurs at intervals of sixty days; the single micronucleus divides three times, forming eight nuclei, some of which degenerate while others form new macronuclei or micronuclei. In some other types of Ciliates endomixis is known to take place while the organism is protected by a cyst.

Study of the Group in India.

Very little work had been done on the Ciliate PROTOZOA in India during the last century. Up to the year 1889, the year of publication of Bütschli's great work on PROTOZOA, practically the only record of freshwater forms was the work of H. J. Carter, who studied these forms in Bombay towards the middle of the last century, and contributed a number of papers on the organization of freshwater INFUSORIA of the island of Bombay to the 'Annals & Magazine of Natural History' (1856–69). The following is a list of Ciliates found by him in Bombay; a number of forms, described as new species by Saville Kent (1880–82) from manuscript notes that Carter placed at his disposal have also been included in the list :—

Holophrya lateralis S. K.
Coleps hirtus (O. F. Müll.).
Halteria pulex = *Mesodinium pulex* Cl. & L.
Trachelium fasciola = *Amphileptus fasciola* = *Lionotus fasciola* Ehrbg.
Nassula sp.
Loxodes cucullulus = *Chilodon cucullulus* Ehrbg. (O. F. Müll.).
Ophryoglena sp. = *Otostoma carteri* S. K.
Loxodes cucullio = ? *Colpoda cucullus* (O. F. Müll.).
Paramæcium aurelia Ehrbg. (O. F. Müll.).
Plagiopyla (?) *carteri* S. K.
Spirostoma virens (?) Ehrbg. = *Climacostomum virens* Ehrbg.
Bursaria leucas (?) Ehrbg. = *Frontonia leucas* Ehrbg.
Stentor sp.
Oxytricha sp.
Himantophorus charon = *Plæsoconia* ? = *Euplotes charon* O. F. Müll.
Euplotes sp.
Vorticella microstoma Ehrbg.
" *convallaria* Ehrbg.
" sp.
Epistylis galea (?) Ehrbg.
Cothurnia sp. = *Pyxicola carteri* S. K.
Sphærophrya sp. Cl. & L.
Podophrya fixa Ehrbg.
" *quadripartita* = *Tokophrya quadripartita* Cl. & L.
Acineta tuberosa Ehrbg.

G. W. Grant had previously (1842) found in Calcutta six species of freshwater PROTOZOA, of which only two were Ciliates, viz., *Coleps hirtus* Ehrbg. and *Vorticella patellina* O. F. Müll. These are recorded in Cantor's work on Chinese forms. In 1862 J. Mitchell contributed a short note on the existence of a valve in a form very similar to *Vaginicola crystallina* from Bangalore. W. J. Simmons (1889) contributed a note on a species of *Podophrya* found in Calcutta, and (1891) noted the occurrence of several genera at Calcutta without specific identification of the forms. H. H. Anderson (1889) described *Anoplophrya ælosomata* from *Ælosoma chlorostictum* in Calcutta.

Scanty as the above recorded work is for a large country like India, it is thus referred to in Schewiakoff's monograph on the geographical distribution of freshwater PROTOZOA (1893, p. 84): "Bedeutend besser erforscht ist die Protozoenfauna Ostindiens, obgleich die vorliegenden Befunde weit davon entfernt sind, eine methodische Durchforschung der Susswasser Protozoen diese landes darzubieten. Es wurden nur wenige Orte, Bombay, Calcutta und einige Seen in Himalaya, von Carter, Grant und Simmon untersucht. Am eingehendsten erforscht Carter die süssen Gewasser von Bombay und fand daselbst 43 verschiedene Formen, darunter 12 Rhizopoden, 3 Heliozoën, 15 Mastigophoren, 10* Ciliaten und 3* Acineten, die sämmtlich auch in Europa anzutreffen sind. Nur wenige von diesen Formen lassen sich nicht ermitteln. In den Seen vom Himalaya fand Carter zwei Dinoflagellaten, darunter eine angeblich neue Art, die aber mit einer europäischen zu identificiren wäre. Bei Calcutta fand G. W. Grant 6, gleichfalls in Europa vorkommende, Protozoën welche in der Arbeit Cantor's beschrieben werden. Endlich traf bei Calcutta noch Simmons eine Acineten an, über die ich aber nichts zu sagen vermag, da ich mir leider die betreffende Arbeit nicht verschaffen Konnte. Somit wurden in Ostindien 50 verschiedene Arten von Protozoën: 12 Rhizopoden, 3 Heliozoën, 19 Mastigophoren, 13* Ciliaten, 3* Suctorien (Acineten) beobachtet, die alle Europaer sind."

From 1891 to 1916 very few persons took up the study of this group in India. Eugen von Daday (1898) studied the freshwater PROTOZOA of Ceylon, and, in addition to a large number of Rhizopods and Flagellates, also recorded six Ciliates, viz., *Colopoda cucullus* (O. F. Müll.), *Codonella lacustris* Entz., *Tintinnopsis ovalis* Dad., *Oxytricha mystacea* St., *Stylonichia pustulata* (O. F. Müll.), and *Epistylis anastatica* Ehrbg. Annandale (1907) recorded *Carchesium polypinum* Ehrbg. and *Folliculina ampulla* (O. F. Müll.) in his work on the Fauna of Brackish Ponds at Port Canning, Lower Bengal. Dobell (1910) published a paper on some parasitic PROTOZOA from Ceylon, in which he described the following new species of Ciliates:—*Balantidium ovale*, *B. hyalinum*, *Nyctotherus papillatus*, *N. termitis*, and *Opalina virgula*.

In 1916 I published some notes on the Ciliate PROTOZOA of Lahore, and followed this up by further papers in 1920, 1922, and 1923. Gulati (1925) published his observations on some more Ciliates from Lahore. Bhatia and Gulati (1927) studied some parasitic Ciliates from a number of frogs, toads, earthworms, and the common cockroach found in the

* This enumeration is not correct, as forms erected into new species by Saville Kent from manuscript notes of Carter are not included.

Punjab; and Bhatia and Mullick (1930) studied the freshwater Ciliates of Kashmir.

During the same period (1916–29) Ekendranath Ghosh worked on the Ciliates at Calcutta, and published no less than fifteen papers recording known and describing many new species. Most of these papers are, however, of the nature of short communications, and his descriptions are not always adequate and reliable. Essential points are very often left undetermined, and future workers will not find it easy to recognize the organisms from his description and figures. Similarly, H. S. Madhava Rao published (1928) a paper on Soil PROTOZOA from Mysore, in which he has shown carelessness of observation and even ignorance of the ordinary rules of zoological nomenclature and description. Sandon (1927) and Chaudhuri (1929) have added a large number of forms to the records from India by examining the soils from various parts of India. Kofoid and MacLennan (1930–33) have described a large number of parasitic Ciliates from *Bos indicus*, the material having been obtained in South India and Ceylon. De Mello (1930–34) has published a number of papers on the parasitic Ciliates from various frogs and toads from Nova Goa (Portuguese India). Kofoid and Christenson (1934) have described a large number of Ciliates from *Bos gaurus* from Mysore, and Kofoid (1935) two remarkable Ciliates from the elephant. Lastly, Das Gupta (1935) has described many Ciliates from *Capra hircus* at Calcutta.

In the present work all the records from India are brought together. The record comprises 310 species, belonging to no less than 104 genera, out of which the specific identity of as many as 39 is uncertain. Of these, 68 species belonging to 41 genera, of which 1 genus and 16 species are new to science, have come under my personal observation. For the description of previously known genera and species I have consulted, among others, the monographs of O. F. Müller, Ehrenberg, Dujardin, Claparède and Lachmann, Stein, Engelmann, Fromentel, Saville Kent, Bütschli, Schewiakoff, Roux, Penard, Metcalf and Kahl. I have in the main followed the classification given in Doflein and Reichenow's 'Lehrbuch' (1929) and in Kahl's recent monograph on INFUSORIA in 'Tierwelt Deutschland' (1930–35). All the families, even when not so far known to be represented in India, have been mentioned, and tables of identification included. Although the ciliate Protozoan fauna of India is now much better known than it was twenty years ago, there are many genera and even families that are not yet represented. As the freshwater forms are known to be cosmopolitan in their distribution, there is every likelihood of their being found in India as the result of further research.

Classification and Phylogeny.

The basis of the present-day systems of classification of the CILIOPHORA was first suggested by Stein in 1857, and with various modifications, introduced by Saville Kent, Bütschli, Schewiakoff, Delage, Doflein, Metcalf, Reichenow and Kahl, is followed even to-day. Stein divided the CILIATA into four orders, viz., HOLOTRICHA, HETEROTRICHA, HYPOTRICHA, PERITRICHA, and to-day these are still recognized as orders or suborders. For many years Stein held the opinion that the organisms, since recognized as constituting the group TENTACULIFERA, represented merely the developmental phases of various Vorticellids. The researches of Claparède and Lachmann won for them an independent position, possessing, as a distinct section of the INFUSORIA, the same status as FLAGELLATA and CILIATA, and, with reference to the possession of sucking tentacles, the title of SUCTORIA was conferred by them on the group. Later Huxley, in view of the fact that in certain forms a portion only of the tentacles are suctorial, and that in some others the tentacles may be entirely non-suctorial and simply prehensile, substituted the title of TENTACULIFERA for the SUCTORIA. At a still later date the name ACINETARIA was given to them by Lankester. The similarities of the early stages of these organisms to the CILIATA were well understood, and Doflein recognized that CILIATA and SUCTORIA constituted two classes of the subphylum CILIOPHORA.

The class CILIATA continued to be described as consisting of four orders, as defined by Stein. The order HOLOTRICHA includes those Ciliates in which the cilia are all of approximately equal length and thickness, and there are never any specialized structures called cirri. It thus included the simplest members of the class, but still presented a considerable range of complexity from the simplest forms to those nearly approaching the HETEROTRICHA. *Opalina* and other astomatous forms were included in the order as primitive forms or as forms which were without a mouth on account of their parasitic mode of life. Excluding these, Stein divided the order into four families. Saville Kent considered these groups or families as more or less heterogeneous, and distributed the genera among twelve families. Later authorities have had to transfer many of the genera and even families to other orders or even other classes of PROTOZOA. Bütschli divided the order into two sub-orders :—(1) the GYMNOSTOMATA, in which the mouth is closed except when the food is being ingested, and (2) the TRICHOSTOMATA, in which the mouth is always open and provided with an undulating membrane. Schewiakoff divided the class CILIATA into the order ASPIROTRICHA (=order HOLOTRICHA St., with the addition of some

families formerly referred to the orders HYPOTRICHA (*e. g.*, Erviliina and Chlamydodonta) and PERITRICHA (Cyclodinina)) ; and SPIROTRICHA, including the suborders HETEROTRICHA, OLIGOTRICHA, HYPOTRICHA, and PERITRICHA. He recognized the distinct position of the Opalinidæ, and divided his order ASPIROTRICHA into GYMNOSTOMATA, TRICHOSTOMATA, and ASTOMATA, and arranged the families included under GYMNOSTOMATA in accordance with the position of the mouth into three tribes, which he called PROSTOMATA, PLEUROSTOMATA, and HYPOSTOMATA. The GYMNOSTOMATA comprised eleven families, the TRICHOSTOMATA seven families, and the ASTOMATA one family. Delage gave the name HYMENOSTOMATA to TRICHOSTOMATA of Schewiakoff ; and Hickson in the main followed Schewiakoff's classification, but used the term HYMENOSTOMATA for TRICHOSTOMATA, and for no valid reason included Opalininæ under this group instead of as a special group as Schewiakoff had done. Chatton and Lwoff have established THIGMOTRICHA and APOSTOMEA as new suborders of HOLOTRICHA.

Ray Lankester (1870) was the first to recognize that the grouping of *Opalina* with the other astomatous Ciliates was an unnatural procedure, and Léger and Duboscq (1904) maintained that the ASTOMATA, as defined till then, did not constitute a natural group, their apparent resemblance being a case of convergence due to parasitism. They separated the Opalininæ from the Anoplophryidæ. This view was accepted by Cépède (1910), who divided the astomatous Ciliates into eleven families. Hartog (1906) went so far as to remove the Opalininæ from the class CILIATA and place it with the trichonymphids among the MASTIGOPHORA. Minchin, Doflein and other authors have, however, not accepted this view. To do justice to the fundamental differences of nuclear structure Metcalf (1920, 1923) has separated the Opalinidæ from the rest of the Ciliates and divided the class into two subclasses, viz., PROTOCILIATA and EUCILIATA, a scheme which is now generally followed.

The SPIROTRICHA of Schewiakoff corresponded with Bütschli's suborder of the same name, and included HETEROTRICHA, OLIGOTRICHA, HYPOTRICHA and PERITRICHA—that is, all the Ciliates which possess a special adoral zone of cilia arranged in a spiral manner in front of the mouth. There are, however, a number of fundamental differences between the HETEROTRICHA, OLIGOTRICHA and HYPOTRICHA on the one hand and the PERITRICHA on the other. The adoral zone of membranelles in the first three orders turns to the left if viewed from the ventral or oral side (taking the oral end of the spiral as its beginning), but in PERITRICHA (with few exceptions) the adoral zone, if viewed from the ventral side, turns to the right, or, as generally stated, forms a right-handed spiral. As,

however, we are dealing with organs which are not developed from the mouth, but play the physiological rôle of carrying the food to the mouth, Reichenow (1929) considers it more reasonable that the end of the adoral zone furthest from the mouth should be regarded as its beginning. So viewed, it may be described as turning to the left in the PERITRICHA and to the right in the HETEROTRICHA, OLIGOTRICHA and HYPOTRICHA. How this reversal of the adoral spiral came about has been discussed among others by Bütschli (1887–89) and Fauré-Fremiet (1905). Bütschli explained the phylogenetic origin of the PERITRICHA from flattened hypotrichous forms in which the ventral surface came to serve for attachment while the peripheral region of the adoral zone became turned over to the side and finally on to the dorsal aspect. The functional ventral (oral) surface of a Vorticellid is thus the morphological dorsal surface, and the attaching surface is the morphological ventral surface. The seeming longitudinal splitting is thus really transverse in a morphological sense. Colony formation, separation of individual cells provided with a temporary ciliated girdle, occurrence of dimorphic gametes and their complete and permanent fusion during fertilization are remarkable features characteristic of the PERITRICHA alone among the Ciliates.

It is now generally believed that, taking the HOLOTRICHA as the more primitive Ciliates, the HETEROTRICHA and the PERITRICHA are derived from them by separate routes. From the HETEROTRICHA are derived the OLIGOTRICHA and HYPOTRICHA. To give expression to this view in classification Kahl has recently emended SPIROTRICHA Bütschli so as to exclude the PERITRICHA, and Reichenow (1929) has followed him. Reichenow has also separated the parasitic forms belonging to the families Ophryoscolecidæ and Cycloposthiidæ from the OLIGOTRICHA, and placed them in a separate suborder ENTODINIOMORPHA, and certain aberrant sapropelic forms belonging to the family Ctenostomidæ have also been placed under a separate suborder by Kahl.

The highly specialized forms in which the peristomial area with the adoral zone of membranelles is spirally rolled have been placed in a separate order CHONOTRICHA. I have followed Kahl and Reichenow in this new classification.

The CILIOPHORA are thus divided into the following classes, orders and suborders :—

I. Class CILIATA Bütschli.

I. Subclass PROTOCILIATA Metcalf.

II. Subclass EUCILIATA Metcalf.

1. Order HOLOTRICHA Stein.

1. Suborder GYMNOSTOMATA Bütschli.
2. Suborder TRICHOSTOMATA Bütschli, em. Kahl.

3. Suborder HYMENOSTOMATA Hickson, em. Kahl.
4. Suborder THIGMOTRICHA Chatton & Lwoff.
5. Suborder APOSTOMEA Chatton & Lwoff.
6. Suborder ASTOMATA Schewiakoff, em. Cépède.

2. Order SPIROTRICHA Bütschli, em. Kahl.
   1. Suborder HETEROTRICHA Stein.
   2. Suborder OLIGOTRICHA Bütschli.
   3. Suborder ENTODINIOMORPHA Reichenow.
   4. Suborder CTENOSTOMIDA Kahl.
   5. Suborder HYPOTRICHA Stein.
3. Order PERITRICHA Stein.
4. Order CHONOTRICHA Wallengren.

II. Class SUCTORIA Bütschli.

The further classification into families, and the genera and species dealt with, will be seen from the Systematic Index.

The Geographical Distribution of Indian Ciliophora.

It is well known that species of freshwater and soil PROTOZOA are cosmopolitan. The majority of the 310 species now known from India are found in Europe and America, and those that have been described as new in the present work are likely to be found in other parts of the world also. This is due to the fact that the conditions of life in pools and ponds are much the same all over the world, and the freshwater forms, especially in an encysted state, can be easily carried from one place to another by wind or by animals.

I have followed the regional divisions of India as adopted by Stephenson in his volume on Oligochæta in the 'Fauna of British India,' and have noted the species so far recorded from each of these divisions; but no importance can be attached to the apparent presence or absence of any species from the different regions. The larger number of species recorded from certain regions is due simply to the fact that these regions have been better explored, and further work will doubtless show the "all-India" distribution of most of the species. The lists will, however, be of some use to workers in different parts of the country, and enable them to make a more thorough search than has hitherto been made.

1. NORTH-WESTERN TERRITORY.

(The drainage system of the Indus, so far as comprised in the plains of India; the Punjab, N.W. Frontier Province, N. Rajputana, Sind.)

OPALINIDÆ.

Cepedea metcalfi (Lahore).
" *punjabensis* (Lahore).
" *sialkoti* (Sialkot).

Opalina coracoidea (Lahore).
,, *lata* (Lahore).
,, *ranarum* (Lahore).

HOLOPHRYIDÆ.

Holophrya indica (Lahore).
,, *simplex* (Lahore).
Urotricha globosa (Lahore).
Prorodon teres (Lahore).
,, *edentatus* (Lahore).
Lacrymaria vermicularis (Lahore).
,, *striata* (Lahore).
Enchelys arcuata (Lahore).
,, sp. (Lahore, Lyallpore).

DIDINIIDÆ.

Didinium nasutum (Lahore).
,, *balbiani* (Lahore).

COLEPIDÆ.

Coleps hirtus (Lahore).
,, *kenti* (Lahore).
,, *uncinatus* (Lahore).

SPATHIDIIDÆ.

Spathidium moniliforme (Lahore).

AMPHILEPTIDÆ.

Lionotus fasciola (Lahore).
,, *pleurosigma* (Lahore).
Loxophyllum meleagris (Lahore).

TRACHELIIDÆ.

Dileptus anser (Lahore).

LOXODIDÆ.

Loxodes punjabensis (Lahore).

NASSULIDÆ.

Nassula stromphii (Lahore).
,, *ambigua* (Lahore).
Cyclogramma rubens (Lahore).

CHLAMYDODONTIDÆ.

Chilodonella cucullulus (Lahore).

COLPODIDÆ.

Colopoda cucullus (Lahore, Gurdaspur, Peshawar, Karachi).
,, *steinii* (Lahore, Peshawar).

PARAMECIIDÆ.

Paramecium caudatum (Lahore).

FRONTONIDÆ.

Frontonia leucas (Lahore).
Sigmostomum indicum (Lahore).
Trichoda pura (Lahore).
Glaucoma scintillans (Lahore).
Colpidium colpoda (Lahore).
,, *campyllum* (Lahore).
,, *striatum* (Lahore).
,, sp. (Peshawar).
Pseudoglaucoma digitata (Lahore).

PLEURONEMATIDÆ.

Cyclidium glaucoma (Lahore).
Balantiophorus elongatus (Lahore, Gurdaspur, Jullundhur, Peshawar).
Balantiophorus minutus (Lahore. Jullundhur, Peshawar).
,, sp. (Lahore).

UROCENTRIDÆ.

Urocentrum turbo (Lahore).
Telotrichidium mathaii (Lahore).

ANOPLOPHRYIDÆ.

Maupasella nova (Lahore).

SPIROSTOMIDÆ.

Spirostomum ambiguum (Lahore).

PLAGIOTOMIDÆ.

Nyctotherus cordiformis (Lahore).
,, *macropharyngeus* (Lahore).
,, *ovalis* (Lahore).
,, *reniformis* (Sialkot).

STENTORIDÆ.

Stentorella polymorphus (Lahore).
,, sp. (Lahore).

BURSARIDÆ.

Bursaria truncatella (Lahore).

BALANTIDIIDÆ.

Balantidium amygdalli (Sialkot).
,, *bicavata* (Lahore).
,, *blattarum* (Lahore).
,, *duodeni* (Lahore).
,, *elongatum* (Lahore).
,, *gracile* (Lahore).
,, *helenæ* (Lahore).

HALTERIIDÆ.

Halteria grandinella (Lahore).
,, sp. (Peshawar).

PERITROMIDÆ.

Peritromoides simplex (Lahore).

OXYTRICHIDÆ.

Urostyla weisii (Lahore).
Uroleptus sp. (Peshawar).
Gonostomum affine (Lahore, Jullundhur ?).
Pleurotricha grandis (Lahore, Peshawar).
,, *lanceolata* (Peshawar).
Gastrostyla setifera (Lahore).
Oxytricha pellionella (Lahore, Jullundhur ?).
Stylonichia pustulata (Lahore).

ASPIDISCIDÆ.

Aspidisca lynceus (Lahore).
,, *costata* (Lahore).

VORTICELLIDÆ.

Scyphidia indica (Lahore).
Vorticella campanula (Lahore).
,, *citrina* (Lahore).
,, *microstoma* (Peshawar).
Carchesium epistylidis (Lahore).
Epistylis plicatilis (Lahore).
,, *articulata* (Lahore).

PODOPHRYIDÆ.

Sphærophrya pusilla (Lahore, Hoshiarpur).

2. WESTERN HIMALAYAN REGION.

(From Hazara to the border of Nepal, including Kashmir.)

COLEPIDÆ.

Coleps hirtus (Srinagar).

AMPHILEPTIDÆ.

Lionotus fasciola (Srinagar).
Loxophyllum helus (Srinagar).

LOXODIDÆ.

Loxodes striatus (Srinagar).
,, *bahaduri* (Srinagar).

CHLAMYDODONTIDÆ.

Chilodonella cucullulus (Srinagar).
,, *spiralidentis* (Srinagar).

COLPODIDÆ.

Colpoda cucullus (Ghora Gali, Srinagar.)
,, *steinii* (Ghora Gali, Srinagar).

PARAMECIIDÆ.

Paramecium caudatum (Srinagar).
,, *aurelia* (Srinagar).
,, *bursaria* (Srinagar).

FRONTONIDÆ.

Glaucoma pyriformis (Srinagar).
Colpidium sp. (Ghora Gali, Srinagar).

PLEURONEMATIDÆ.

Balantiophorus elongatus (Ghora Gali, Srinagar).

UROCENTRIDÆ.

Urocentrum turbo (Srinagar).

SPIROSTOMIDÆ.

Spirostomum ambiguum (Srinagar).
,, *teres* (Srinagar).

STENTORIDÆ.

Stentorella polymorphus (Srinagar).

OXYTRICHIDÆ.

Uroleptus mobilis (Ghora Gali, Srinagar).
,, *piscis* (Srinagar).
Gonostomum affine (Srinagar).
Pleurotricha grandis (Ghora Gali).
,, *lanceolata* (Ghora Gali, Srinagar).
Stylonichia pustulata (Srinagar).

VORTICELLIDÆ.

Vorticella microstoma (Ghora Gali, Srinagar).
,, sp. (Ghora Gali).

3. NORTH-EASTERN FRONTIER REGION.

(Nepal and eastwards, including Assam.)

COLPODIDÆ.

Colpoda cucullus (Assam).

PLEURONEMATIDÆ.

Balantiophorus elongatus (Cinnamara near Jorhat).

BALANTIDIIDÆ.

Balantidium coli var. *bovis* (Assam).

OXYTRICHIDÆ.

Gonostomum sp. (Dacca).
Pleurotricha grandis (Assam).

4. INDO-GANGETIC PLAIN.

(United Provinces, Bihar, Bengal.)

OPALINIDÆ.

Opalina plicata (Calcutta).
,, *scalpriformis* (Calcutta).
,, *triangularis* (Calcutta).

HOLOPHRYIDÆ.

Holophrya annandalei (Calcutta).
,, *bengalensis* (Calcutta).
Urotricha sp. (Calcutta).
Prorodon stewarti (Calcutta).
Lacrymaria olor (Calcutta).
Enchelis sp. (Sibpore).
Trachelocerca sp. (Calcutta).

COLEPIDÆ.

Coleps hirtus (Calcutta).
,, sp. (Calcutta).

AMPHILEPTIDÆ.

Amphileptus sp. (Calcutta).
Lionotus fasciola (Calcutta).
,, *similis* (Calcutta).
,, *infusionus* (Calcutta).

LOXODIDÆ.

Loxodes sp. (Calcutta).

TRACHELIIDÆ.

Trachelius gutta (Calcutta).

NASSULIDÆ.

Chilodontopsis bengalensis (Calcutta).
Orthodonella banerjeei (Calcutta).

CHLAMYDODONTIDÆ.

Chilodonella rhesus (Calcutta).
„ sp. (Calcutta).
„ sp. (Sibpore).

COLPODIDÆ.

Colpoda cucullus (Delhi, Agra, Dehra Dun, Sibpore, Calcutta, Dacca, Cuttack, Pusa).
„ *steinii* (Delhi, Dehra Dun).
„ *maupasi* (Pusa).

FRONTONIDÆ.

Colpidium sp. (Chittagong).

PARAMECIIDÆ.

Paramecium caudatum (Calcutta, Lucknow).
„ sp. (Calcutta).

TRICHOPELMIDÆ.

Drepanomonas dentata (Calcutta).

Incertæ sedis.

Opisthostomum bengalensis (Calcutta).

CONCHOPHTHIRIDÆ.

Conchophthirius curtus (Calcutta).
„ *lamellidens* (Calcutta).
„ *elongatus* (Calcutta).

ISOTRICHIDÆ.

Isotricha prostoma (Calcutta).
Dasytricha ruminantium (Calcutta).

FRONTONIDÆ.

Colpidium sp. (Dehra Dun, Agra, Patna, Dacca).
Stegochilum ovale (Calcutta).

PLEURONEMATIDÆ.

Cyclidium glaucoma (Sibpore).
Pleuronema chrysalis (Calcutta).
Balantiophorus elongatus (Benares, Agra, Patna, Sibpore, Calcutta, Chittagong).
„ *minutus* (Dehra Dun, Patna, Sibpore, Calcutta, Chittagong),

ANOPLOPHRYIDÆ.

Anoplophrya ælosomata (Calcutta).
„ *cylindrica* (Calcutta).
„ *elongata* (Calcutta).
„ *lloydi* (Calcutta).
„ *variabilis* (Calcutta).

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SPIROSTOMIDÆ.

Spirostomum ambiguum (Calcutta).
,, sp. (Agra).

PLAGIOTOMIDÆ.

Nyctotherus cordiformis (Calcutta).
,, *kempi* (Calcutta).
,, *macropharyngeus* (Calcutta).

STENTORIDÆ.

Stentorella polymorphus (Calcutta).
,, *viridis* (Calcutta).

FOLLICULINIDÆ.

Folliculina ampulla (Port Canning, Lower Bengal).

BURSARIDÆ.

Parabursaria pheretima (Calcutta).

BALANTIDIIDÆ.

Balantidium blattarum (Calcutta).
,, *coli* (Calcutta).
,, *depressum* (Calcutta).
,, *knowlesii* (Calcutta).
,, *ovatum* (Calcutta).
,, *ranarum* (Calcutta).
,, *rhesum* (Calcutta).
,, *sushilii* (Calcutta).

OPHRYOSCOLECIDÆ.

Entodinium bursa (Calcutta).
,, *dubardi* (Calcutta).
,, *lobosospinosum* (Calcutta).
,, *longinucleatum* (Calcutta).
,, *biconcavum* (Calcutta).
,, *elongatum* (Calcutta).
,, *laterale* (Calcutta).
,, *rectangulatum* (Calcutta).
,, *anteronucleatum læve* (Calcutta).
,, ,, *monolobum* (Calcutta).
,, ,, *dilobum* (Calcutta).
,, *caudatum* (Calcutta).
,, *chatterjeei* (Calcutta).
,, *ekendræ* (Calcutta).
,, *furca dilobum* (Calcutta).
,, *nanellum* (Calcutta).
,, *ovinum* (Calcutta).
,, *ovoido-nucleatum* (Calcutta).
,, *setnai* (Calcutta).
,, *simplex* (Calcutta).
Diplodinium anisacanthum (Calcutta).
,, *consors* (Calcutta).
,, *costatum* (Calcutta).
,, *crista-galli* (Calcutta).
Eremoplastron rostratum (Calcutta).
,, *brevispinum* (Calcutta).
Eudiplodinium maggii (Calcutta).
Diploplastron affine (Calcutta).

Metadinium medium (Calcutta).
Elytroplastron bubali (Calcutta).
Epidinium ecaudatum (Calcutta).
,, *caudatum* (Calcutta).
,, *cattanei* (Calcutta).
Ophryoscolex tricoronatus (Calcutta).

OXYTRICHIDÆ.

Uroleptus mobilis (Chittagong).
Gonostomum affine (Delhi, Agra).
Pleurotricha grandis (Agra, Sibpore).
,, *lanceolata* (Delhi).
Stylonichia sp. (Agra, Calcutta).
Balladinopsis nuda (Calcutta).

EUPLOTIDÆ.

Euplotes sp. (Calcutta).

ASPIDISCIDÆ.

Aspidisca costata (Lucknow).
Aspidiscopsis bengalensis (Calcutta).

VORTICELLIDÆ.

Scyphidia purniensis (Purnea, Bengal).
Vorticella patellina (Calcutta).
,, *globosa* (Calcutta).
,, *subcylindrica* (Calcutta).
,, *submicrostoma* (Calcutta).
,, *subprocubens* (Calcutta).
,, *subsinuata* (Calcutta).
,, sp. (Calcutta).
Carchesium polypinum (Port Canning, Lower Bengal).
,, sp. (Calcutta).
Epistylis sp. (Calcutta).
Cothurnia sp. (Calcutta).
Vaginicola sp. (Calcutta).
Platycola sp. (Calcutta).

ACINETIDÆ.

Tokophrya bengalensis (Calcutta).

PODOPHRYIDÆ.

Podophrya bengalensis (Calcutta).
,, *sandi* (Calcutta).

5. BURMA.

(Including the Andamans and Nicobars.)

COLPODIDÆ.

Colpoda cucullus (Hmawbi).
,, *steinii* (Rangoon, Hmawbi).

PLEURONEMATIDÆ.

Pleuronema sp. (Hmawbi).

OXYTRICHIDÆ.

Uroleptus mobilis (Rangoon).

6. MAIN PENINSULAR AREA.

(Including S. Rajputana and the Central India Agency.)

HOLOPHRYIDÆ.

Prorodon sp. (Indore).

AMPHILEPTIDÆ.

Lionotus sp. (Indore).

CHLAMYDODONTIDÆ.

Chilodonella sp. (Indore).

COLPODIDÆ.

Colpoda cucullus (Nagpur, Hyderabad).
" *steinii* (Indore, Nagpur, Hyderabad).

PLEURONEMATIDÆ.

Balantiophorus elongatus (Indore, Cuttack).

SPIROSTOMIDÆ.

Blepharisma sp. (Indore).
Spirostomum sp. (Indore, Hyderabad).

HALTERIIDÆ.

Halteria sp. (Indore).

OXYTRICHIDÆ.

Stichotricha sp. (Indore).
Uroleptus mobilis (Indore).
" *piscis* (Indore).
" sp. (Indore).
Pleurotricha grandis (Indore).
" *lanceolata* (Indore, Hyderabad).
Oxytricha pellionella (Indore).

VORTICELLIDÆ.

Vorticella microstoma (Indore).
" sp. (Indore).

7. SOUTHERN REGION.

(S. of Latitude 15°.)

HOLOPHRYIDÆ.

Enchelys sp. (Coimbatore).

COLPODIDÆ.

Colpoda cucullus (Madras, Mysore, Coimbatore).
" *steinii* (Madras, Mysore, Coimbatore).
" *maupasi* (Madras, Coimbatore).

ISOTRICHIDÆ.

Isotricha intestinalis (Mysore).
" *prostoma* (Mysore, Coonoor).
Dasytricha ruminantium (Coonoor).

FRONTONIDÆ.

Colpidium striatum (Mysore).
Uronema marinum (Mysore).
,, *accuminata* (Mysore).

PLEURONEMATIDÆ.

Balantiophorus elongatus (Coimbatore, Kanara).
,, *minutus* (Coimbatore).

HAPTOPHRYIDÆ.

Caudalina bangalorensis (Mysore).
,, *armata* (Mysore).

SPIROSTOMIDÆ.

Spirostomum sp. (Madras).

CONDYLOSTOMIDÆ.

Condylostoma patens (Mysore).

Incertæ sedis.

Octocirrus sphæratus (Mysore).

OPHRYOSCOLECIDÆ.

Entodinium curtum (Mysore).
,, *ellipsoideum* (Coonoor).
,, *longinucleatum* (Coonoor, Mysore).
,, *acutonucleatum* (Coonoor, Mysore).
,, *contractum* (Mysore).
,, *rostratum* (Coonoor).
,, *pisciculum* (Coonoor).
,, *biconcavum* (Coonoor).
,, *bifidum* (Coonoor).
,, *acutum* (Coonoor).
,, *laterale* (Coonoor).
,, *rectangulatum* (Coonoor).
,, *brevispinum* (Coonoor).
,, *laterospinum* (Coonoor).
,, *nanellum* (Coonoor, Mysore).
,, *ovoideum* (Coonoor).
,, *rhomboideum* (Coonoor).
,, *bismatus* (Coonoor).
,, *gibberosum* (Coonoor).
,, *tricostatum* (Coonoor).
,, *indicum* (Coonoor, Mysore).
Eodinium lobatum (Coonoor).
,, *bilobosum* (Mysore).
,, *rectangulatum* (Coonoor).
Diplodinium dentatum (Coonoor).
,, *monacanthum* (Coonoor).
,, *diacanthum* (Mysore).
,, *triacanthum* (Mysore).
,, *tetracanthum* (Mysore).
,, *pentacanthum* (Mysore).
,, *anisacanthum* (Mysore).
,, *psittaceum* (Coonoor).
,, *minor* (Mysore).
,, *flabellum* (Coonoor).

ORPHROSCOLECIDÆ (*cont.*).

Eremoplastron rostratum (Mysore).
" *rotundum* (Coonoor).
" *bovis* (Coonoor).
" *magnodentatum* (Coonoor).
Eudiplodinium maggii (Coonoor, Mysore).
Metadinium medium (Coonoor Mysore).
" *rotundatum* (Mysore).
Elytroplastron bubali (Coonoor).
Ostracodinium gauri (Mysore).
" *mysorei* (Mysore).
" *mammosum* (Coonoor).
" *gracile* (Coonoor, Mysore).
" *trivesiculatum* (Coonoor, Mysore).
" *quadrivesiculatum* (Coonoor).
" *venustum* (Coonoor).
" *clipeolum* (Coonoor).
" *rugoloricatum* (Coonoor).
Epidinium caudatum (Mysore).
" *quadricaudatum* (Mysore).
" *parvicaudatum* (Mysore).
" *cattanei* (Coonoor).
" *eberleini* (Coonoor).
Ophryoscolex spinosus (Coonoor).
Polydinium mysoreum (Mysore).
Elephantophilus zeta (Mysore).

OXYTRICHIDÆ.

Uroleptus mobilis (? Coimbatore).
" *piscis* (Coimbatore).
Gonostomum affine (Kanara, Coimbatore).
Pleurotricha lanceolata (Kanara, Madras).
Oxytricha sp. (Coimbatore).

EUPLOTIDÆ.

Euplotes charon (Mysore).

VORTICELLIDÆ.

Vorticella microstoma (Coimbatore, Mysore).
Carchesium polypinum (Mysore).
Vaginicola sp. (Bangalore).

8. WESTERN REGION.

(Goa to Cutch, the Ghats to the Sea.)

OPALINIDÆ.

Cepedea longa (Nova Goa).
" *seychellensis* var. *angusta* (Nova Goa).
" *subcylindrica* (Nova Goa).
" *thiagi* (Nova Goa).
Opalina scalpriformis (Nova Goa).
" *triangularis* (Nova Goa).
" *ranarum* (Nova Goa).
" *lata* (Nova Goa).
" " var. *cordata* (Nova Goa).
" *coracoidea* (Nova Goa).
" *virgula* (Nova Goa).

HOLOPHRYIDÆ.

Holophrya lateralis (Bombay).
Urotricha sp. (Bombay).

DIDINIIDÆ.

Mesodinium pulex (Bombay).

NASSULIDÆ.

Nassula sp. (Bombay).

CHLAMYDODONTIDÆ.

Chilodonella cucullulus (Bombay).

PLAGIOPYLIDÆ.

Plagiopyla carteri (Bombay).

COLPODIDÆ.

Colpoda cucullus (Bombay, Dharwar).
,, *steinii* (Bombay, Poona, Kanara, Dharwar).

PARAMECIIDÆ.

Paramecium aurelia (Bombay).

FRONTONIDÆ.

Frontonia leucas (Bombay).

OPHRYOGLENIDÆ.

Ophryoglena flava (Bombay).

PLEURONEMATIDÆ.

Balantiophorus elongatus (Dharwar).
,, *minutus* (Dharwar).

UROCENTRIDÆ.

Urocentrum turbo (Bombay).

PLAGIOTOMIDÆ.

Nyctotherus cordiformis (Nova Goa).
,, *macropharyngeus* (Bombay, Nova Goa).
,, *magnus* var. *malabarica* (Nova Goa).
,, *ovalis* (Nova Goa).
,, *papillatus* (Nova Goa).

BALANTIDIIDÆ.

Balantidium gracile (Nova Goa).
,, *helenæ* (Nova Goa).

STENTORIDÆ.

Climacostomum virens (Bombay).
Stentorella sp. (Bombay).

OXYTRICHIDÆ.

Gonostomum affine (Dharwar).
Pleurotricha grandis (Bombay).
Oxytricha sp. (Bombay).

EUPLOTIDÆ.

Euplotes charon (Bombay).

VORTICELLIDÆ.

Vorticella convallaria (Bombay).
" *microstoma* (Bombay).
" sp. (Bombay).
Epistylis galea (Bombay).
Pyxicola carteri (Bombay).

ACINETIDÆ.

Tokophrya quadripartita (Bombay).
Acineta tuberosa (Bombay).

PODOPHRYIDÆ.

Podophrya fixa (Bombay).
Sphærophrya sp. (Bombay).

9. CEYLON.

OPALINIDÆ.

Opalina virgula (Peradeniya).

HOLOPHRYIDÆ.

Prorodon sp. (Colombo).

AMPHILEPTIDÆ.

Lionotus sp. (Colombo).

NASSULIDÆ.

Phascolodon sp. (Colombo).

COLPODIDÆ.

Colpoda cucullus (Kandy).

ISOTRICHIDÆ.

Isotricha prostoma (Colombo).
Dasytricha ruminantium (Colombo).

PARAISOTRICHIDÆ.

Blepharocorys ventriculi (Colombo).

FRONTONIDÆ.

Colpidium sp. (Colombo).

PLEURONEMATIDÆ.

Balantiophorus sp. (Colombo).

PLAGIOTOMIDÆ.

Nyctotherus macropharyngeus (Colombo).
" *papillatus* (Paradeniya).
" *termitis* (Colombo).

BALANTIDIIDÆ.

Balantidium duodeni (Colombo).
" *helenæ* (Colombo).
" *testudinis* (Colombo).

TINTINNIDÆ.

Tintinnopsis ovalis (Madatugama).
" *lacustris* (Madatugama, Lake Kalawewa).

OPHRYOSCOLECIDÆ.

Entodinium ellipsoideum (Colombo).
,, *longinucleatum* (Colombo).
,, *acutonucleatum* (Colombo).
,, *rostratum* (Colombo).
,, *pisciculum* (Colombo).
,, *biconcavum* (Colombo).
,, *acutum* (Colombo).
,, *aculeatum* (Colombo).
,, *laterale* (Colombo).
,, *rectangulatum* (Colombo).
,, *brevispinum* (Colombo).
,, *laterospinum* (Colombo).
,, *nanellum* (Colombo).
,, *ovoideum* (Colombo).
,, *rhomboideum* (Colombo).
,, *bismatus* (Colombo).
,, *gibberosum* (Colombo).
,, *tricostatum* (Colombo).
,, *indicum* (Colombo).
,, *ovalis* (Colombo).
,, *bursa* (Colombo).
,, *dubardi* (Colombo).
Eodinium lobatum (Colombo).
,, *rectangulatum* (Colombo).
Diplodinium dentatum (Colombo).
,, *monocanthum* (Colombo).
,, *psittaceum* (Colombo).
Eremoplastron rostratum (Colombo).
,, *rotundum* (Colombo).
,, *bovis* (Colombo).
,, *brevispinum* (Colombo).
,, *magnodentatum* (Colombo).
,, *maggii* (Colombo).
Metadinium medium (Colombo).
Elytroplastron bubali (Colombo).
Ostracodinium mammosum (Colombo).
,, *gracile* (Colombo).
,, *trivesiculatum* (Colombo).
,, *quadrivesiculatum* (Colombo).
,, *venustum* (Colombo).
,, *clipeolum* (Colombo).
,, *rugoloricatum* (Colombo).
Epidinium ecaudatum (Colombo).
,, *caudatum* (Colombo).
,, *bicaudatum* (Colombo).
,, *tricaudatum* (Colombo).
,, *quadricaudatum* (Colombo).
,, *cattanei* (Colombo).
,, *eberleini* (Colombo).

OXYTRICHIDÆ.

Holosticha mystacea (Kandy).
Gonostomum affine (Colombo).
Stylonichia pustulata (Kandy).

VORTICELLIDÆ.

Epistylis anastatica.

Distribution of Parasitic Forms.

Unlike the freshwater PROTOZOA, the geographical distribution of parasites usually follows that of their hosts. Up to the present time only a very small number of animals found in India have been examined for their parasites, and a more extensive survey is highly desirable. The following lists of (i) parasites and their hosts, and (ii) the hosts and their parasites, will, it is hoped, be found useful, and indicate at a glance which of our commoner animals still remain to be examined for their parasites.

(i) *List of Parasites and their Hosts.*

Parasite.	Host.	Seat.
Zelleriella macronucleata .	*Bufo melanostictus* ...	Rectum.
Cepedea lanceolata	*Rana esculenta* var. *chinensis.*	Rectum.
Cepedea longa	*Rana limnocharis*	Rectum.
	Rhacophorus maculatus.	Intestine.
Cepedea metcalfi	*Bufo melanostictus* ...	Rectum.
Cepedea punjabensis	*Bufo melanostictus* ...	Rectum.
Cepedea seychellensis var. *angusta.*	*Rana tigrina*	Intestine.
	Bufo melanostictus ...	Intestine.
Cepedea sialkoti	*Bufo macrotis*	Rectum.
Cepedea subcylindrica ..	*Bufo melanostictus* ...	Intestine.
Cepedea thiagi	*Rhacophorus maculatus.*	Intestine.
Opalina coracoidea	*Rana cyanophlyctis* ...	Intestine.
Opalina coracoidea lahoriensis.	*Rana tigrina*	Rectum.
	Bufo melanostictus ...	Rectum.
Opalina lata	*Rana limnocharis*.....	Intestine and rectum.
	Rana hexadactyla	Rectum.
Opalina lata var. *cordata* .	*Rana cyanophylctis* ...	Intestine.
	Rana malabarica	Intestine.
Opalina plicata	*Bufo melanostictus* ...	Rectum.
Opalina ranarum.....	*Rana esculenta*	Rectum.
	Rana cyanophlyctis....	Intestine and rectum.
	Rana tigrina	Intestine.
	Bufo cinereus	Rectum.
	Bufo melanostictus ...	Intestine.
	Bufo variabilis	Rectum.
Opalina scalpriformis ..	*Bufo melanostictus* ...	Rectum and intestine.
Opalina triangularis	*Bufo melanostictus* ...	Rectum and intestine.
Opalina virgula	*Polypedates* (*Rhacophorus*) *maculatus.*	Rectum.
	Bufo melanostictus ...	Intestine.
Chilodonella rhesus	*Macacus rhesus*	Intestine.
Conchopthirius curtus....	*Lamellidens marginalis.*	Mantle-chamber.
Conchopthirius lamellidens	*Lamellidens marginalis.*	Mantle-chamber.
Conchopthirius elongatus .	*Lamellidens marginalis.*	Mantle-chamber.

Parasite.	Host.	Seat.
Isotricha intestinalis	*Bos gaurus*	Stomach.
Isotricha prostoma	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
	Capra hircus	Rumen.
Dasytricha ruminantium..	*Bos indicus*.....	Stomach.
	Capra hircus.....	Rumen.
Blepharocorys ventriculi ..	*Bos indicus*	Stomach.
Anoplophrya ælosomatis..	*Ælosoma chlorostictum*.	Alimentary canal.
Anoplophrya cylindrica ..	*Vivipara bengalensis* ..	Intestinal canal.
Anoplophrya elongata ...	Small freshwater gastropods.	Rectum.
Anoplophrya lloydii	*Pheretima posthuma* ..	Seminal vesicles.
Anoplophrya variabilis ..	Small freshwater gastropods.	Intestine.
Maupasella nova	*Pheretima posthuma* ..	Alimentary canal.
	Pheretima hawayana .	Alimentary canal.
Nyctotherus cordiformis ..	*Bufo melanostictus* ...	Intestine and cloaca.
	Rana tigrina	Intestine.
	Rana malabarica	Intestine.
	Rana limnocharis	Intestine.
Nyctotherus kempi	*Ampullaria globosa* ..	Rectum.
Nyctotherus macropharyngeus.	*Rana tigrina*	Intestine and cloaca.
	Rana cyanophlyctis. ..	Intestine and cloaca.
	Rana hexadactyla	Cloaca.
	Rana limnocharis	Intestine.
Nyctotherus magnus	*Rana hexadactyla*	Cloaca.
Nyctotherus magnus var. *malabarica*.	*Rana tigrina*	Intestine.
Nyctotherus ovalis	*Periplaneta americana*.	Mid- and hind-gut.
Nyctotherus papillatus ...	*Bufo melanostictus* ...	Cloaca.
	Rhacophorus maculatus.	Intestine and cloaca.
Nyctotherus reniformis ...	*Bufo macrotis*	Rectum.
Nyctotherus termitis	*Calotermes militaris*...	Intestine.
Parabursaria pheretima ..	*Pheretima posthuma* ..	Seminal vesicles.
Balantidium amygdalli ..	*Bufo macrotis*	Rectum.
Balantidium bicavata	*Bufo melanostictus* ...	Rectum.
Balantidium blattarum ..	*Periplaneta americana*.	Intestine.
Balantidium coli	*Homo sapiens*	Intestine.
Balantidium coli var. *bovis*	Cattle	Intestine.
Balantidium depressum ..	*Ampullaria globosa* ...	Rectum.
Balantidium duodeni ...	*Rana tigrina*	Duodenum and small intestine.
Balantidium elongatum ..	*Rana tigrina*	Intestine.
Balantidium gracile.....	*Rana cyanophlyctis* ...	Rectum.
	Rana hexadactyla	Rectum.
	Rana tigrina	Small intestine.
Balantidium helenæ	*Rana tigrina*	Intestine and rectum.
	Rana cyanophlyctis ...	Intestine.
	Rana limnocharis	Intestine.
Balantidium giganteum ..	*Rana esculenta* var. *chinensis*.	Cloaca.
Balantidium knowlesii ...	*Culicoides peregrinus*..	Cœlom.
Balantidium ovatum	*Periplaneta americana*.	Intestine.

Parasite.	Host.	Seat.
Balantidium ranarum	*Rana tigrina*	Rectum.
Balantidium rhesum	*Macacus rhesus*	Intestine.
Balantidium rotundum ..	*Rana esculenta* var. *chinensis.*	Small intestine.
Balantidium sushilii	*Rana tigrina*	Intestine.
Balantidium testudinis ..	*Nicoria trijuga*	Large intestine.
Entodinium bursa	*Tragulus meminna* ...	Stomach.
	Capra hircus.....	Rumen.
Entodinium curtum	*Bos gaurus*	Stomach.
Entodinium dubardi	*Tragulus meminna* ...	Stomach.
	Capra hircus.....	Rumen.
Entodinium lobosospinosum.	*Capra hircus*.....	Rumen.
Entodinium ellipsoideum .	*Bos indicus*	Stomach.
Entodinium longinucleatum.	*Bos indicus*	Stomach.
	Bos gaurus	Stomach.
	Capra hircus	Rumen.
Entodinium acutonucleatum.	*Bos indicus*	Stomach.
	Bos gaurus	Stomach.
Entodinium rostratum....	*Bos indicus*	Stomach.
Entodinium pisciculum ..	*Bos indicus*	Stomach.
Entodinium biconcavum .	*Bos indicus*	Stomach.
	Capra hircus.....	Rumen.
Entodinium elongatum ...	*Capra hircus*.....	Rumen.
Entodinium bifidum	*Bos indicus*	Stomach.
Entodinium acutum	*Bos indicus*	Stomach.
Entodinium aculeatum ..	*Bos indicus*	Stomach.
Entodinium laterale.....	*Bos indicus*	Stomach.
	Capra hircus	Rumen.
Entodinium rectangulatum	*Bos indicus*	Stomach.
	Capra hircus.....	Rumen.
Entodinium anteronucleatum læve	*Capra hircus*	Rumen.
Entodinium anteronucleatum monolobum.	*Capra hircus*.....	Rumen.
Entodinium anteronucleatum dilobum.	*Capra hircus*	Rumen.
Entodinium bismatus	*Bos indicus*	Stomach.
Entodinium brevispinum .	*Bos indicus*	Stomach.
Entodinium caudatum ..	*Capra hircus*.....	Rumen.
Entodinium chatterjeei ...	*Capra hircus*.....	Rumen.
Entodinium contractum ..	*Bos gaurus*	Stomach.
Entodinium ekendræ	*Capra hircus*.....	Rumen.
Entodinium furca dilobum.	*Capra hircus*	Rumen.
Entodinium gibberosum ..	*Bos indicus*	Stomach.
Entodinium indicum	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
Entodinium laterospinum.	*Bos indicus*	Stomach.
Entodinium nanellum ...	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
	Capra hircus.....	Rumen.
Entodinium ovalis	*Tragulus meminna*....	Stomach.
Entodinium ovinum	*Capra hircus*	Rumen.
Entodinium ovoideum ...	*Bos indicus*	Stomach.
Entodinium ovoido-nucleatum.	*Capra hircus*.....	Rumen.
Entodinium rhomboideum.	*Bos indicus*	Stomach.

Parasite.	Host.	Seat.
Entodinium setnai	*Capra hircus*	Rumen.
Entodinium simplex	*Capra hircus*	Rumen.
Entodinium tricostatum ..	*Bos indicus*	Stomach.
Eodinium lobatum	*Bos indicus*	Stomach.
Eodinium bilobosum	*Bos gaurus*	Stomach.
Eodinium rectangulatum .	*Bos indicus*	Stomach.
Diplodinium dentatum ...	*Bos indicus*	Stomach.
Diplodinium ceylonicum .	*Bos indicus*	Stomach.
Diplodinium monacanthum.	*Bos gaurus*	Stomach.
Diplodinium diacanthum .	*Bos gaurus*	Stomach.
Diplodinium triacanthum.	*Bos gaurus*	Stomach.
Diplodinium tetracanthum.	*Bos gaurus.*	Stomach.
Diplodinium pentacanthum.	*Bos gaurus*	Stomach.
Diplodinium anisacanthum.	*Bos gaurus*	Stomach.
	Capra hircus	Rumen.
Diplodinium psittaceum .	*Bos indicus*	Stomach.
Diplodinium consors	*Capra hircus*.....	Rumen.
Diplodinium costatum	*Capra hircus*.....	Rumen.
Diplodinium minor	*Bos gaurus*	Stomach.
Diplodinium crista-galli..	*Capra hircus*	Rumen.
Diplodinium flabellum ...	*Bos indicus*	Stomach.
Eremoplastron rostratum..	*Bos indicus*	Stomach.
	Bos gaurus	Stomach.
	Capra hircus	Rumen.
Eremoplastron rotundum .	*Bos indicus*	Stomach.
Eremoplastron bovis	*Bos indicus*	Stomach.
Eremoplastron brevispinum	*Bos indicus*	Stomach.
	Capra hircus.....	Rumen.
Eremoplastron megalodentatum.	*Bos indicus*	Stomach.
Eudiplodinium maggii ...	*Bos indicus*	Stomach.
	Bos gaurus	Stomach.
	Capra hircus.....	Rumen.
Diploplastron affine	*Capra hircus*.....	Rumen.
Metadinium medium	*Bos indicus*	Stomach.
	Bos gaurus	Stomach.
	Capra hircus.....	Rumen.
Metadinium rotundatum..	*Bos gaurus*	Stomach.
Elytroplastron bubali	*Bos indicus*	Stomach.
	Capra hircus	Rumen.
Ostracodinium clipeolum..	*Bos indicus*	Stomach.
Ostracodinium gauri	*Bos gaurus*	Stomach.
Ostracodinium gracile ...	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
Ostracodinium mammosum	*Bos indicus*	Stomach.
Ostracodinium mysorei ..	*Bos gaurus*	Stomach.
Ostracodinium quadrivesiculatum.	*Bos indicus*	Stomach.
Ostracodinium rugoloricatum.	*Bos indicus*	Stomach.
Ostracodinium trivesiculatum.	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
Ostracodinium venustum..	*Bos indicus*	Stomach.
Epidinium caudatum ...	*Capra hircus*	Rumen.
	Tragulus meminna....	Stomach.

Parasite.	Host.	Seat.
Epidinium caudatum	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
	Capra hircus.....	Rumen.
	Tragulus meminna....	Stomach.
Epidinium bicaudatum...	*Bos indicus*	Stomach.
	Tragulus meminna....	Stomach.
Epidinium tricaudatum ..	*Bos indicus*	Stomach.
	Tragulus meminna....	Stomach.
Epidinium quadricaudatum.	*Bos gaurus*	Stomach.
	Bos indicus	Stomach.
	Tragulus meminna....	Stomach.
Epidinium parvicaudatum.	*Bos gaurus*	Stomach.
Epidinium cattanei	*Bos indicus*	Stomach.
	Capra hircus.....	Rumen.
Epidinium eberleini	*Bos indicus*	Stomach.
Ophryoscolex spinosus....	*Bos indicus*	Stomach.
Ophryoscolex tricoronatus.	*Capra hircus*.....	Rumen.
Polydinium mysoreum ...	*Elephas indicus*	Cæcum and colon.
Elephantophilus zeta	*Elephas indicus*	Cæcum and colon.
Sphærophrya pusilla	*Paramecium caudatum.*	Cytoplasm.

(ii) *List of Hosts and their Parasites.*

Host.	Parasite.	Seat.
MAMMALIA.		
Homo sapiens	*Balantidium coli*	Intestine.
Macacus rhesus	*Chilodonella rhesus* ..	Intestine.
	Balantidium rhesum ..	Intestine.
Bos indicus	*Isotricha prostoma*	Stomach.
	Dasytricha ruminantium.	Stomach.
	Blepharocorys ventriculi.	Stomach.
	Entodinium ellipsoideum.	Stomach.
	Entodinium longinucleatum.	Stomach.
	Entodinium acutonucleatum.	Stomach.
	Entodinium rostratum .	Stomach.
	Entodinium pisciculum	Stomach.
	Entodinium biconcavum.	Stomach.
	Entodinium bifidum ..	Stomach.
	Entodinium acutum ..	Stomach.
	Entodinium aculeatum.	Stomach.
	Entodinium laterale ..	Stomach.
	Entodinium rectangulatum.	Stomach.
	Entodinium brevispinum.	Stomach.
	Entodinium laterospinum.	Stomach.
	Entodinium nanellum .	Stomach.
	Entodinium ovoideum .	Stomach.
	Entodinium rhomboideum.	Stomach.
	Entodinium bimastus..	Stomach.
	Entodinium gibberosum	Stomach.

Host.	Parasite.	Seat.
Bos indicus	*Entodinium tricostatum*	Stomach.
	Entodinium indicum .	Stomach.
	Eodinium lobatum ...	Stomach.
	Eodinium rectangulatum.	Stomach.
	Diplodinium dentatum.	Stomach.
	Diplodinium ceylonicum.	Stomach.
	Diplodinium psittaceum.	Stomach.
	Diplodinium flabellum.	Stomach.
	Eremoplastron rostratum.	Stomach.
	Eremoplastron rotundum.	Stomach.
	Eremoplastron bovis ...	Stomach.
	Eremoplastron brevispinum.	Stomach.
	Eremoplastron megalodentatum.	Stomach.
	Eudiplodinium maggii.	Stomach.
	Metadinium medium .	Stomach.
	Elytroplastron bubali .	Stomach.
	Ostrocodinium mammosum.	Stomach.
	Ostrocodinium gracile .	Stomach.
	Ostrocodinium trivesiculatum.	Stomach.
	Ostrocodinium quadrivesiculatum.	Stomach.
	Ostrocodinium venustum.	Stomach.
	Ostrocodinium clipeolum.	Stomach.
	Ostrocodinium rugoloricatum.	Stomach.
	Epidinium caudatum .	Stomach.
	Epidinium bicaudatum.	Stomach.
	Epidinium tricaudatum.	Stomach.
	Epidinium quadricaudatum.	Stomach.
	Epidinium cattanei ...	Stomach.
	Epidinium eberleini ..	Stomach.
	Ophryoscolex spinosus..	Stomach.
	Isotricha intestinalis ..	Stomach.
Bos gaurus	*Isotricha prostoma*	Stomach.
	Dasytricha ruminantium.	Stomach.
	Entodinium curtum ...	Stomach.
	Entodinium longinucleatum.	Stomach.
	Entodinium acutonucleatum.	Stomach.
	Entodinium contractum.	Stomach.
	Entodinium indicum ..	Stomach.
	Entodinium nanellum .	Stomach.
	Eodinium bilobosum ..	Stomach.
	Diplodinium monacanthum.	Stomach.
	Diplodinium diacanthum.	Stomach.
	Diplodinium triacanthum.	Stomach.

Host.	Parasite.	Seat.
Bos gaurus	*Diplodinium tetracanthum.*	Stomach.
	Diplodinium pentacanthum.	Stomach.
	Diplodinium anisacanthum.	Stomach.
	Diplodinium minor ...	Stomach.
	Eremoplastron rostratum.	Stomach.
	Eudiplodinium maggii.	Stomach.
	Metadinium medium .	Stomach.
	Metadinium rotundatum.	Stomach.
	Ostracodinium gauri ..	Stomach.
	Ostracodinium gracile .	Stomach.
	Ostracodinium mysorei.	Stomach.
	Ostracodinium trivesiculatum.	Stomach.
	Epidinium caudatum ..	Stomach.
	Epidinium quadricaudatum.	Stomach.
	Epidinium parvicaudatum.	Stomach.
Cattle	*Balantidium coli* var. *bovis.*	Intestine.
Capra hircus	*Isotricha prostoma*	Rumen.
	Dasytricha ruminantium.	Rumen.
	Entodinium bursa	Rumen.
	Entodinium dubardi ..	Rumen.
	Entodinium lobospinosum.	Rumen.
	Entodinium longinucleatum.	Rumen.
	Entodinium biconcavum.	Rumen.
	Entodinium elongatum.	Rumen.
	Entodinium laterale ..	Rumen.
	Entodinium rectangulatum.	Rumen.
	Entodinium anteronucleatum læve.	Rumen.
	Entodinium anteronucleatum monolobum .	Rumen.
	Entodinium anteronucleatum dilobum	Rumen.
	Entodinium caudatum .	Rumen.
	Entodinium chatterjeei.	Rumen.
	Entodinium ekendræ ..	Rumen.
	Entodinium furca dilobum.	Rumen.
	Entodinium nanellum .	Rumen.
	Entodinium ovinum ..	Rumen.
	Entodinium ovoidonucleatum.	Rumen.
	Entodinium setnai	Rumen.
	Entodinium simplex ..	Rumen.

Host.	Parasite.	Seat.
Capra hircus	*Diplodinium anisacanthum.*	Rumen.
	Diplodinium consors ..	Rumen.
	Diplodinium costatum .	Rumen.
	Diplodinium cristagalli.	Rumen.
	Eremoplastron rostratum.	Rumen.
	Eremoplastron brevispinum.	Rumen.
	Eudiplodinium maggii.	Rumen.
	Diploplastron affine ...	Rumen.
	Metadinium medium ..	Rumen.
	Elytroplastron bubali ..	Rumen.
	Epidinium ecaudatum .	Rumen.
	Epidinium caudatum..	Rumen.
	Epidinium cattanei ...	Rumen.
	Ophryoscolex tricoronatus.	Rumen.
Elephas indicus	*Polydinium mysoreum*.	Cæcum and colon.
	Elephantophilus zeta ..	Cæcum and colon.
Tragulus meminna	*Entodinum bursa*	Stomach.
	Entodinium dubardi ..	Stomach.
	Entodinium ovalis	Stomach.
	Epidinium ecaudatum .	Stomach.
	Epidinium caudatum..	Stomach.
	Epidinium bicaudatum.	Stomach.
	Epidinium tricaudatum	Stomach.
	Epidinium quadricaudatum.	Stomach.
REPTILIA.		
Nicoria trijuga	*Balantidium testudinis.*	Large intestine.
AMPHIBIA.		
Rana cyanophlyctis	*Opalina coracoidea*....	Intestine.
	Opalina lata v. *cordata*.	Intestine.
	Opalina ranarum	Intestine and rectum.
	Nyctotherus macropharyngeus.	Cloaca.
	Balantidium gracile ..	Rectum.
	Balantidium helenæ ..	Intestine.
Rana esculenta var. *chinensis.*	*Cepedea lanceolata* ...	Rectum.
	Opalina ranarum	Rectum.
	Balantidium giganteum.	Cloaca.
	Balantidium rotundum.	Small intestine.
Rana hexadactyla	*Opalina lata*	Rectum.
	Nyctotherus macropharyngeus.	Cloaca.
	Nyctotherus magnus...	Cloaca.
	Balantidium gracile ..	Rectum.
Rana limnocharis	*Cepedea longa*	Rectum.
	Opalina lata	Intestine and rectum.
	Balantidium helenæ ..	Intestine.
	Nyctotherus cordiformis	Intestine.
	Nyctotherus macropharyngeus.	Intestine.

Host.	Parasite.	Seat.
Rana malabarica	*Opalina lata* v. *cordata*.	Intestine.
	Nyctotherus cordiformis	Intestine.
Rana tigrina	*Opalina coracoidea* ...	Rectum.
	Opalina ranarum	Intestine and rectum.
	Cepedea seychellensis v. *angusta*.	Intestine and rectum.
	Nyctotherus macropharyngeus.	Rectum.
	Nyctotherus magnus v. *malabarica*.	Intestine.
	Nyctotherus cordiformis	Intestine.
	Balantidium duodeni ..	Duodenum and small intestine.
	Balantidium elongatum.	Intestine.
	Balantidium gracile ..	Small intestine.
	Balantidium helenæ ..	Rectum and intestine.
	Balantidium ranarum .	Rectum.
	Balantidium sushilii ..	Intestine.
Rhacophorus maculatus ..	*Cepedea longa*	Intestine.
	Cepedea thiagi	Intestine.
	Opalina virgula	Rectum.
	Nyctotherus papillatus.	Intestine and cloaca.
Bufo cinereus	*Opalina ranarum*	Rectum.
Bufo macrotis	*Cepedea sialkoti*	Rectum.
	Nyctotherus reniformis.	Rectum.
	Balantidium amygdalli.	Rectum.
Bufo melanostictus	? *Zelleriella macronucleata*.	Rectum.
	Cepedea metcalfi	Rectum.
	Cepedea punjabensis ..	Rectum.
	Cepedea seychellensis v. *angusta*.	Intestine.
	Cepedea subcylindrica .	Intestine.
	Opalina coracoidea....	Rectum.
	Opalina plicata	Rectum.
	Opalina ranarum	Intestine.
	Opalina scalpriformis .	Intestine and rectum.
	Opalina triangularis ..	Intestine and rectum.
	Opalina virgula	Intestine.
	Nyctotherus cordiformis.	Intestine and cloaca.
	Nyctotherus papillatus.	Cloaca.
	Balantidium bicavata..	Rectum.
Bufo variabilis.....	*Opalina ranarum*	Rectum.
MOLLUSCA.		
Ampullaria globosa	*Nyctotherus kempi* ...	Rectum.
	Balantidium depressum	Rectum.
Lamellidens marginalis ..	*Conchopthirius curtus* .	Mantle-chamber.
	Conchopthirius lamellidens.	Mantle-chamber.
	Conchopthirius elongatus.	Mantle-chamber.

Host.	Parasite.	Seat.
Small gastropods	*Anoplophrya elongata* .	Rectum.
	Anoplophrya variabilis.	Intestine.
Vivipara bengalensis	*Anoplophrya cylindrica*	Intestinal canal.
ARTHROPODA.		
Calotermes militaris.....	*Nyctotherus termitis* ..	Intestine.
Culicoides peregrinus	*Balantidium knowlesii*.	Cœlom.
Periplaneta americana ...	*Nyctotherus ovalis*	Mid-gut and hind-gut.
	Balantidium blattarum.	Intestine.
	Balantidium ovatum ..	Intestine.
ANNELIDA.		
Ælosoma chlorostictum ..	*Anoplophrya ælosomata.*	Alimentary canal.
Pheretima hawayana	*Maupasella nova*	Alimentary canal.
Pheretima posthuma	*Anoplophrya lloydi* ...	Seminal vesicles.
	Maupasella nova	Alimentary canal.
	Parabursaria pheretima	Seminal vesicles.
PROTOZOA.		
Paramecium caudatum ..	*Sphærophrya pusilla* ..	Cytoplasm.

Technique.

Methods for the examination and study of PROTOZOA are adequately dealt with in such works as Prowazek and Jollos (1921), Wenyon (1926), Hartmann (1928), Bělař (1928), and Gatenby and Cowdry (1928). The principal methods followed in the study of the CILIOPHORA are given here for the benefit of those taking up the study of the group.

Examination in the Living Condition.—It is desirable to make observations on the living animals in the first instance. The specimens are mostly studied in a drop of the natural medium in which they are found, either under a small cover-slip or as hanging drop preparations. In such preparations the general features of the anatomy of the organism can be better interpreted than in the dead and preserved animal. It is also possible to observe the animal from different sides. For that purpose the cover-slip is carefully removed with the help of a needle, and through the addition or abstraction of water the necessary pressure on the organism is regulated. One has to be careful in these manipulations, especially if the organism is rather rare or only few specimens are available. If the water under the cover-slip begins to evaporate, even partially, the pressure of the cover-slip becomes sufficient to injure the general form or some particular part, and the animal is rendered unfit for further study. In some cases the protoplasm flows out and the organisms are quickly destroyed, in others the protoplasm does not flow out, but the animals are killed outright by the gentlest pressure applied to them.

As a rule a preliminary examination of a sample of water should be carried out with the aid of a centrifuge on the day the collection is made. With a speed of 2,000 revolutions per minute almost all the Ciliates in a sample are collected at the bottom of the tube in about thirty seconds, so that it is necessary to examine only 1 centimetre of water, which can be drawn from the bottom of the tube by means of a pipette. This is rather important if a complete census of the forms inhabiting a particular sample of water is to be made, as very often some of the less hardy organisms die off during the night, especially under the conditions of temperature and atmosphere in a laboratory.

If the observations have to be interrupted (as, for example, under the exigencies of class work) it is best to surround the cover-slip with a ring of wax or vaseline, or transfer the slide to a moist chamber. A jar with a tight-fitting stopper and with some wet blotting-paper placed inside it serves as a simple but effective moist chamber, in which the slides can be kept and observations made from day to day. The organisms will live and continue to multiply in such a chamber provided they are supplied with their proper food. In many cases the drop of water containing the organisms may also contain a certain amount of silt or earthy matter, and the animal cannot be satisfactorily studied unless this is removed. For this purpose a noose of cotton-thread or a loop of fine wire can be used. This is introduced into the drop of water on a slide, and by pulling away the noose with the earthy particles the drop very often may be rendered clear, with the organism swimming freely in it and no longer able to hide itself among the earthy particles.

Parasitic Ciliates should be examined in the fluid in which they naturally occur. The contents of the alimentary canal of an animal may usually be diluted with ordinary physiological saline solution (0·75 per cent. sodium chloride in distilled water).

Slowing the Movements.—The various methods for slowing the movements of rapidly-moving forms, and thus making possible their study in the living condition, are fully described by Statkewitsch (1905). For workers in India I (1920) suggest the use of the mucilage obtained by soaking *Ispaghul* seeds (seeds of *Plantago ovata*). This can be readily obtained in varying degrees of consistency, and has the further advantage of being perfectly transparent. It can be added directly to the drop of water containing the Ciliates on the slide, or, better still, the seeds may be spread at the bottom of a tube in a layer about 1–2 cm. thick, and the culture containing the Ciliates poured on to them to the height of 8–10 cm.,

when in a day or two, by the diffusion of the mucilage into the culture, a proper consistency is obtained. If a drop is now examined under the microscope the Ciliates will be found to be moving hardly at all, yet without showing any change in body-form or in the character of the ciliary movement of the organism. *Paramecia* and certain other Ciliates show a positive chemotactic reaction towards this mucilage, and in a culture that has been standing over the seeds for twenty-four hours they will be found in large numbers just at the junction of the culture fluid and the layer of seeds.

If the culture is allowed to stand in contact with the *Ispaghul* seeds for two days or a longer period, the colouring matter of the seeds also diffuses out into the culture, and the organisms are thereby stained *intra vitam* a beautiful brick-red colour.

The exact position and character of the cytostome and the character and arrangement of the cilia are often difficult to determine in the living organism. For the former a little Indian ink or finely powdered carmine particles is run under the cover-slip, and for the latter the preparation may be irrigated with a drop or two of a 1 per cent. solution of alum. This latter treatment renders the cilia very distinct but often kills the organism, so it should be applied only after other observations have been completed on the living creature. For studying the stalk and the axial filament of Vorticellids the addition of a drop or two of 10 per cent. alcohol gives the best results. *Stentor* is best observed in an extended condition by mounting the specimen on a slide, covering it with a cover-glass, and leaving it overnight in a moist chamber.

Intra-vitam Staining.—Examination of the living organisms is facilitated by *intra-vitam* staining: different parts of the organism or the contents of the vacuoles are thus coloured without killing the animal or affecting its movements. For this purpose "neutral red" in very dilute solution (1 in 10,000) may be employed, and it is necessary to add only a very small quantity of the stain to the fluid containing the organisms. Neutral red assumes a bright cherry-red colour in acid and a brown colour in alkaline media, and thus serves to indicate the reaction of the substances which it stains.

As mentioned above, *Ispaghul* seeds, when added to the water containing the Ciliates, will serve to slow their movements as well as to stain them.

Cultivation.—Cultures of PROTOZOA have been classified by Williams as being of three types:—

(1) *Mixed Cultures.*—Those that contain the "*omnium*

gatherum" of pond or tap water; a heterogeneous mixture of protozoan, bacterial and fungoid organisms mixed with lower metazoan forms, such as rotifers, crustaceans, and so forth.

(2) *Pure Mixed Cultures.*—These involve the cultivation of one species of PROTOZOA in association with a pure strain of one other micro-organism, such as a bacterium or some other protozoon.

(3) *Pure Cultures.*—These are cultures of PROTOZOA grown in a medium that contains no other organism.

If care is taken to keep up the proper food-supply and to make up for loss of water by evaporation by the addition of more water, it is often possible to keep cultures in good condition for several weeks. For pure mixed cultures a decoction of dry leaves is prepared and sterilized. The sterilized medium is then filtered into corked tubes, and a single individual of the species it is desired to cultivate is isolated under the microscope and transferred to the culture medium. As the tubes are not sterilized, and are only half filled with the medium, one or more strains of bacteria soon make their appearance in the culture, and the Ciliate thrives quite well in association with them.

For the cultivation of *Paramecia* and some other freshwater Ciliates the following methods are usually recommended, the object being in every case to develop a bacterial flora which will be suitable for the Ciliate it is desired to cultivate:—

(1) Fill to ¼ height a small glass tumbler with boiled water, and suspend in it by means of a thread a linen or muslin bag containing previously boiled salad-leaves, and keep the glass covered with a glass plate.

(2) A solution of 0·0125 or 0·025 per cent. of Liebig's meat extract may be employed as a culture medium. In the stronger solution bacterial growth is stronger, and the culture must be renewed after eight to ten days. In weaker solutions the culture can continue for about six weeks.

(3) Obtain a 6-inch by 8-inch battery jar and fill it with pure distilled water to a depth of 5 or 6 inches. Add 30 or 40 grains of boiled wheat. After several days a heavy bacterial scum will develop on the surface of the water. Two days after the scum appears inoculate by adding *Paramecia* from another culture. *Paramecia* will feed on the bacteria and reproduce very rapidly. They will clear up the culture in a few

days and will remain in good condition for some time. A new culture should be started about once every month.

Barret and Yarbrough (1921) reported the successful culture of *Balantidium coli* for over thirty-two days, during which time eleven subcultures were made. Schumaker (1931) has also successfully cultivated the Ciliate on a medium consisting of 1·0 c.c. of sterile horse serum and 9·0 c.c. of sterile Ringer's solution, following the technique of Rees (1927) and of Jameson (1927). Various methods for the culture of special organisms are discussed by Bělař (1928).

Fixation and Staining.—Of the reagents commonly employed the following may be used for fixing : (1) concentrated solution of corrosive sublimate, hot or cold ; (2) Schaudinn's sublimate alcohol (2 parts saturated aqueous solution of corrosive sublimate, 1 part absolute alcohol ; immediately before use, add acetic acid to the quantity to be used to the strength of 5 per cent.) ; (3) Bouin's fluid (saturated aqueous solution of picric acid 75 parts, formol 25 parts, and acetic acid 5 parts) ; (4) Zenker's fluid (mercuric chloride 5 grms., potassium bichromate 2·5 grms., sodium sulphate 1 grm. in 100 c.c. of distilled water ; with 2·5 to 5 per cent. of glacial acetic acid added just before use) ; (5) formalin ; and (6) vapour of 4 per cent. solution of osmic acid.

Mass Method.—If the Ciliates are abundantly present the mass method is used for staining them. The fluid containing the PROTOZOA is put in a centrifuge tube and fixative (twice the quantity of the fluid containing the PROTOZOA) added, and the two well shaken together. The fixative is allowed to act, and, after centrifuging, the bulk of the fluid is poured off and the washing fluid (alcohol or water as the case may be) poured on. After again centrifuging this is poured off, and the process repeated until the fixative is completely removed. Then the organisms are stained and dehydrated according to any of the usual methods (such as the borax-carmine method or Delafield's hæmatoxylin method), centrifuging after each stage. Then clear in clove-oil and mount in Canada balsam ; for this purpose pure clove-oil is put in the bottom of the tube and absolute alcohol gently poured over it, so that the two fluids may not mix. With a pipette the material to be cleared is added and allowed to sink down through the media. When it has passed through the pure clove-oil and reached the bottom of the tube it will be cleared and ready for mounting.

Centrifuged PROTOZOA, especially the parasitic forms, tend to stick together in masses after fixation. These can be treated like bits of tissue, embedded in paraffin and cut into sections.

Staining under the Cover-slip.—For staining large organisms, when not abundantly present, the following method is used :—

Wax feet are put at the corners of a square cover-slip, which is inverted over a drop of water containing the organisms. The wax feet should hold the cover-slip firmly to the slide. With a pipette a little fixative is run under one side of the cover-slip, and drawn through by holding a piece of filter-paper at the opposite side. When the fixative has had time to act it is washed out by substituting another fluid (alcohol or water as the case may be) and drawing this through with filter-paper in the same manner. The stream should not be so violent as to wash away the organisms, but the substitution should be complete. The stain is then run under, allowed to act, and washed out and differentiated if necessary, the process being controlled under the microscope. The specimen is dehydrated and then cleared in clove-oil or xylol, and a very fluid Canada balsam is run under. It is very important to see that the transfer from one fluid to another is not too rapid, as otherwise there is great risk of shrinkage, and also that the dehydration is complete.

The following is an indication of the length of time generally required, but should be regarded as no more than an indication. Fix in Bouin's fluid, 5 mins. ; wash in 70 per cent. alcohol, 5 mins. (several changes) ; stain in borax-carmine, 5 mins. or more ; differentiate in acid-alcohol, 5 mins. or more ; dehydrate with 70 per cent., 90 per cent. and absolute alcohol, 5 mins. each, changing the absolute alcohol once or twice ; clear by running in a mixture of clove-oil and absolute alcohol, and then pure clove-oil ; mount in Canada balsam by running the same under the cover-slip.

Staining the Organisms fixed on a Cover-slip.—Another method, specially serviceable in the staining of parasitic organisms, is either to make a number of smears of the fluid containing the organism on cover-slips, and when the fluid has partially dried to invert the cover-slips and let them float on the surface of the fixative contained in a dish, or to put a small drop of water containing the organism on a cover-slip and add with a pipette twice the quantity of hot fixative. When the organisms are fixed on the cover-slips these are passed successively through the washing fluid, alcohols, stain, clearing fluid, etc., all these reagents being contained in shallow dishes. In all these subsequent stages the cover-slip is put at the bottom of the fluid in the dish, with the face bearing the organisms upward. Finally, the cover-slips are removed and put, face downward, on slides on each of which a drop of Canada balsam has been put. In this way quite a large number

of smears or preparations can be fixed and stained in practically the same time as would be taken to make one preparation.

Staining Methods.—The following stains are usually employed for staining the PROTOZOA :—

Borax-carmine.—Fix in Bouin's fluid for 10 to 20 minutes according to bulk and permeability. Wash out in 70 per cent. alcohol (several changes). Stain in borax-carmine till thoroughly penetrated ; 15 minutes are usually enough for small objects. Differentiate in acid alcohol, controlling under the microscope. Dehydrate, 90 per cent. to absolute alcohol. Put in clove-oil and absolute alcohol, equal parts. After a few minutes transfer to pure clove-oil, and leave there till cleared. Mount in Canada balsam.

Delafield's Hæmatoxylin.—This is suitable for staining PROTOZOA in smears or for staining in mass. Fix in Schaudinn's fluid. Wash in 30 per cent. alcohol, and bring down through 10 per cent. alcohol to distilled water. Add a few drops of Delafield's hæmatoxylin solution to a watch-glass full of distilled water. Leave in stain for a few minutes to an hour or more, according to bulk. If overstained, wash out excess of colour with alcohol containing 1 per cent. nitric or hydrochloric acid. The material should be brought up from distilled water gradually to 70 per cent. alcohol in which there is a trace of acid. Dehydrate ; clear ; mount.

Heidenhain's Iron Hæmatoxylin.—Fix in Schaudinn's fluid for 10 to 30 minutes, according to size and permeability of the object. Bring down through 30 per cent. and 10 per cent. alcohol to distilled water. The fixative must be thoroughly washed out. Mordant in 4 per cent. aqueous solution of iron alum for ½ hour to 12 hours according to size of organism. Wash for a second or two in water. Stain in Heidenhain's aqueous hæmatoxylin solution (about 0·5 per cent.) for 30 minutes to several hours. Wash in water. Differentiate in 1 per cent. iron alum solution. Control under microscope. Wash in running water for at least half an hour. Bring through alcohols to absolute alcohol. Clear in xylol. Mount in Canada balsam.

Dobell's Iron Hæmatein.—Fix in Schaudinn's fluid. Bring down through 30 per cent. and 10 per cent. alcohol to distilled water. After washing bring up through various grades of alcohol to 70 per cent., and from that transfer to 1 per cent. solution of iron alum in 70 per cent. alcohol for 10 minutes, (The solution is made by dissolving 1 grm. iron alum in 23 c.c. warm distilled water and adding 77 c.c. of 90 per cent. alcohol). Rinse in 70 per cent. alcohol. Stain in 1 per cent. solution of hæmatein in 70 per cent. alcohol for 10 minutes. Rinse

in 70 per cent. alcohol. Differentiate films in original iron alum solution, and sections in 70 per cent. acid alcohol. Wash in several changes of 70 per cent. alcohol. Dehydrate; clear; mount. The whole process may be carried out in 30 minutes. Light green in 90 per cent. alcohol may be used as a counter-stain.

Hæmalum and Picro-carmine.—A drop containing the organisms is spread on a cover-slip, and before the preparation is dried the cover-slip is inverted over hot corrosive sublimate solution contained in a watch-glass. The animals will thus be fixed and will stick to the cover-slip. Then transfer the cover-slip for 2 minutes to iodine alcohol, 15 to 30 minutes in 70 per cent. alcohol, 15 minutes in weaker alcohols, to water. Stain for 5 minutes in dilute hæmalum solution (equal parts of stain and water), keep for 3 minutes in water (till no more colour comes off), and pass the preparation through ascending grades of alcohol (5 to 10 minutes in each); or, after staining and washing off excess of hæmalum, stain in picro-carmine (2 to 3 minutes), wash in water (till no more colour comes off), and then pass through ascending grades of alcohol to absolute alcohol. Clear in xylol (5 minutes), and invert the cover-slip over a slide on which a drop of Canada balsam has been put.

In simple staining the nuclei are seen with dark-blue stained chromatin on a clear blue ground, in double staining on red ground.

Instead of hæmalum alum-carmine can be used, but not in conjunction with picro-carmine.

Mallory's Eosin and Methylene Blue.—This is recommended for sections fixed in Zenker's fluid. Wash out the fixative in running water for several hours. Stain in warm 5 per cent. aqueous solution of eosin for 20 minutes or longer, wash in water, and stain in Unna's alkaline methylene-blue solution, diluted with 4 to 5 parts of water, for 10 to 15 minutes. Wash in water, differentiate in 95 per cent. alcohol, controlling under a microscope, until sections are pinkish, but nuclei deep blue. Dehydrate quickly and mount.

Mallory's Triple Stain.—This is recommended for sections of tissues containing parasites. Fix in Zenker's fluid. Thoroughly wash out the fixative for several hours in gently running water. Stain sections in 0·5 per cent. aqueous solution of acid fuchsin for 2 to 4 minutes, and transfer to the second solution (consisting of aniline blue soluble in water (Grübler) 0·5 grm., Orange G (Grübler) 2·0 grm., 1 per cent. aqueous solution of phosphomolybdic acid 100 c.c.) for 10 to 20 minutes or longer. Wash and differentiate the sections in tap-water, dehydrate rapidly, clear, and mount.

Sharp (1914) employed a slightly modified method for demonstrating the neuromotor system in Ciliates. Lund (1933) recommends Zenker's fluid with 2·5 per cent. acetic acid, staining the sections for 2 minutes in Mallory No. I, and 1 minute in No. II, then dipping rapidly into 95 per cent. and absolute alcohol, blotting quickly between each change, and then clearing in xylol for about 3 minutes.

Silver Impregnation Methods.—Both the dry silver method of Klein (1926) and the wet silver method of Gelei and Horváth (1931) depend on the reduction of silver nitrate by sunlight depositing colloidal silver on certain structures, which are thus rendered visible.

(a) *Klein's Dry Silver Method.*—Air-dry the smear. Put the slide in 2 per cent. silver nitrate solution in the dark for 15 to 20 minutes. Rinse in distilled water and expose the slide to diffuse sunlight, from time to time watching under the microscope till the ciliary lines are well shown. Finally, dip the slide in a very weak solution of hyposulphite of soda (one or two crystals in 100 c.c. of distilled water) for a very short period (one or two dips will do). Dry the smear again and mount in Canada balsam.

(b) *Gelei and Horváth's Wet Silver Method.*—The following procedure is suggested by Lund (1933) :—Concentrate the Ciliates by centrifuging. Fix for 3 minutes in a mixture of 95 c.c. concentrated aqueous solution of mercuric chloride and 5 c.c. formalin. Wash twice in filtered river-water. Impregnate for 3 minutes in 2 per cent. solution of silver nitrate. Without washing, reduce in distilled water by direct sunlight for 8 minutes. Wash five times in distilled water. Dehydrate slowly. Pass through absolute alcohol, clear in xylol, and mount in Canada balsam.

Bresslau's Method of Staining with Opal Blue.—This gives very pretty preparations showing the arrangement of the cilia and other superficial structures. Centrifuge the Ciliates, and put a drop of water or culture fluid containing a large number of organisms on a perfectly clean slide. Place close to it a similar-sized drop of a colloidal anilin blue stain known as opal blue. Mix the two drops and spread out into a film either by a needle or a second clean slide, rapidly dry the films by swinging in the air, and mount in Canada balsam.

Grübler's ready-made solution of cyanochin (3 parts of China blue and 1 part of cyanosin in concentrated watery solution) can be employed in the same way as opal blue.

Gelei's Osmium-Toluidin blue Method.—Very instructive preparations of pellicular structure and ciliary arrangement are obtained by this method. Fix for 1 to 12 hours in a

mixture of 10 parts of 2 per cent. osmium-tetraoxide solution and 1 part of formol (as the mixture rapidly deteriorates, it should be prepared immediately before use, and fixation carried on inside an iron cupboard) or in osmic and acetic acid mixture. After fixing in formol-osmium do not wash, but put immediately for 1 to 12 hours in potassium-bichromate-alum solution (potassium bichromate 2 grms., potash alum 1 grm., distilled water 100 c.c.), then wash for a short time in distilled water and keep for 1 to 12 hours in ammonium molybdate solution. After washing again in distilled water, stain for 2 to 4 minutes in a 0·3 to 0·1 per cent. watery solution of toluidin blue. Then quickly dehydrate and mount in Canada balsam. Cilia, basal granules and many other pellicular structures are stained deep blue, while cytoplasm and nucleus are left uncoloured.

ZOOLOGICAL GARDEN CALCUTTA.

Phylum PROTOZOA.

Subphylum CILIOPHORA.

The subphylum CILIOPHORA is divided into two classes, as follows :—

1. Provided with cilia throughout life ; ingestion through a cytostome or by osmosis ..... **Ciliata** Bütsch., [p. 49.
2. Cilia present only in the young free-swimming embryos budded off from the adult. Adult provided with sucking-tubes or tentacles which serve for ingestion ..... **Suctoria** Bütsch., [p. 423.

Class I. CILIATA Bütschli.

The main features of the organisms belonging to this class have been outlined in the chapter dealing with the general organization and structure. The class CILIATA is distinguished from the class SUCTORIA by the cilia, covering the body, being present throughout life, and by ingestion taking place through a definite cytostome or through osmosis over the general surface of the body.

The class is divided into two subclasses, PROTOCILIATA and EUCILIATA, as follows :—

1. Parasitic forms ; without a cytostome, uniformly ciliated, and possessing either two or many nuclei, the nuclei not being differentiated into two kinds ..... **Protociliata** Metcalf., [p. 50.
2. Freshwater or parasitic forms ; the majority possessing a cytostome, some without a cytostome, ciliation entire or confined to various parts of the body ; nuclear apparatus showing a differentiation into a macronucleus and a micronucleus ..... **Euciliata** Metcalf. [p. 72.

I. Subclass *PROTOCILIATA* Metcalf.

Parasitic forms, generally found in the alimentary canal of Amphibia. Body oval or elongated, cylindrical or flattened, and covered with a uniform covering of cilia, arranged in longitudinal rows. Cytostome absent, liquid food being absorbed over the whole surface. Contractile vacuole absent; a non-contractile excretory canal present in a few species. Two or many nuclei present, not showing any differentiation. The nuclei are vesicular. Each nucleus contains, besides a nucleolus, a number of large massive chromosomes or macrochromosomes and small granular chromosomes or microchromosomes. In the ectoplasm there are numerous spherules known as cytomicrosomes, and somewhat similar but smaller granules in the endoplasm are known as endoplasm spherules. Multiplication takes place by binary fission, mitotic division of the nuclei being followed by an oblique longitudinal splitting of the organism. Repeated divisions in multinucleate forms give rise to small individuals with a small number of nuclei. These become encysted and are passed out into the water by their hosts. Tadpoles ingest these cysts and the Ciliates are set free in the rectum. In the spring, by repeated divisions, minute uninucleate individuals are formed, which are differentiated as microgametes and macrogametes. These conjugate in pairs, and the resulting zygotes by continued multiplication of the nucleus become the adult multinucleate organisms.

Metcalf (1918, 1923) has separated the Opalinids from the other Ciliates in a separate subclass PROTOCILIATA. "The Opalinidæ are an offshoot from the primitive Ciliata before the latter had acquired true binuclearity and the subsequent dimorphism of nuclei." Hartog (1906) and Neresheimer (1907*b*) placed the Opalinids among the Flagellates, but Minchin (1912), Doflein (1916), and other writers have included them with the astomatous Ciliates. Cépède (1910) clearly showed that the Opalinids are not closely related to other astomatous Ciliates, and Metcalf, as the result of his extensive studies on this group, separated them from the other astomatous Ciliates and placed them in a separate subclass, in order to give expression to their primitive character. Gatenby and King (1925) have, however, again revived the claim that *Opalina* should be classified among the Flagellates, since its motile organs are flagellar in nature. Their claim rests

on their observation that, as in Flagellates, "the 'cilia' enter right into the substance of the organism, and take their origin from the peculiar granules which exist in very large numbers in the protoplasm of *Opalina*" (as shown in their figure). As against this observation we have the statement of Metcalf that the kinetoplasm is in the form of basal granules of the cilia, and that a network of neural fibrillæ connects these. In *Protoopalina intestinalis* the axial fibre of each cilium arises from a spherical basal granule which lies just beneath the pellicle. Bezzenberger (1904) described basal granules elongated perpendicularly to the pellicle in *Cepedea longa*. Metcalf found spherical basal granules in *C. longa*. Bhatia and Gulati (1927) found that in *Cepedea metcalfi* the basal granules of the cilia, which are extremely fine, and situated just beneath the pellicle, are not connected with the endospherules that are situated deeper in the protoplasm; and the same was also the case in *Opalina coracoidea* and *Opalina ranarum*.

The subclass includes a single family.

Family OPALINIDÆ Claus.

Metcalf has divided the family into two subfamilies, as follows :—

[Metc., p. 51.

1. Cylindrical or flattened binucleate forms .. PROTOOPALININÆ
2. Cylindrical or flattened multinucleate forms. OPALININÆ Metc., [p. 53.

Subfamily PROTOOPALININÆ Metcalf, 1923.

Opalinids with cylindrical or flattened body and possessing only two nuclei.

No members of this subfamily, which includes the genera *Protoopalina* and *Zelleriella*, have been found in India. This is in accord with the previous findings of Metcalf. *Z. macronucleata* has been reported by Bezzenberger in *Bufo melanostictus* from "Asia." The presence of a *Zelleriella* in a south-eastern Asian toad is so strange that Metcalf questions the Asiatic origin of the host. He considers the possibility of confusion of labels or of the host in question having become infected from some South American Anuran. Metcalf opened thirty-nine specimens of this toad without finding *Zelleriella*, and Bhatia and Gulati (1927) have also examined a number of specimens of *Bufo melanostictus*, but did not find any *Zelleriella* in them.

Genus **ZELLERIELLA** Metcalf, 1923.

Zelleriella, Metcalf, 1923, p. 85.

Much flattened binucleate Opalinids. Nuclei large, about 10 μ in greatest diameter, with few macrochromosomes, 4 to 10 so far observed. Microchromosomes equal or about equal in number to the macrochromosomes.

1. **Zelleriella macronucleata** (Bezzenberger). (Fig. 1.)

Opalina macronucleata, Bezzenberger, 1904, pp. 163–5, figs. 14, 15.
Zelleriella macronucleata, Metcalf, 1923, pp. 117–9, figs. 82, 83.

Form ovoidal. Nucleus spherical, diameter of resting nucleus 12 μ. Cilia uniform, close, length of cilia 4 μ.

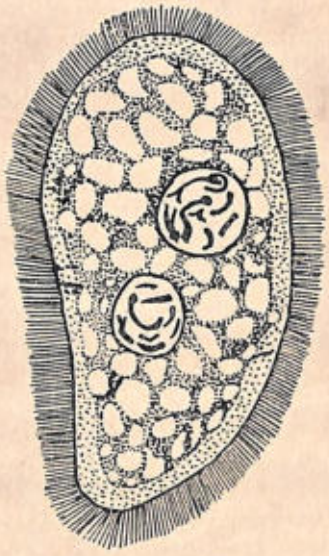


Fig. 1.—*Zelleriella macronucleata* (Bezz.).
(After Bezzenberger.)

Dimensions.—Length 63 μ, width 40 μ; thickness of body 30 μ.

Remarks.—The chromatin in the spherical, resting nucleus is in the form of two or three large plaques at the surface of the nucleus, while the rest of the nuclear contents show a finely reticulate structure. Bezzenberger has figured stages of mitosis in daughter organisms.

Habitat.—Rectum of *Bufo melanostictus* Schneider: Asia (exact locality not cited by Bezzenberger). Metcalf has expressed doubt as regards the assigning of this *Zelleriella* to *Bufo melanostictus* from "Asia."

Subfamily OPALININÆ Metcalf, 1923.

Opalinids with cylindrical or flattened body and possessing many nuclei.

This subfamily is well represented in Indian frogs and toads.

Key to Indian Genera.

1. Form cylindrical, circular in cross-section.. CEPEDEA Metc., p. 53.
2. Form flattened, ellipsoidal in cross-section.. OPALINA Purk. & Val., [p. 60.

Genus **CEPEDEA** Metcalf, 1923.

Cepedea, Metcalf, 1920, p. 136; 1923, p. 137; Wenyon, 1926, p. 1153; Calkins, 1926, p. 401; Bhatia & Gulati, 1927, p. 89; Reichenow, 1929, p. 1164.

Multinucleate Opalinids that are circular or nearly so in cross-section, or at least not uniformly flattened throughout the body.

The genus *Cepedea* is cosmopolitan, except that it is at present not known from Australasia or north-eastern North America. Discussing the geographical distribution of the species of this genus Metcalf comes to the conclusion that its place of origin was probably India or some portion of the India–Ceylon–Madagascar–Africa bridge. "Two-thirds of the known species of *Cepedea* are from the Eastern Hemisphere, a fact which is some indication that the genus arose in the east. This seems the more true, since we have so scant data from Southern Asia. Probably the list of eastern species would be considerably increased if we knew the southern Asian forms" (Metcalf, 1923, p. 336). Again, on p. 345 of his work Metcalf observes, "It is unfortunate that Indian Anura have been so little explored for Opalinids, for thorough knowledge of southern Asian Opalinids might give light upon the presence of a member of this group of Cepedeas in the Seychelles."

Bhatia and Gulati (1927) examined only *Bufo melanostictus* from Lahore and *Bufo macrotis* from Sialkot in the Punjab, and found three new species of *Cepedea*, two in the first and one in the second host. No species of this genus were found to occur in the three species of *Rana*, viz., *R. tigrina*, *R. cyanophlyctis* and *R. hexadactyla*.

Key to Indian Species.

1 (3).	With a pointed spine-like projection at the anterior end	2.
2.	Body triangular in cross section. Posterior end bluntly rounded. Length 82 μ	[p. 57. *C. punjabensis* Bh. & G..
3 (1).	Anterior end without a spine-like projection	4.
4 (5).	Body greatly elongated, anterior end rounded, posterior tapering to a point. Length 200–1000 μ	*C. longa* Bezz., p. 55.
5 (4).	Body not greatly elongated	6.
6 (9).	Body cylindrical	7.
7 (8).	Sides of the body curved. Anterior end rounded, posterior pointed. Length 71–108 μ	[p. 56. *C. metcalfi* Bh. & G.,
8 (7).	Sides of the body straight. Anterior end presenting a vacuolated appearance, posterior end rounded or sometimes pointed. Length 125–440 μ .	[p. 60. *C. thiagi* de Mello.
9 (6).	Body ovoid or fusiform	10.
10 (11).	Body ovoid, anterior end broad and rounded, posterior end slender and tapering. Nuclei only four or five. Length 82 μ	[p. 54. *C. lanceolata* Bezz.,
11 (10).	Body fusiform	12.
12 (13).	Body subcylindrical, both ends rounded or anterior end less pointed than the posterior. Length 35–250 μ.	[de Mello, p. 60. *C. subcylindrica*
13 (12).	Both ends pointed	14.
14 (15).	Posterior end drawn out into a sharp point. Length 64–89 μ	[p. 58. *C. sialkoti* Bh. & G..
15 (14).	Posterior end not drawn out into a sharp point. Length 51–218 μ	[de Mello, p. 58. *C. seychellensis angusta*

2. **Cepedea lanceolata** (Bezzenberger). (Fig. 2.)

Opalina lanceolata, Bezzenberger, 1904, pp. 165–6, pl. xi, fig. 7.
Cepedea lanceolata, Metcalf, 1923, pp. 137–8, figs. 102, 103.

Body ovoid, with anterior end rounded and posterior end elongated into a slender tapering point. Nuclei large, irregularly spherical; generally four, rarely five in number, lying one behind the other in an axial row; diameter of nucleus 7 μ. Cilia fine and close; length of cilia 2 μ.

Dimensions.—Length 82 μ, width of body 22 μ.

Remarks.—The nuclei are quite large and the number of macrochromosomes quite small for a *Cepedea*. Metcalf thinks that in the size of its nuclei and the number of its macrochromosomes *C. lanceolata* is more like the Protopalinas than are other Cepedeas, and may well be a transitional species between the two genera.

Habitat.—Rectum of *Rana esculenta* Linn. var. *chinensis* Osborn: Asia (exact locality not cited by Bezzenberger).

3. **Cepedea longa** (Bezzenberger). (Fig. 3.)

Opalina longa, Bezzenberger, 1904, pp. 167–8, pl. xi, fig. 11, text-figs. 18–20.
Cepedea longa, Metcalf, 1923, pp. 168–70, fig. 137.
†*Cepedea longa*, de Mello, 1930, p. 955, figs. 14–24; 1931 *a*, p. 1184; 1931 *b*, pp. 1443–5, pl. xxxviii, figs. 14–24.

Body greatly elongated, rounded in front and tapering posteriorly to a rounded point, anterior end flattened; body

Fig. 3.

Fig. 2.

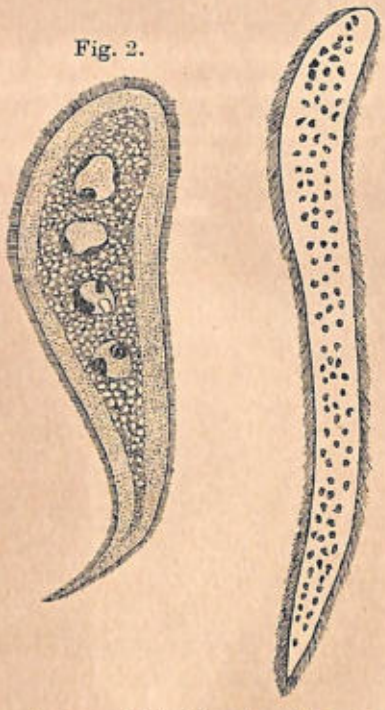


Fig. 2.—*Cepedea lanceolata* (Bezz.). (After Bezzenberger.)
Fig. 3.—*Cepedea longa* (Bezz.). (After de Mello.)

broadly elliptical in cross-section. Endoplasm with a thick central zone of closely compact alveoli, contrasting strongly with a thin and loose peripheral zone. Nuclei spherical or ellipsoidal, with a diameter of 4·5–7 μ. Cilia of moderate length.

† prefixed to a reference indicates that the record of the species from India, Burma or Ceylon is based on this reference.

Dimensions.—Length 200–1000 μ, usually 450–575 μ; width 52–75 μ.

Remarks.—Bezzenberger describes the basal granules of cilia as very slender elongated rods, which is exceptional for Opalinids. Metcalf finds that his specimens are larger, have more elongated and smaller nuclei, and the basal granules of cilia are spherical or nearly so.

Habitat.—Rectum of *Rana limnocharis* Wiegmann: Asia (exact locality not cited by Bezzenberger). Intestine of *Rhacophorus maculatus*: Nova Goa.

4. **Cepedea metcalfi** Bhatia & Gulati. (Fig. 4.)

†*Cepedea metcalfi*, Bhatia & Gulati, 1927, pp. 89–91, fig. 1.

Body form varies much in smaller and bigger forms, but intergrades are present. Contour of the body not a straight

Fig. 4.

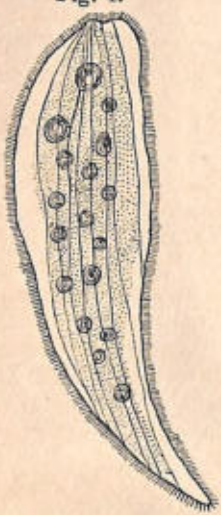


Fig. 5.

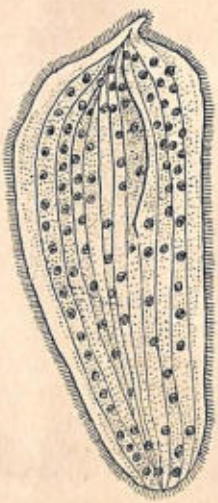


Fig. 6.

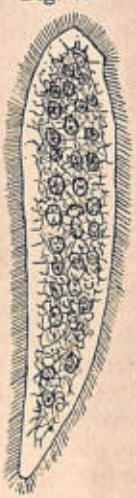


Fig. 4.—*Cepedea metcalfi* Bh. & G. (After Bhatia and Gulati.)
Fig. 5.—*Cepedea punjabensis* Bh. & G. (After Bhatia and Gulati.)
Fig. 6.—*Cepedea seychellensis* var. *angusta* de Mello. (After de Mello.)

cylinder, but the sides are curving in and out slightly. Anterior end rounded, posterior drawn to a point. In smaller individuals body pointed at both ends, but posterior end much

narrower and tapering. Ciliation fine and close. Nuclei many and rounded in form.

Dimensions.—Length from 71–108μ.

Remarks.—The pellicle is a fairly thick membrane and exhibits longitudinal grooves running somewhat spirally. These grooves are demonstrable with difficulty, and the ciliary rows are set in them. The outer layer of ectoplasm is homogeneous and does not show any alveoli, reticulations or granules. The basal granules of the cilia are extremely fine, lie in this outer layer just beneath the pellicle, and are so close set as to make the pellicle appear a thick membrane under the lower powers of the microscope. The basal granules are united by extremely fine threads both longitudinally and transversely. The internal layer of the ectoplasm has an alveolar structure, the alveoli being bigger than those of the endoplasm. There are no ectoplasm spherules in this layer. The endop asm is alveolar and the alveoli are smaller than those of the inner layer of the ectoplasm. Besides the numerous large, rounded nuclei in this region, there are other spherules of a smaller size which are more deeply staining. Each of these latter has an outer thick wall bounding a clear area. The endoplasm is also dotted over with innumerable darkly-staining granules, which may be described as "cytomicrosomes." The cilia are small, fine and close set, and are arranged in longitudinal rows running parallel to the margin of the body.

Even the biggest examples of this species are smaller than the small specimens of *Cepedea pulchra javensis*. There are many rounded nuclei. In the resting nucleus the nuclear membrane is of appreciable thickness. Chromatin may be in the form of a single big mass or several smaller masses connected by threads, and a number of rod-like masses lying just within the nuclear membrane. When dividing, the nucleus elongates, a constriction appears in the middle and deepens till the two halves are practically separated. The nuclear membrane does not disappear in the process, and for a time the two daughter nuclei remain connected by a thread-like portion derived from the nuclear membrane.

Habitat.—Rectum of *Bufo melanostictus* Schneider : PUNJAB, Lahore.

5. **Cepedea punjabensis** Bhatia & Gulati. (Fig. 5.)

†*Cepedea punjabensis*, Bhatia & Gulati, 1927, pp. 91–2, fig. 2.

Form oval, with a sharply pointed spine-like projection at the anterior end. Body pulled out along three planes so as

to appear triangular in cross-section. Greatest width in front of the middle of the body, narrower posteriorly. Posterior end bluntly rounded. Ciliation fine and close. Nuclei many and rounded.

Dimensions.—Length about 82 μ.

Remarks.—The layer of ectoplasm is thinner than in *C. metcalfi*, but is well marked off from the endoplasm, which has an alveolar appearance. There are a large number of rounded nuclei. Also contained in the endoplasm in great abundance are darkly-staining spherules and minute granules. The cilia are fine and close-set. The basal granules are hardly visible. Over the general surface of the body the cilia are arranged in longitudinal rows.

This species has some resemblance to *C. pulchra javensis* in its general form, but the specimens are smaller than those of *C. pulchra* or its subspecies, and the form is not considerably flattened as in that species.

Habitat.—Rectum of *Bufo melanostictus* Schneider : PUNJAB, Lahore.

6. **Cepedea seychellensis** var. **angusta** de Mello. (Fig. 6.)

†*Cepedea seychellensis* var. *angusta*, de Mello, 1932, pp. 96–7, pl. xii, fig. 15 ; pp. 105, 124, pl. xiii, fig. 5.

Form regularly fusiform, with the posterior pole drawn out. Body consisting of a peripheral zone of loose alveoli and a central zone of small and closely crowded meshes, with numerous rounded nuclei irregularly dispersed in it. Diameter of nuclei 3–3·5 μ.

Dimensions.—Mininum 50 μ by 21 μ, maximum 218 μ by 39 μ, usually between 86–175 μ in length.

Remarks.—The dimensions of the form encountered in *Rana tigrina* are smaller than those found in *Bufo melanostictus* and quoted above. The eighty-two individuals measured by de Mello were mostly between 75–110 μ in length.

Habitat.—Intestine of *Bufo melanostictus* Schneider and *Rana tigrina* Daud. : NOVA GOA.

7. **Cepedea sialkoti** Bhatia & Gulati. (Fig. 7.)

†*Cepedea sialkoti*, Bhatia & Gulati, 1927, pp. 92–3, fig. 3.

Body has an oval, cylindrical form, pointed at both ends, posterior end tapering to a point. Greatest width of the body in front of the middle. Ciliation fine and close. Nuclei numerous, rounded or oval.

Dimensions.—Length 64–89 μ.

Remarks.—The structureless region below the pellicle is hardly defined. The inner layer of the ectoplasm also is not well differentiated. The endoplasm has a granular appearance. The bigger specimens contain fewer nuclei than the smaller

Fig. 7.



Fig. 9.



Fig. 8.

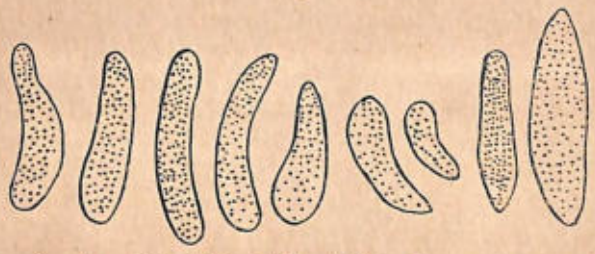


Fig. 7.—*Cepedea sialkoti* Bh. & G. (After Bhatia and Gulati.)
Fig. 8.—*Cepedea subcylindrica* de Mello. Cilia not shown in the figure. (After de Mello.)
Fig. 9.—*Cepedea thiagi* de Mello. (After de Mello.)

ones. The nuclei vary in size. The nuclei showing division seem to be drawn out into two points, with the chromatin gathered at the poles. The cilia are fine and close-set and

are arranged in longitudinal rows on the surface of the body. Basal granules are not distinguishable.

Habitat.—Rectum of *Bufo macrotis* Boulenger: PUNJAB, Sialkot.

8. **Cepedea subcylindrica** de Mello. (Fig. 8.)

†*Cepedea subcylindrica*, de Mello, 1932, pp. 93–5, 120, 124, pl. xii, fig. 13.

†*Opalina subcylindrica*, de Mello, 1932, pl. xii, fig. 13.

Form elongated, fusiform, the anterior pole in general less pointed than the posterior pole. Many variations from this form have been seen, the anterior pole in some examples being blunt and rounded and the posterior pole having sometimes the same disposition, so that the organism looks like a regular cylinder. Diameter of the nucleus 2·5–3·5 μ.

Dimensions.—Minimum 35 μ by 15 μ, maximum 250 μ by 80 μ, usually between 80–185 μ in length.

Habitat.—Intestine of *Bufo melanostictus* Schneid.: NOVA GOA.

9. **Cepedea thiagi** de Mello. (Fig. 9.)

†*Cepedea thiagi*, de Mello, 1930, pp. 955–6, figs. 25–31; 1931 *a*, p. 1184; 1931 *b*, p. 1445, pl. xxxviii, figs. 25–31.

Form cylindrical, with the posterior pole rounded or sometimes pointed, anterior pole with alveoli loosely arranged in such a manner as to present a single vacuole surrounded by a compact zone. Numerous nuclei, 4–5 μ in diameter.

Dimensions.—Length, minimum 125 μ, maximum 440 μ.

Habitat.—Intestine of *Rhacophorus maculatus* Gray: NOVA GOA.

Genus **OPALINA** Purkinje & Valentin, 1835, emend. Metcalf, 1923.

Opalina, Purkinje & Valentin, 1835, p. 43; Englemann, 1876, p. 574; Zeller, 1877, p. 352; Hickson, 1901, p. 404; Metcalf, 1909, pp. 195–375, pls. xiv–xxviii; Minchin, 1912, pp. 439, 452–4; Metcalf, 1920, p. 136; 1923, p. 175; Hegner & Taliaferro, 1924, pp. 383, 410; Wenyon, 1926, p. 1153; Calkins, 1926, pp. 374–5, 401; Reichenow, 1929, pp. 1164–5; Thomson & Robertson, 1929, p. 276.

Multinucleate Opalinids with uniformly and much flattened body.

According to Metcalf two subgeneric groups, not sharply marked off from each other, can be recognized, namely, the *obtrigona*-like species, *Opalinæ angustæ*, which are in general oblanceolate in form, and *ranarum*-like species, *Opalinæ latæ*, which are more rounded.

Key to Indian Species.

1 (12).	More or less rounded in form	2.
2 (5).	Posterior end of the body with a pointed spur	3.
3 (4).	Form ovoid, asymmetrical	*O. coracoidea* Bezz., [p. 61.
4 (3).	Form oval, broader, and with a proportionately longer and more curved posterior beak	*O. coracoidea lahoriensis* Bh. & G., p. 62.
5 (2).	Posterior end of the body broadly rounded	6.
6 (11).	Anterior end of the body distinctly narrower than the posterior end. Width always greater than half the length	7.
7 (10).	Form oval	8.
8 (9).	Central medullary zone does not show the alveoli crowded together in longitudinal columns	*O. lata* Bezz., p. 64.
9 (8).	Central medullary zone shows the alveoli crowded together in longitudinal columns	*O. lata cordata* de Mello, [p. 65.
10 (7).	Form ovate. Dorsal surface with two or four ridges	*O. plicata* Ghosh, p. 65.
11 (6).	Anterior end only slightly narrower than the posterior end. Width less than half the length up to two-thirds the length	*O. ranarum* (Ehrbg.), [p. 66.
12 (1).	Body oblanceolate in form	13.
13 (14).	Form strongly curved, with long, slender, rod-like endospherules	*O. virgula* Dobell, [p. 70.
14 (13).	Form not strongly curved, without rod-like endospherules. Anterior portion of the body thrown into a number of folds or ridges	15.
15 (16).	Body about 4 to 5 times as long as broad	*O. scalpriformis* Ghosh, [p. 68.
16 (15).	Body about twice as long as broad	*O. triangularis* Ghosh, [p. 68.

10. **Opalina coracoidea** Bezzenberger. (Fig. 10.)

Opalina coracoidea, Bezzenberger, 1904, p. 166, pl. xi, figs. 8, 9; Metcalf, 1923, pp. 234–5, fig. 209.
†*Opalina coracoidea*, de Mello, 1932, pp. 118–9, pl. xiv, fig. 4.

Form very flattened, ovoid, asymetrical. Posterior pole in the form of a pointed spur. Numerous nuclei about 3·5μ in diameter.

Dimensions.—204μ by 120μ (Bezz.); 82–136μ by 45–81μ (de Mello).

Remarks.—De Mello in his examples found the nuclei to be elliptical and measuring 4–5μ by 3·88–4·5μ.

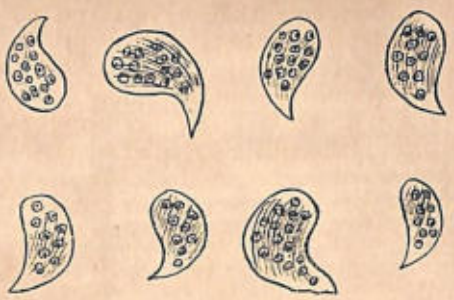


Fig. 10.—*Opalina coracoidea* Bezz. Cilia not shown in the figures. (After de Mello.)

Habitat.—Intestine of *Rana cyanophlyctis* Schneid. : Nova Goa.

11. **Opalina coracoidea** subsp. **lahoriensis** Bhatia & Gulati. (Fig. 11.)

Opalina coracoidea, Bezzenberger, 1904, p. 166, pl. xi, figs. 8, 9.
Opalina coracoidea, Metcalf, 1923, pp. 234–5, fig. 209.
†*Opalina coracoidea lahoriensis*, Bhatia & Gulati, 1927, pp. 93–6, fig. 4.

Form oval, about $1\frac{1}{2}$ to $2\frac{1}{2}$ times as long as broad, with sharply pointed posterior end bent to one side. Broader and with a proportionately longer and more curved posterior beak than in the typical species. The greatest width is usually near the posterior end, but some individuals are broadest in the anterior half of the body.

Dimensions.—Length 117–231 μ, width 48–148 μ.

Remarks.—Bezzenberger (1904) described *Opalina coracoidea* from *Rana cyanophlyctis* from "Asia." Metcalf was not able to get any material of this species. Bhatia and Gulati (1927) recorded the species from two new hosts, viz., *Rana tigrina* and *Bufo melanostictus*. *Opalina coracoidea* is abundantly found in *Rana tigrina*, and may be regarded as the commonest Opalinid in this host.

The characteristic feature of *O. coracoidea* is that the posterior end of the body is sharply pointed and beaked, the beak being bent to one side. *O. japonica* also shows a beaked end, but the beak is much less developed. The specimens found by Bhatia and Gulati were broad, with a proportionately longer and curved beak. In the outline of the body, measurements of length and breadth, and dimensions of the beak their specimens differed markedly from the typical form of *O. coracoidea* Bezz., and on account of these differences they described

it as a new subspecies ; they have given a full description of its structure and life-history.

The usual layers of the body, viz., the pellicle, the outer ectoplasm, the inner ectoplasm, and the endoplasm are recognizable, but the ectoplasm is not so thick as indicated by Bezzenberger for *O. coracoidea*. The cilia arise from spherical basal granules situated just beneath the pellicle and connected with each other by fine fibres. The cilia are long and fine and arranged in longitudinal rows. There is a large number of nuclei. Each resting nucleus contains four large chromatin masses just inside the nuclear membrane and one or more karyosomes

Fig. 11. Fig. 12.

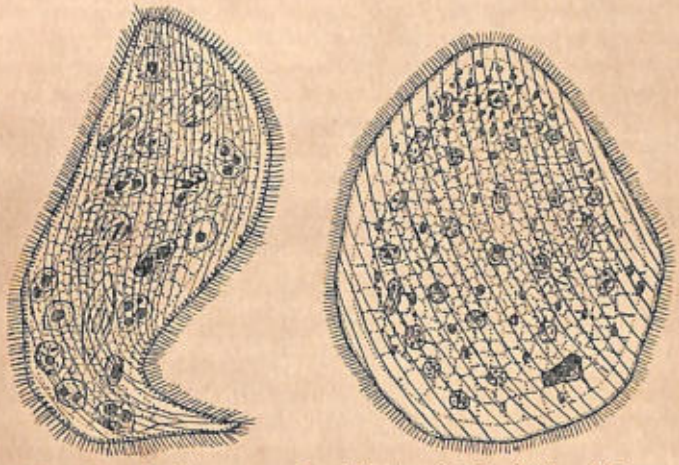


Fig. 11.—*Opalina coracoidea lahoriensis* Bh. & G. (After Bhatia and Gulati.)
Fig. 12.—*Opalina lata* Bezz. (After Bhatia and Gulati.)

lying in the centre. Smaller chromatin particles are also present at the nodes of the achromatin network. The mitosis is of the usual type. The chromatin resolves into a number of chromosomes which arrange themselves in a linear manner on the spindle-fibres. A constriction finally appears in the middle of the elongated nucleus, and the daughter nuclei separate. Besides the nuclei there are many spherical or elongate oval masses called endospherules in the endoplasm, and other much more minute, darkly-staining granules, known as cytomicrosomes, are found abundantly.

The full-grown individuals divide by longitudinal or oblique fission, but the beaked end is always involved in such a division. The two daughter Opalinas, after separation, exhibit for

a time a broad anterior end, and are narrowed and drawn out posteriorly into a fine tail, which appears to be a simple continuation of the body; but as the individuals grow in size the tail-end assumes a beak-shaped appearance.

By rapid and repeated divisions smaller individuals, each with only two or three nuclei, result. These become encysted, and such infection cysts, passing out with the fæces, are readily devoured by other tadpoles or frogs. Cysts were found in the stomach and duodenum of a frog. On the cyst-wall being dissolved minute individuals screw themselves out. These individuals possess two or more nuclei and a number of chromidial masses lying close to them. Having escaped from the cysts they divide into as many parts as there are nuclei, and thus form uninucleate gametes. The gametes in this species are nearly similar. In conjugation they are seen to approach each other either by their tail or by their anterior ends, lie parallel to one another, and then fuse. Copulation cysts were not found, and development of zygotes into full-sized Opalinas was not followed.

Habitat.—Rectum of *Rana tigrina* Daud. and *Bufo melanostictus* Schneider: PUNJAB, Lahore.

12. **Opalina lata** Bezzenberger. (Fig. 12.)

Opalina lata, Bezzenberger, 1904, pp. 166–7, pl. xi, fig. 10: Metcalf, 1923, p. 238, fig. 213.
†*Opalina lata*, Bhatia & Gulati, 1927, pp. 97–8, fig. 6.
†*Opalina lata*, de Mello, 1932, pp. 117.

Form oval, anterior end narrower, posterior broadly rounded. Rows of cilia extraordinarily close together. Nuclei very numerous.

Dimensions.—Length of body 260–300 μ, width 180–224 μ.

Remarks.—The anterior half of the body is more or less triangular. The greatest width is about the middle of the body. Some specimens of *O. ranarum* approach this species in form, but the relative proportion of the length of the body to the breadth is never 2 : 1, as it is in *O. ranarum*. In *O. lata* the breadth is always greater than half the length, and is very nearly equal to it in some examples. Bezzenberger gives 0·3 mm. as length and 0·18 mm. as breadth, but specimens found at Lahore were usually shorter and broader. De Mello gives 60 μ by 40 μ as the minimum and 160 μ by 80 μ as the maximum dimensions, usually the length of his specimens being between 120–140 μ. His specimens were thus markedly smaller than is generally the case for the species. The rows of cilia are extraordinarily close together and the cilia are very close-set in the rows. The nuclei are very numerous and smaller than those of *O. ranarum*.

Habitat.—Rectum of *Rana limnocharis* Wiegmann and *R. hexadactyla* Lesson : Asia (exact locality not cited by Bezzenberger) ; *R. hexadactyla* Lesson : PUNJAB, Lahore ; intestine of *Rana limnocharis* Wiegman : NOVA GOA.

13. **Opalina lata** var. **cordata** de Mello. (Fig. 13.)

†*Opalina lata* var. *cordata*, de Mello, 1932, pp. 114–16, 118, pl. xiv, figs. 2, 3, & 6.

Form oval, with the anterior end narrower and posterior end broader and rounded. Width usually greater than half the length. Body shows a fine membrane, a cortical zone, and a central medullary zone formed of alveoli closely crowded together. The disposition of these alveoli in longitudinal columns or bundles is characteristic of the variety, bands

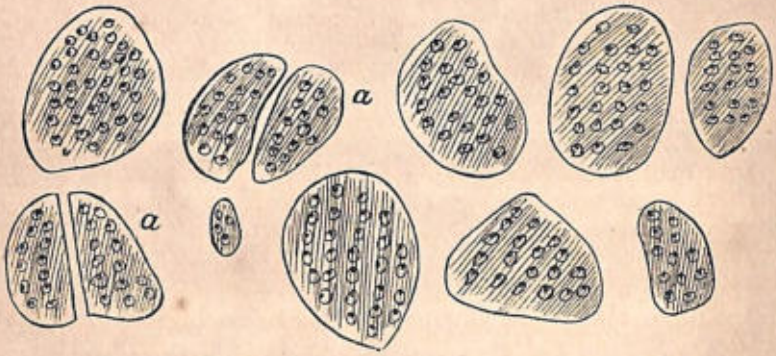


Fig. 13.—*Opalina lata* var. *cordata* de Mello. *a*, dividing forms. Cilia not shown in the figures. (After de Mello.)

of closely crowded alveoli alternating with bands of loose and colourless alveoli. Nuclei rounded or oval, generally elliptical ; diameter of nuclei 2–5 μ.

Dimensions.—Minimum 30 μ by 20 μ (young forms), maximum 340 μ by 170 μ, usually between 150–245 μ in length.

Habitat.—Intestine of *Rana malabarica* Tsch. and *R. cyanophlyctis* Schneid. : NOVA GOA.

14. **Opalina plicata** Ghosh. (Fig. 14.)

†*Opalina plicata*, Ghosh, 1919 *b*, p. 102, figs. 3, 4 ; 1921, p. 6.

Body broadly or elongately ovate (slightly longer than broad), tapering and rounded anteriorly, wide and rounded posteriorly.

Dorsal surface with two or four ridges, two of which are nearly parallel and extend from near the anterior end down to each side posteriorly; sometimes in broader forms two ridges of one side may be absent. Numerous nuclei.

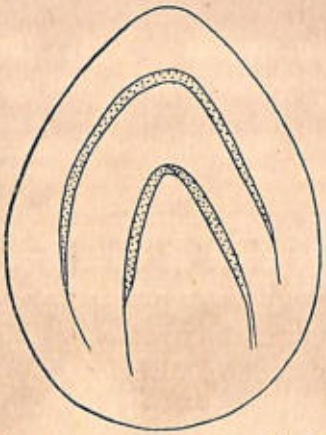


Fig. 14.—*Opalina plicata* Ghosh.
Cilia not shown in the figure. (After Ghosh.)

Habitat.—Intestine and rectum of *Bufo melanostictus* Schneid. : Calcutta.

15. **Opalina ranarum** (Ehrenberg). (Fig. 15.)

Bursaria ranarum, Ehrenberg, 1831, p. 110; 1835, p. 164; 1838, p. 330, pl. xxxv, fig. 7.
Opalina ranarum, Purkinje & Valentin, 1835, pp. 43, 59; Dujardin, 1841, pp. 462, 463, pl. xiii, fig. 13; Claparède & Lachmann, 1858–61, p. 374; Stein, 1859 *b*, p. 37; 1867, pp. 10–11, 24.
Bursaria ranarum, Ray Lankester, 1870, p. 148, pl. ix, fig. 9.
Opalina ranarum, Engelmann, 1876, pp. 574–7, pl. xxi, figs. 1–15; Zeller, 1877, pp. 353–65, pl. xxiii, figs. 1–26; Kent, 1880–2, pp. 559–60, pl. xxvi, figs. 1–9, 20, pl. xxxi, fig. 19; Bütschli, 1887–9, pp. 1718–19, pl. lxv, fig. 8, *a–h*; Schewiakoff, 1896, p. 393, pl. vi, fig. 153; Loewenthal, 1904, pp. 387–90, figs. 1–10; 1909, pp. 115–20, 1 fig.; Metcalf, 1923, pp. 222–4, figs. 197–8; King & Gatenby, 1926, pp. 217–19, pl. xxi; Wenyon, 1926, pp. 1154–7, figs. 488–9.
†*Opalina ranarum*, Bhatia & Gulati, 1927, p. 96, fig. 5.
Opalina ranarum, Reichenow, 1929, pp. 1159–65, figs. 1145–6, 1148–51.
†*Opalina ranarum*, de Mello, 1932, pp. 98–100, 124, pl. xii, fig. 17; pp. 103–5, pl. xiii, fig. 4; p. 118, pl. xiv, fig. 5.

Form variable, generally oval, anterior end being a little narrower than the posterior, which is broadly rounded. Length of the body one and a half to three times the width.

Dimensions.—Minimum 80 μ by 27 μ, maximum 299 μ by 105 μ, usually between 120–190 μ in length; diameter of nucleus 3 μ.

Remarks.—Both *O. ranarum* and *O. coracoidea* are usually found inhabiting the rectum of *Rana cyanophlyctis*. Generally in these infections there are a few specimens of *O. coracoidea* along with a very much larger number of *O. ranarum*.

The ectoplasm is thick. The pellicle and the basal granules from which the cilia arise are distinctly seen. The anterior edge of the body is specially thickened. The cilia are fine

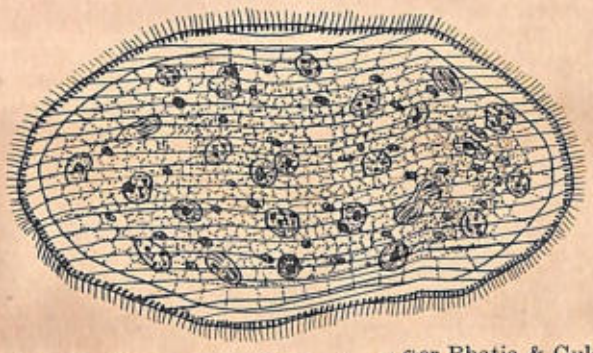


Fig. 15.—*Opalina ranarum* (Ehrbg.). (After Bhatia & Gulati.)

and close-set and arranged in longitudinal rows. The ciliary lines run in continuous spirals on the two surfaces of the flattened body.

The endoplasm has the usual structure. The nuclei are numerous. They all show one or more massive clumps of chromatin lying within the nuclear membrane. These masses are seen to be connected by fine chromatin fibres forming a network. The nuclei and the endospherules are specially crowded together in the anterior region of the body.

Habitat.—Rectum of *Rana esculenta*, *Bufo cinereus*, and *Bufo variabilis*: Asia (exact locality not cited by Bezzenberger); rectum of *Rana cyanophlyctis* Schneider: Punjab, Lahore; intestine of *Rana tigrina* Daud., *R. cyanophlyctis* Schneider, and *Bufo melanostictus* Schneid.: Nova Goa.

16. **Opalina scalpriformis** Ghosh. (Fig. 16.)

†*Opalina scalpriformis*, Ghosh, 1919 *b*, p. 103, fig. 5; 1920 *b*, pp. 78–84 2 pls.; 1921 *a*, p. 6.
Opalina obtrigonoidea forma *plicata*, Metcalf, 1923, p. 185, fig. 154.
†*Opalina scalpriformis*, de Mello, 1932, pp. 97–8, pl. xii, fig. 16.
†*Opalina obtrigonoidea* forma *plicata*, de Mello, 1932, pp. 123–4.

Body elongated cylindrical, anteriorly rounded, posteriorly narrower. Anterior portion of the body thrown into a variable number of longitudinal folds or ridges.

Dimensions.—Minimum 97 μ by 23 μ, maximum 350 μ by 75 μ, usually between 140 μ and 275 μ in length. Diameter of nuclei 3–3·5 μ.

Remarks.—Ghosh (1919) described *O. scalpriformis* as a new species, with the following brief description, and later (1920) described its cytology more fully :—" Body elongated, about



Fig. 16.—*Opalina scalpriformis* Ghosh. Cilia not shown in the figures. (After de Mello.)

4 to 5 times as long as broad, being flattened at the anterior end with a truncate edge, four sided (in transverse section) in the anterior half or so, and cylindrical and slightly tapering to a blunt point posteriorly; the four ridges in the anterior portion of the body run in a slightly spiral curve posteriorly, so that the animal appears twisted round the long axis; numerous nuclei." De Mello (1932) has studied the form more fully, and has given the measurements and figures of a number of individuals. He identifies it with *O. obtrigonoidea* forma *plicata* Metcalf, 1923.

Habitat.—Intestine and rectum of *Bufo melanostictus* Schneid.: Bengal, Calcutta; intestine of *Bufo melanostictus* Schneid.: Nova Goa.

17. **Opalina triangularis** Ghosh. (Fig. 17.)

†*Opalina triangularis*, Ghosh, 1919 *b*, p. 102, figs. 1, 2; 1921 *a*, p. 6.
Opalina obtrigonoidea, Metcalf, 1923, pp. 177–85, figs. 143–53.
†*Opalina triangularis*, de Mello, 1932, pp. 95–6, pl. xii, fig. 14.
†*Opalina obtrigonoidea*, de Mello, 1932, pp. 122–4.

Body oblanceolate, more or less rounded and widest anteriorly, narrow and tapering posteriorly, one margin of the

body convex, the other concave. Differentiated from *O. obtrigona* by its greater diversity in form, not only between different infections, but between different individuals in a single infection, and by the small size of its nuclei. Diameter of nuclei, 3–4 μ.

Dimensions.—Minimum 85 μ by 40 μ, maximum 390 μ by 175 μ, usually between 150 and 300 μ in length.

Remarks.—Ghosh (1919 *b*) described *O. triangularis* as a new species, giving a brief description, which is quoted below, as it is published in a journal which is not easily obtainable :— " Body flattened, leaf-like, twice as long as broad or less,

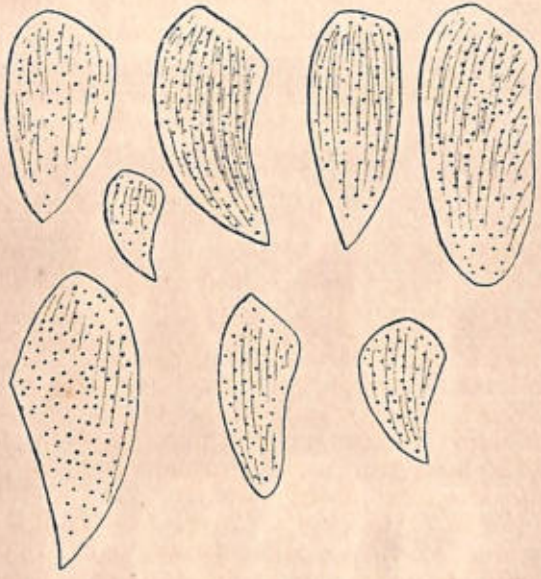


Fig. 17.—*Opalina triangularis* Ghosh. Cilia not shown in the figures. (After de Mello.)

widest in the anterior body-half ; one side nearly straight, and other strongly convex, giving the appearance of two curved sides meeting at the widest part of the body ; anterior end rounded and in the same line with the straight side ; posterior end tapering and rounded ; numerous nuclei." De Mello (1932) has studied the same form more fully, and given the measurements and figures of a large number of individuals. After identifying his form with *O. triangularis* Ghosh, he has later come to the conclusion that both his form and that met with by Ghosh belong to the same species as *O. obtrigonoidea*

Metcalf, 1923. The name *O. triangularis* Ghosh must be given priority over *O. obtrigonoidea*. Metcalf described many varieties, and *O. triangularis* shows the closest resemblance with the one described from *Rana pipiens* (Metcalf, 1923, fig. 150, *c*).

Habitat.—Intestine and rectum of *Bufo melanostictus* Schneid. : Bengal, Calcutta ; intestine of *Bufo melanostictus* Schneid. : Nova Goa.

18. **Opalina virgula** Dobell. (Fig. 18.)

†*Opalina virgula*, Dobell, 1910, p. 76, pl. ii, fig. 17.
Opalina virgula, Metcalf, 1923, pp. 202–3, fig. 171.
†*Opalina virgula*, de Mello, 1930, pp. 952–5, figs. 1–13 ; 1931 *a*, p. 1184 ; 1931 *b*, pp. 1442–3, pl. xxxviii, figs. 1–13 ; 1932, pp. 92–3, pl. xii, fig. 12.

Body-form strongly curved, long and slender or broader and shorter, with the greatest width in the anterior half,

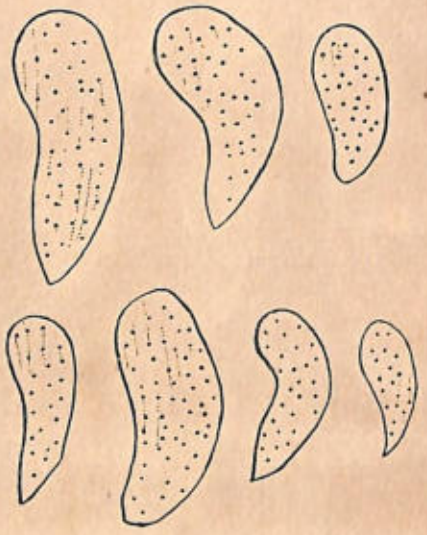


Fig. 18.—*Opalina virgula* Dobell. Cilia not shown in the figures. (After de Mello.)

posterior end always narrower and rounded. Nuclei many, large, spherical ; diameter of nucleus 4·5–5·5 μ. Cytoplasm with large number of elongated, slender endospherules, which lie with their long axes transverse to the length of the body and parallel to its surface. Cilia fine, close, and moderately long.

Dimensions.—Length of body 38–380μ, usually between 100–200μ, width 13–85μ, at the broadest part of the anterior portion.

Remarks.—Metcalf considers the occurrence of *O. virgula* in *Polypedates* (?) *maculatus* from Ceylon as a most surprising occurrence which needs careful scrutiny. With the exception of *Opalina virgula*, the Ceylonese form, the *virgula*-like species are so similar to *obtrigona*-like species, both in structure and distribution, that they may be treated together as one group. *O. virgula* is demarcated by its long, slender, rod-like, endoplasmic plastids. Metcalf is inclined to believe that it should be regarded as distinct in origin from the other *Opalinæ angustæ*, and that it probably arose independently from some *Cepedea*.

Habitat.—Rectum of *Polypedates* (*Rhacophorus*) *maculatus* (Gray) : Ceylon, Peradeniya ; Nova Goa ; intestine of *Bufo melanostictus* Schneid. : Nova Goa.

II. Subclass *EUCILIATA* Metcalf.

The subclass Euciliata includes Ciliates which show the characteristic nuclear dimorphism, a macronucleus and a micronucleus being always present.

The shape of the body varies considerably: it may be ovoid, elongate, dorso-ventrally flattened, or bell-shaped. The forms are free-swimming or attached by means of a stalk. The majority of them possess a mouth or cytostome followed by an œsophagus or cytopharynx leading into the endoplasm. Very often the cytostome is situated at the end of a groove or depression known as the peristome. The cilia are uniformly distributed over the body or are restricted to particular areas. By fusion of adjacent cilia either stout processes, known as cirri, or membranes may be formed. In a large number of forms special adoral cilia are arranged in a spiral manner in front of the cytostome and are continued into the cytopharynx as cilia or as membranes. In one group of parasitic Ciliates the cytostome is absent.

The subclass is divided into the following four orders :—

1.	Body uniformly covered with cilia, or cilia limited to certain areas. No adoral zone of spirally arranged cilia	**Holotricha**, p. 73.
2.	Peristome provided with an adoral zone of spirally arranged cilia	3.
3 (6).	From its starting point at the anterior end of the body the adoral zone turns to the right	4.
4 (5).	Entire body, or at least the ventral surface, covered with cilia	**Spirotricha**, p. 209.
5 (4).	Entire body not covered with cilia. Adoral zone not formed of distinct membranelles	**Chonotricha**, p. 422.
6 (3).	From its starting point at the anterior end of the body the adoral zone turns to the left. Body not covered by cilia except for a posterior ciliary wreath, which may be temporarily or permanently present	**Peritricha**, p. 393.

I. Order HOLOTRICHA Stein.

The order HOLOTRICHA includes forms in which the body is uniformly covered with cilia arranged in longitudinal rows, or the cilia may be restricted to certain areas. Cytostome usually present (absent only in ASTOMATA), and may be terminal, subterminal, or somewhere on the ventral surface or the right side. Cytostome may be a simple opening leading to a tubular cytopharynx, not provided with special cilia or membranes (GYMNOSTOMATA), or the cytopharynx may be provided with free cilia (TRICHOSTOMATA) or with membranes (HYMENOSTOMATA). Some forms bear a contractile proboscis. Spines and caudal filaments are present in some forms. Nutrition is holozoic, or parasitic (in ASTOMATA). Reproduction by transverse fission. Encystment common. Found in fresh water, brackish water, or, less commonly, in sea water. Some forms are parasitic.

Identification Table of Suborders.

1 (6 or 9).	Cytostome present	2.	
2	(3). Cytostome kept closed except at the moment of ingestion, not provided with cilia or membranes; cytopharynx simple or supported by a rod-apparatus; peristome usually absent	[p. 74.	**Gymnostomata,**
3	(2). Cytostome permanently open, provided with cilia or membranes; cytopharynx, if present, bearing cilia or membranes; peristome usually present; not parasitic in Molluscs and not strikingly thigmotactic.....	4.	
4	(5). Oral groove provided with more or less thickly situated rows of free cilia	[p. 137.	**Trichostomata,**
5	(4). Oral groove provided with membranes formed by the fusion of one or more rows of cilia, and also with fine cilia ..	[p. 162.	**Hymenostomata,**
6 (1 or 9).	Cytostome present or rudimentary or even absent; parasitic on Molluscs, etc., or commensals on other Ciliophora; strikingly thigmotactic	7.	
7	(8). Strikingly thigmotactic, with a ciliated area specially differentiated for attachment to a substratum; usually found in the branchial cavities of mussels; a few forms ectoparasitic on Vorticellids and Suctoria	[p. 193.	**Thigmotricha,**

8	(7). With complicated life-history and change of hosts; alternately on the body of Crustacea or in Cœlenterates; a few forms endo-parasitic in Cephalopoda and Heteropoda	**Apostomea**, p. 198.
9 (1 or 6).	Cytostome absent	**Astomata**, p. 199.

1. Suborder *GYMNOSTOMATA* Bütschli.

HOLOTRICHA with body not always entirely covered with cilia. Cilia may be confined to one side of the body or limited to widely separated spiral rows. Cytostome lies on the surface of the body—that is, it is not sunken, and no peristomial groove leads to it. It is kept closed except at the moment of ingestion, and is not provided with cilia or membranes. It may be round or slit-like and situated at the anterior pole (PROSTOMATA), or shifted back so as to lie along one border (PLEUROSTOMATA), or lie on the ventral surface (HYPOSTOMATA). Cytopharynx is tubular, simple or provided with rod-apparatus consisting of trichites.

In some forms the body is covered with a tightly fitting armour of plates. Pseudopodia are present in some forms in addition to cilia.

The genera of GYMNOSTOMATA are classified into fourteen families, which are placed in three tribes, as follows :—

(1).	Cytostome at the anterior pole or its immediate neighbourhood.....	**Prostomata**, p. 74.
(2).	Cytostome slit-like, running from the anterior pole along the compressed ventral border or rounded and situated at the base of a proboscis	[p. 105. **Pleurostomata**,
(3).	Cytostome in the anterior half of the flattened ventral surface	**Hypostomata**, p. 124.

1. Tribe **PROSTOMATA** Schewiakoff, 1896.

Gymnostomatous Ciliates with the cytostome at the anterior pole of the body or close to it.

Identification Table of the Families.

1	(2). Cytostome slit-like, surrounded by a prominent, laterally compressed, padded margin provided with trichocysts.....	[p. 101. **Spathidiidæ** Kahl,
2	(1). Cytostome round, with or without padded margins	3.

3	(4).	Cytostome borne on a receptacle situated on the anterior part of the body; test-dwelling	**Metacystidæ** * Kahl.
4	(3).	Cytostome without receptacle, not test-dwelling	5.
5	(6).	Cytostome at the summit of an apical truncated cone, which is surrounded at its base by a ciliary girdle, with one or more additional ciliary girdles; rest of the body uniformly ciliated or naked.	[p. 93. **Didiniidæ** Poche.
6	(5).	Cytostome at the anterior end	7.
7	(8).	Body covered with a lorica of regularly arranged plates	[Lachm., p. 96. **Colepidæ** Clap. &
8	(7).	Surface of the body otherwise	9.
9	(10).	Body with radially arranged, stiff, retractile pseudopodia	[Kent. **Actinobolinidæ** *
10	(9).	Body without pseudopodia	11. [p. 75.
11	(12).	Body uniformly ciliated	**Holophryidæ** Perty.
12	(11).	Long cilia densely covering entire anterior end, cilia over rest of the body may be absent; parasitic	[p. 103. **Bütschliidæ** Poche.

1. Family HOLOPHRYIDÆ Perty, 1852.

Body spherical or ellipsoidal, with cilia uniformly arranged in longitudinal rows; not covered with a lorica and not provided with retractile pseudopodia. Cytostome round, situated at the anterior end, not provided with any special appendages. Cytopharynx almost always provided with trichocysts or trichites.

Key to Indian Genera.

1	(8).	Body egg-shaped or flask-shaped, never with an oral cone which is provided posteriorly with a wreath of longer cilia	2.
2	(3).	Posterior end of the body with one or more setæ	[Lachm., p. 80. UROTHRICHA Clap. &
3	(2).	Posterior end of the body without setæ	4.
4	(7).	Body not drawn out into a neck	5.
5	(6).	Cytopharynx absent or tubular, with at the most weakly developed rods	[p. 76. HOLOPHRYA Ehrbg.,
6	(5).	Cytopharynx conical, with distinct rods or fine longitudinal striations	[p. 81. PRORODON Ehrbg.,
7	(4).	Anterior end drawn out	ENCHELIS Müll.,
8	(1).	Body elongate, worm-like or flask-shaped, may be provided with an oral cone; at the posterior end of which is a circle of longer cilia	[p. 90. 9.

* Indicates that no representative of the family has been recorded from India so far.

9 (10).	With an annular furrow near anterior end, marking off an apical portion provided with spiral rows of cilia	[p. 85. LACRYMARIA Ehrbg..
10 (9).	Without an annular furrow marking off an apical portion	11.
11 (12).	Anterior region not narrowed ; no spiral stripes.....	[Ehrbg., p. 92. TRACHELOCERCA
12 (11).	Anterior region narrowed, with longitudinal or slightly spiral stripes.....	[p. 92. CHÆNEA Quenn..

Genus **HOLOPHRYA** Ehrenberg, 1831.

Holophrya, Ehrenberg, 1831, p. 101 ; 1838, p. 314 ; Claparède & Lachmann, 1858–61, p. 312 ; Fromentel, 1874, p. 188 ; Kent, 1880–82, p. 498 ; Schewiakoff, 1889, p. 10 ; 1896, p. 118 ; Roux, 1901, p. 20 ; Penard, 1922, p. 13 ; Calkins, 1926, p. 404 ; Lepsi, 1926 *a*, p. 34 ; Schoenichen, 1927, p. 177 ; Sandon, 1927, p. 171 ; Reichenow, 1929, p. 1168 ; Kahl, 1930–5, p. 47.

Animalcules free-swimming ; body regularly ellipsoidal to cylindrical, nearly uniform at the two poles or with the hinder end somewhat pointed, flexible, uniformly ciliate. Mouth terminal, situated at the anterior pole, generally with no specially large cilia round it ; pharynx absent, or when present a short simple tube without or with weakly-developed rod-apparatus. Anal aperture situated at the posterior extremity. Contractile vacuole usually single, terminal, sometimes with a few smaller ones in its neighbourhood, or more numerous and arranged in rows. Macronucleus spherical, oval, kidney-shaped, horseshoe-shaped, or elongated band-shaped. Micronucleus small, oval. They form spherical cysts surrounded by a gelatinous case inside which in certain cases numerous small swarm-spores are produced by rapid and repeated fission. Fresh water and marine, sometimes parasitic on freshwater fish.

Key to Indian Species.

1.	Cytopharynx absent	2.
2 (5).	Contractile vacuole terminal or subterminal	3.
3 (4).	Macronucleus rounded or oval	[p. 79. *H. simplex* Schew.,
4 (3).	Macronucleus band-shaped	*H. indica* Bhatia,
5 (2).	Contractile vacuole not terminal or subterminal	[p. 78.
6 (9).	Macronucleus single	6.
7 (8).	Macronucleus spindle-shaped, contractile vacuole lateral in the posterior fourth ..	7. [Ghosh, p. 77. *H. bengalensis*
8 (7).	Macronucleus rounded, contractile vacuole lateral, about the middle	[p. 79. *H. lateralis* Kent,
9 (6).	Macronuclei two, contractile vacuole lateral, in the anterior half	[Ghosh, p. 77. *H. annandalei*

19. **Holophrya annandalei** Ghosh.

†*Holophrya annandalei*, Ghosh, 1919 *a*, p. 41 ; 1921 *a*, p. 7.

Body cylindrical, rounded at both ends, three times as long as broad. Ciliary striæ faint. Cytostome anteroterminal and circular, cytopharynx a slight depression. Contractile vacuole single, placed at the junction of the anterior and middle thirds of the body, on one side. Macronuclei two, spherical, one situated in the middle on one side and the other towards the anterior end.

Dimensions.—Length 150–220 μ.

Remarks.—No figure of the form is given by the author of the species. The position of the macronuclei is very unusual for a species of this genus.

Habitat.—Fresh water : BENGAL, Calcutta.

20. **Holophrya bengalensis** Ghosh. (Fig. 19.)

†*Holophrya bengalensis*, Ghosh, 1919 *a*, p. 41, fig. 1.
Holophrya bengalensis, Kahl, 1930–5, p. 50, fig. 5, 8.

Body cylindrical with rounded ends, slightly stouter posteriorly. Cilia long. Cytostome small and circular, at

Fig. 19.

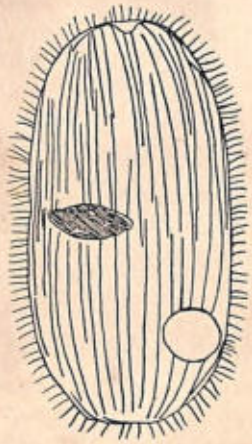


Fig. 20.



Fig. 19.—*Holophrya bengalensis* Ghosh. (After Ghosh.)
Fig. 20.—*Holophrya lateralis* Kent. (After Kahl.)

anterior end. Cytopharynx absent. Contractile vacuole single, subterminal, situated close to one side. Macronucleus broadly fusiform, situated in the middle of the body, near one side.

Dimensions.—Length 75 μ, width 37 μ.

Remarks.—Description of the species is based on the examination of a single specimen by Ghosh.

Habitat.—Fresh water : BENGAL, Calcutta.

21. **Holophrya indica** Bhatia. (Fig. 21.)

†*Holophrya indica*, Bhatia, 1916, p. 178, fig. 1.
Holophrya indica, Kahl, 1930–5, p. 50, fig. 5, 6.

Body evenly elliptical, of medium size, a little more than one and a half times as long as broad ; colourless ; cuticular surface presenting distinct alternating longitudinal striæ and furrows. Ciliation uniform, cilia fairly long and distinct,

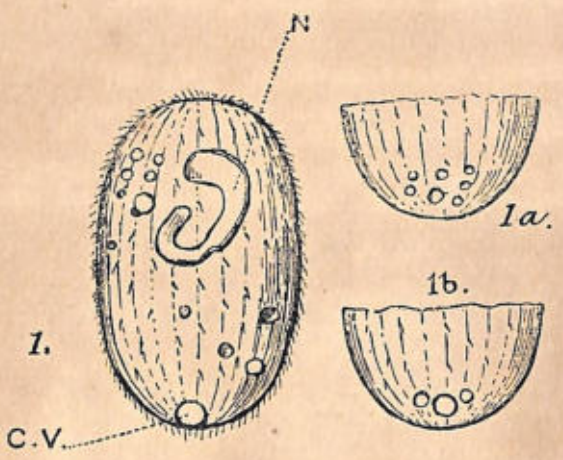


Fig. 21.—*Holophrya indica* Bhatia. 1, whole animal ; 1 *a*, posterior end, showing one principal and six subsidiary vacuoles ; 1 *b*, posterior end, showing one principal and two subsidiary vacuoles. *N*, macronucleus ; *C.V.*, contractile vacuole or vacuoles. (After Bhatia.)

disposed along the longitudinal striæ. Border of the oral aperture not projecting, pharynx absent. Contractile vacuole single, spherical, postero-terminal, with a number of small circular feeding-vacuoles in its neighbourhood which are not arranged in longitudinal rows. Macronucleus large, band-shaped, curved in a horseshoe-shaped manner, situated in the anterior half of the body.

Dimensions.—Length 105 μ, width 63 μ.

Remarks.—The body showed only a slight degree of flexibility, and was almost equally rounded at the anterior and

posterior ends. On the surface presented to view thirteen longitudinal striæ, along which the cilia were disposed, were distinctly made out. The single spherical contractile vacuole, situated near the posterior pole, was surrounded by 5 to 7 small feeding vacuoles at the commencement of its diastolic phase. These were seen to contract, and there would remain three only, the central one considerably larger than the two subsidiary ones now left. This main contractile vacuole then contracted and disappeared, the others following almost simultaneously and contributing to the formation of the vacuole afresh, the neighbouring subsidiary ones soon making their appearance again (fig. 21, 1 *a*, 1 *b*).

This species shows some resemblance to *H. simplex* in the absence of trichocysts and pharynx, but differs considerably from it in the size of the body and the form of the macronucleus.

Habitat.—Fresh water : PUNJAB, Lahore.

22. **Holophrya lateralis** Kent. (Fig. 20.)

†*Holophrya lateralis*, Kent, 1880–2, p. 500, pl. xxvi, fig. 46.
Holophrya lateralis, Lepsi, 1926 *a*, p. 37, fig. 27; Kahl, 1930–5, p. 50, fig. 5, *9*.

Body cylindrical, oval or elliptical, a little over twice as long as broad, flexible. Cilia conspicuous, arranged in numerous closely approximated longitudinal rows. Endoplasm thickly granular. Contractile vacuole single, lateral, a little in front of the middle. Macronucleus inconspicuous.

Dimensions.—Length 250 μ.

Remarks.—The species was described by Kent from the figure and description contained in manuscript notes of H. J. Carter.

Habitat.—Fresh water : BOMBAY.

23. **Holophrya simplex** Schewiakoff. (Fig. 22.)

Holophrya simplex, Schewiakoff, 1889, pp. 30–1, pl. ii, fig. 31; 1893, p. 45; 1896, pp. 120–1, pl. i, fig. 1; Roux, 1901, p. 20, pl. i, fig. 2.
†*Holophrya simplex*, Gulati, 1925, p. 745, pl. i, fig. 1.
Holophrya simplex, Lepsi, 1926 *a*, p. 37; Schoenichen, 1927, p. 18, fig. 700; Kahl, 1930–5, p. 49, fig. 5, *10*.

Body ellipsoid, not contractile. Cilia small, close-set, in 18–20 longitudinal rows. Cytostome small, polar, only visible at the time of ingestion, without trichocysts or trichites. Cytopharynx absent. Anus and contractile vacuole posteroterminal. Macronucleus large, rounded.

Dimensions.—Length 34 μ, width 18 μ.

Remarks.—The form described and figured by Gulati differs from the description of the species as given above in size,

Fig. 22.

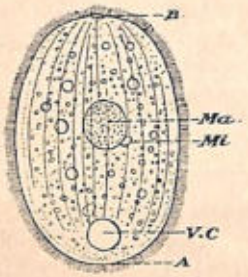


Fig. 23.

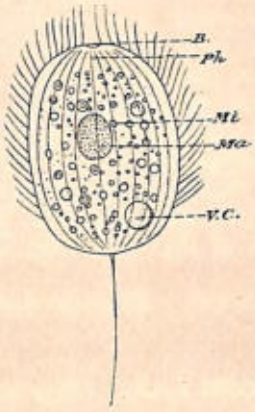


Fig. 24.



Fig. 22.—*Holophrya simplex* Schew. *A*, anus; *B*, cytostome; *Ma*, macronucleus; *Mi*, micronucleus; *Ph*, cytopharynx; *V.C.*, contractile vacuole. (After Roux.)

Fig. 23.—*Urotricha globosa* Schew. Lettering as in fig. 22. (After Roux.)

Fig. 24.—*Prorodon edentatus* Clap. & Lach. *a*, anus; *al*, alveolar layer; *C.V.*, contractile vacuole; *N*, macronucleus; *o*, cytostome; *oe*, cytopharynx. (After Schewiakoff.)

being 52 μ by 39 μ, in the macronucleus being oval, and the contractile vacuole being subcentral.

Habitat.—Fresh water: PUNJAB, Lahore.

Genus **UROTRICHA** Claparède & Lachmann, 1858.

Pantotrichum, Ehrenberg, 1830, p. 39.
Urotricha, Claparède & Lachmann, 1858–61, p. 314; Fromentel, 1874, p. 189; Kent, 1880–2, p. 504; Schewiakoff, 1889, p. 7; 1896, p. 124; Roux, 1901, p. 21; Penard, 1922, pp. 17–20; Calkins, 1926, pp. 381, 403; Lepsi, 1926 *a*, p. 34; Schoenichen, 1927, p. 179; Sandon, 1927, p. 171; Kahl, 1930–5, p. 57.

Animalcules small, free-swimming, spherical or elliptical, entirely ciliate; motion of cilia irregular and independent. Posterior end of the body provided with one or more setæ. Mouth antero-terminal or slightly subpolar, pharynx present. Contractile vacuole near the posterior end. Macronucleus oval or spherical. Fresh water.

24. **Urotricha globosa** Schewiakoff. (Fig. 23.)

Urotricha globosa, Schewiakoff, 1889, p. 33, pl. ii, fig. 33; 1893, p. 46; 1896, p. 127, pl. i, fig. 8; Roux, 1901, p. 22, pl. i, fig. 7.
†*Urotricha globosa*, Bhatia, 1916, p. 179.
Urotricha globosa, Lepsi, 1926*a*, p. 38, fig. 33; Schoenichen, 1927, p. 179, pl. xii, fig. 2; Kahl, 1930–5, p. 59, fig. 6, *11*.

Body small, spherical to egg-shaped. Cilia long, near the mouth shorter and finer, scantier or absent at the posterior end, posterior end with one or two setæ. Mouth at the anterior pole, pharynx long. Macronucleus spherical and accompanied by a small micronucleus. Locomotion swift, animalcule often changing its direction.

Dimensions.—Length 15–18μ, width 13–15μ.

Remarks.—The animalcules examined at Lahore closely resembled the description of the species. They showed swift movement, often changing their direction suddenly, and the posterior springing bristle was elongated in the direction of the long axis of the body. A few points of difference were, however, observed: the macronucleus, which was spherical, was seen to be proportionately larger in size than in the figure given by Roux; the contractile vacuole was placed in the median line near the posterior end and not on one side: and there were cilia on the posterior part of the body in the neighbourhood of the springing bristle also. As regards the first two points there is agreement with the figure given by Schewiakoff, but no cilia are indicated by him on the sides of the springing bristle. This difference is not of sufficient importance to justify the creation of a new species.

Habitat.—Fresh water: PUNJAB, Lahore.

25. **Urotricha** sp.

†*Urotricha* sp., Chaudhuri, 1929, p. 54.

Habitat.—Soils from Calcutta and Bombay.

Genus **PRORODON** Ehrenberg, 1833, emend. Kahl, 1927.

Prorodon, Ehrenberg, 1833, p. 308; 1838, p. 315; Fromentel, 1874, p. 167; Kent, 1880–2, p. 491; Schewiakoff, 1889, p. 13; 1896, p. 146; Roux, 1901, p. 27; Penard, 1922, pp. 36–43; Calkins, 1926, pp. 378, 403; Lepsi, 1926*a*, p. 34; Schoenichen, 1927, p. 181; Sandon, 1927, p. 171; Kahl, 1927*b*, p. 44; 1930–5, p. 72; Reichenow, 1929, p. 1168.

Animalcules small to very large, persistent in shape, symmetrically ovate, uniformly rounded at the poles, entirely and evenly ciliate throughout, with somewhat thicker cilia in the neighbourhood of the mouth. Mouth at or closely

adjacent to the anterior pole, and the anal aperture at the opposite one. Pharynx strengthened by rod-like teeth. Contractile vacuole almost always single and terminal, rarely numerous and distributed over the whole body. Macronucleus spherical, sometimes band-like and curved. Cysts spherical, showing division or not. Locomotion rapid and chiefly revolving on the longitudinal axis. Fresh water and marine.

Key to Indian Species.

1 (4).	Cytopharynx with rod-apparatus	2.
2 (3).	Body ellipsoidal, twice as long as broad; macronucleus oval or spherical; contractile vacuole single, postero-terminal.	*P. teres* Ehr., p. 84.
3 (2).	Body oval, less than twice as long as broad; macronucleus horseshoe-shaped; contractile vacuoles two	[p. 83. *P. stewarti* Ghosh,
4.	Cytopharynx without rod-apparatus	5.
5.	Body elongate-ellipsoidal, nearly three times as long as broad; macronucleus oval; contractile vacuole single, postero-terminal	[Lach., p. 82. *P. edentatus* Clap. &

26. **Prorodon edentatus** Claparède & Lachmann. (Fig. 24.)

Prorodon edentatus, Claparède & Lachmann, 1858–61, pp. 320–1, pl. xviii, fig. 1; Kent, 1880–2, p. 493; pl. xxvi, fig. 43; Schewiakoff, 1896, p. 152, pl. i, fig. 24.

†*Prorodon edentatus*, Bhatia, 1922, p. 27.

Prorodon edentatus, Schoenichen, 1927, p. 182; Sandon, 1927, p. 174; Kahl, 1930–5, p. 73.

Body elongate-ellipsoidal, cylindrical, nearly three times as long as broad, transparent; surface of cuticle longitudinally striate. Mouth terminal, somewhat eccentric, succeeded by a simple, conical and corneous tube-like pharynx, extending backwards and gradually diminishing in size, not provided with any rod-apparatus. No trichocysts. Cilia of the posterior extremity longer than those of the general surface, produced in a tuft-like manner. Contractile vacuole, single, spherical, postero-terminal. Macronucleus oval, elongate.

Dimensions.—Length up to 150 μ.

Remarks.—The body was flexible, longitudinally striate, and with its anterior part more transparent. The cilia were uniform all over the body, and the anterior end showed a small beak-like projection curved to one side. The cytostome was anterior, eccentric, and was followed by a short, narrow, conical pharynx, without any cilia or rod-apparatus. Macronucleus small, oval, and situated in the anterior half of the body. The contractile vacuole very large and situated near the posterior end. Anal aperture postero-terminal, situated

in a slight indentation of the posterior margin of the body. An average specimen measured 74 μ by 24 μ.

The form, however, differs from the type as described and figured by the original authors in the following features :— The anterior and posterior margins of the body were not regularly rounded, there was no tuft of longer cilia at the posterior end, the pharyngeal tube did not extend to the centre of the body but only a short distance behind the anterior end, the macronucleus was proportionately much smaller and situated in the anterior half of the body. All these features give the form found at Lahore a distinctive appearance, but do not justify the creation of a new species for it.

Habitat.—Fresh water : PUNJAB, Lahore.

27. **Prorodon stewarti** Ghosh. (Fig. 25.)

†*Prorodon stewarti*, Ghosh, 1928, p. 382, fig. 1.
Prorodon stewarti, Kahl, 1930–5, pp. 73–4, fig. 25, *21*.

Body elongately oval, less than twice as long as the greatest width, rounded at both ends. Cilia arranged in close meridional rows. Cytostome anterior and slightly lateral. Cytopharynx

Fig. 25.

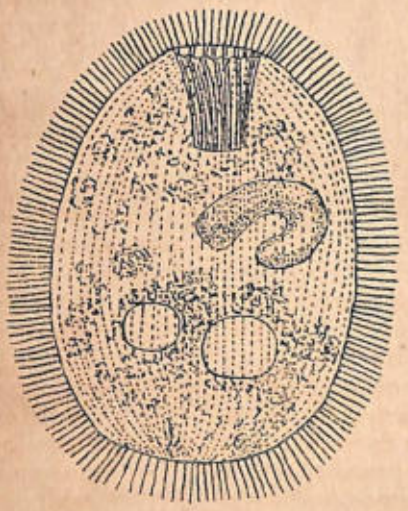


Fig. 26.

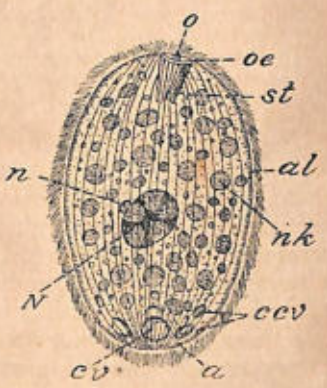


Fig. 25.—*Prorodon stewarti* Ghosh. (After Ghosh.)
Fig. 26.—*Prorodon teres* Ehrbg. *a*, anus; *al*, alveolar layer; *ccv*, subsidiary vacuoles; *cv*, contractile vacuole; *N*, macronucleus; *n*, micronucleus; *nk*, food-vacuoles; *o*, cytostome; *oe*, cytopharynx with rod-apparatus; *st*, meridional rows of cilia. (After Schewiakoff.)

truncately conical, from one-fourth to one-third the length of the body, with distinct rod-apparatus. Contractile vacuoles two, spherical, and placed, one a little in front of the other, in the posterior half of the body. Macronucleus stout, horse-shoe-shaped, and placed laterally in front of the middle of the body. Micronucleus not identified.

Dimensions.—Length 140–150 μ.

Remarks.—Kahl doubts if the form is a true *Prorodon* at all, as the position of the contractile vacuoles and the horseshoe-shaped macronucleus are unlike any other species of the genus. He thinks that the position of its contractile vacuoles reminds one of *Holophrya haplostoma*, from which, however, it differs in several respects. I do not feel disposed to agree with Kahl in questioning the form as a true *Prorodon*.

Habitat.—Sewer water : Bengal, Calcutta.

28. **Prorodon teres** Ehrenberg. (Fig. 26.)

Prorodon teres, Ehrenberg, 1838, p. 316, pl. xxxii, fig. xi ; Dujardin, 1841, p. 501 ; Claparède & Lachmann, 1858–61, p. 319.
Prorodon griseus, Claparède & Lachmann, 1858–61, pp. 319–20, pl. xviii, fig. 3.
Prorodon teres, Stein, 1859*d*, pp. 82, 90, 95, 96, 100 ; 1867, pp. 58, 65, 87, 99, 100 ; Engelmann, 1862, p. 368.
Prorodon? teres, Fromentel, 1874, p. 280, pl. iii, figs. 9, 9 *a*.
Prorodon teres, Kent, 1880–2, p. 492 ; Maupas, 1889, pp. 272–5, pl. xvi, figs. 19–25 ; Bütschli, 1887–9, p. 1682, pl. xlii, fig. 3 ; Schewiakoff, 1889, pp. 13–14, pl. i, figs. 9–13 ; 1893, p. 37 ; 1896, p. 151, pl. i, fig. 22, pl. vii, figs. 188, 194 ; Roux, 1901, p. 28, pl. i, fig. 16 ; Lang, 1913, p. 38.
†*Prorodon teres*, Bhatia, 1920, pp. 259–60.
Prorodon teres, Lepsi, 1926*a*, p. 39, fig. 46 ; Wenyon, 1926, figs. 24, 25 ; Schoenichen, 1927, p. 182, pl. xii, *5* ; Reichenow, 1929, p. 1168 ; Kahl, 1930–5, p. 80, fig. 8, *10–13*.

Body ovate, ellipsoidal, twice as long as broad, slightly narrowed anteriorly. Mouth exactly terminal ; pharynx elongate, slightly conical, enclosing an elongate cylindrical fascicle of rod-like teeth. No trichocysts. Contractile vacuole single, postero-terminal. Macronucleus oval or spherical, with a small micronucleus lying close to it.

Dimensions.—Length 63–200 μ.

Remarks.—The animals examined at Lahore measured 63–84 μ by 45 μ in size, and contained yellow or brown ingested food-particles. The form, however, differed from the one figured by Schewiakoff in certain important respects. The macronucleus was large and spheroidal, was situated in the anterior half of the body, and was carried about in the granular endoplasm ; it was of the granular type, and a small rounded micronucleus was placed on its surface. The cytostome

was anterior and terminal, but the pharynx did not extend as far back as figured. The pharynx was 12μ in length and measured 9μ across at its anterior end, becoming somewhat narrower posteriorly. The fascicle of rods was distinct, and eight rods could be counted in the surface presented to view. The cilia on either side of the mouth were slightly longer than those over the rest of the body.

Habitat.—Fresh water : PUNJAB, Lahore.

29. **Prorodon** sp.

Prorodon sp., Chaudhuri, 1929, p. 54, pl. iii, fig. 8.

Habitat.—Soils from Indore and Colombo.

Genus **LACRYMARIA** Ehrenberg, 1830.

Lacrymaria, Bory, 1824 ; *sic* Agassiz, *sed nem comp.* (Sherborn).
Lacrymatoria, Bory de St. Vincent, 1824–7, p. 479.
Phialina, Bory de St. Vincent, 1824–7, p. 616.
Lacrymaria, Ehrenberg, 1830, p. 42 ; 1831, pp. 104–5 ; 1838, pp. 309–11.
Phialina, Ehrenberg, 1838, pp. 333–4.
Lacrymaria, Claparède & Lachmann, 1858–61, pp. 295–304.
Phialina, Claparède & Lachmann, 1858–61, pp. 304–6.
Lacrymaria, Fromentel, 1874, p. 174.
Phialina, Fromentel, 1874, p. 174.
Lacrymaria, Kent, 1880–2, p. 517.
Phialina, Kent, 1880–2, p. 519.
Lacrymaria, Bütschli, 1887–9, pp. 1682–4 ; Schewiakoff, 1896, p. 138 ; Roux, 1901, p. 26 ; Wenyon, 1926, pp. 1163, 1175 ; Schoenichen, 1927, p. 183 ; Reichenow, 1929, p. 1168 ; Kahl, 1930–5, p. 89 ; 1933, pp. 53–4.

Animalcules free-swimming, medium-sized to very large, subcylindrical or flask-shaped, narrowed anteriorly, apical region projecting like a stopper on the neck of a flask, separated from the rest of the body by a circular groove, and bearing one or more spiral rows of longer, usually reflected cilia. Cytostome at the summit of the plug, and followed by a short, conical cytopharynx without rods. Cuticular surface finely and entirely ciliate or sometimes glabrous. Contractile vacuole single, postero-terminal, sometimes with one or two additional ones situated more anteriorly. Macronucleus central, spherical to elongated or bipartite, micronucleus believed to be present. Forming spherical cysts inside which multiplication takes place. Fresh water and marine.

Remarks.—Bory de St. Vincent (1824–7) first described a new genus *Lacrymatoria* with six species, and another as *Phialina* with five species. Agassiz gives *Lacrymaria* Bory, 1824, also as a generic name, but this seems to be an error,

as this name is not to be found in 'Encyclopédie Méthodique.' Ehrenberg revised both these genera, and remarked (1838) that out of the six (later eight) species described by Bory perhaps only one doubtfully belonged to *Lacrymaria* Ehrbg., 1830, the others being referred to *Euglena*, *Phialina* and *Trachelocerca*. The genus *Lacrymatoria* Bory, having been dismembered, the name *Lacrymaria* Ehrbg. has always been adopted in later literature. Ehrenberg established the genus *Lacrymaria* in 1830, and later transferred *Phialina proteus* Bory to it. Of the remaining four species of *Phialina* Bory, he identified *Ph. cygnus* with *Trachelocerca olor* (Müller), and identifying *Ph. hirundinoides* with *Trichoda vermicularis* Müller, retained it in the genus *Phialina* as *Ph. vermicularis*. The two genera *Lacrymaria* and *Phialina* were regarded as distinct for a long time, the former described with the cytostome at the summit of the conical protuberance, and the latter with the cytostome in the furrow surrounding the base of the conical protuberance. Bütschli (1887–9) amalgamated *Lacrymaria* and *Phialina*, and transferred a number of other genera and subgenera to *Lacrymaria* Ehrbg. He doubted if the position of the cytostome was antero-lateral in *Phialina*, and remarked that in case this position was confirmed later, *Phialina* would be regarded as a separate subgenus. Since then the cytostome has been shown to lie at the summit of the conical protuberance, and the two genera completely merged.

Key to Indian Species.

1(3).	Neck long, slightly flattened. Macronucleus dumb-bell-shaped. Contractile vacuoles two	2.
2.	Body cylindrical, posteriorly pointed or rounded. Cilia in spiral rows. Animals swim with extended neck, now forwards, now backwards. Length 100–400 μ...	[p. 87. *L. olor* (O. F. Müll.),
3(1).	Neck short, thick. Macronucleus oval. Contractile vacuole single, posterior....	4.
4(5).	Body sometimes green through the presence of zoochlorellæ. Length about 120 μ. Locomotion, briskly turning round	[(O. F. Müll.), p. 89. *L. vermicularis*
5 (4).	Body ellipsoid, tapering at the posterior end, with longitudinal and transverse striations. Locomotion, calm and gliding, rotating on its axis. Length 90 μ	[p. 87. *L. striata* Gulati,

30. **Lacrymaria olor** (O. F. Müller). (Fig. 27.)

Vibrio olor, O. F. Müller, 1786, p. 75, pl. x, figs. 12–15.
Lacrymaria olor, Ehrenberg, 1831, p. 105.
Trachelocerca olor, Ehrenberg, 1833, p. 316; 1838, p. 342, pl. xxxvii, fig. 7.
Lacrymaria proteus, Ehrenberg, 1838, p. 310, pl. xxxi, fig. 17.
Lacrymaria gutta, Ehrenberg, 1838, p. 310, pl. xxxi, fig. 18.
Trachelocerca viridis, Ehrenberg, 1838, p. 342, pl. xxxviii, fig. 8.
Trachelocerca biceps, Ehrenberg, 1838, p. 343, pl. xxxviii, fig. 9.
Lacrymaria olor, Dujardin, 1841, p. 469.
Lacrymaria proteus, Dujardin, 1841, p. 470.
Lacrymaria viridis, Dujardin, 1841, p. 470.
Lacrymaria gutta, Dujardin, 1841, p. 471.
Trachelocerca olor, Cohn, 1853, pp. 265–6, pl. xiii, figs. 10, 11.
Lacrymaria olor, Claparède & Lachmann, 1858–61, pp. 298–302, pl. xvi, figs. 5–8.
Trachelocerca viridis, Stein, 1859 *d*, p. 65.
Lacrymaria olor, Stein, 1867, pp. 48, 65, 67; Fromentel, 1874, p. 284, pl. xv, fig. 7.
Trachelocerca versatilis, Kent, 1880–2, p. 516, pl. xxvii, fig. 33.
Lacrymaria olor, Bütschli, 1887–9, pp. 1683–4, pl. lvii, fig. 9; Schewiakoff, 1893, p. 38; 1896, pp. 141–2, pl. i, fig. 17; Roux, 1901, p. 26, pl. i, fig. 13.
†*Lacrymaria olor*, Ghosh, 1921 *a*, p. 7.
Lacrymaria olor, Penard, 1922, p. 43, fig. 44; Schoenichen, 1927, p. 184, pl. xii, fig. 7; Kahl, 1930–5, p. 93, fig. 13, *22*, *25*.

Body divided into two parts, one elongated, cylindrical, more or less pointed or simply rounded posteriorly, the other long and narrow, slightly flattened and extremely contractile. Oral cone well developed. Mouth small, pharynx little developed, with a circlet of large cilia surrounding the buccal cone. No furrow separating the head from the neck. Cilia arranged spirally. Two contractile vacuoles, one at the junction of the neck with the trunk and the other in the posterior part of the body. Macronucleus consists of two rounded parts united together. Micronucleus in a depression of the macronucleus. Animal swims with extended neck, now forwards, now backwards.

Dimensions.—Length 100–400 μ according to the state of extension of the neck, width variable.

Habitat.—Pond water and vegetable infusions: BENGAL, Calcutta.

31. **Lacrymaria striata** Gulati. (Fig. 28.)

†*Lacrymaria striata*, Gulati, 1925, p. 746, pl. i, fig. 3.
Lacrymaria (*Enchelis*) *pupula*, Kahl, 1930–5, p. 94, fig. 13, *1*, *12*, *27*.
Lacrymaria striata, Kahl, 1930–5, p. 96.

Body ellipsoid, neck short and thick, shaped like the cork of a bottle and surrounded by a ring of cilia, trunk tapering posteriorly to a narrow end. Mouth at the summit of the

neck, without a pharynx. Length of the body twice as much as the width, with the greatest width in front of the middle. The whole of the body has a dark brown appearance except at the two ends, where it is transparent. Surface marked by longitudinal and transverse striations. Contractile vacuole single, occupying the whole of the narrow posterior end.

Fig. 27.



Fig. 28.

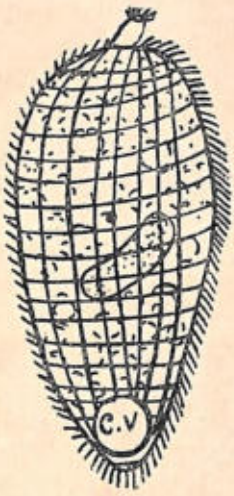


Fig. 27.—*Lacrymaria olor* (O. F. Müll.). *B*, mouth; *Ma*, macronucleus; *Mi*, micronucleus; *V.C*, contractile vacuoles. (After Roux.)

Fig. 28.—*Lacrymaria striata* Gulati. *C.V*, contractile vacuole. (After Gulati.)

Macronucleus oval, a little behind the middle of the body. Micronucleus small, rounded, and lying a little in front of the macronucleus. Locomotion calm and gliding, rotating round its axis.

Dimensions.—90 μ by 43 μ.

Remarks.—According to Kahl (1930–5) it is probably a stronger form of *L. pupula* (O. F. Müller), of which species *L. coronata*

Clap. & Lach. var. *aqua dulcis* Roux is a synonym. That the pellicle should have both longitudinal and transverse striations is very unusual for a *Lacrymaria*. *L. coronata* and *L. pupula* show longitudinal striations, and if Gulati has correctly observed transverse striations this species indicates an approach to *Coleps*.

Habitat.—Stagnant water of a drain : PUNJAB, Lahore.

32. **Lacrymaria vermicularis** (O. F. Müller). (Fig. 29.)

Trichoda vermicularis, O. F. Müller, 1786, p. 198, pl. xxviii, figs. 1–4.
Phialina vermicularis, Ehrenberg, 1831, p. 111 ; 1838, p. 334, pl. xxvi, fig. 3 ; Dujardin, 1841, pp. 472–3 ; Claparède & Lachmann, 1858–61, pp. 304–5, pl. xviii, fig. 8.
Lacrymaria vermicularis, Fromentel, 1874, pp. 282–3, pl. xv, figs. 3, 3 *a*.
Phialina vermicularis, Kent, 1880–2, p. 519, pl. xxvi, fig. 36.
Lacrymaria vermicularis, Bütschli, 1887–9, p. 1684 ; Schewiakoff, 1896, pp. 143–4.
†*Lacrymaria vermicularis*, Bhatia, 1916, p. 180, fig. 2.
Lacrymaria spiralis, Kahl, 1926, p. 217.
Lacrymaria vermicularis, Schoenichen, 1927, p. 184 ; Kahl, 1930–5, p. 95, fig. 13, *5–7*.

Body cylindrical, ovate or pyriform, narrowest anteriorly, very contractile, apical portion in front of the annular furrow

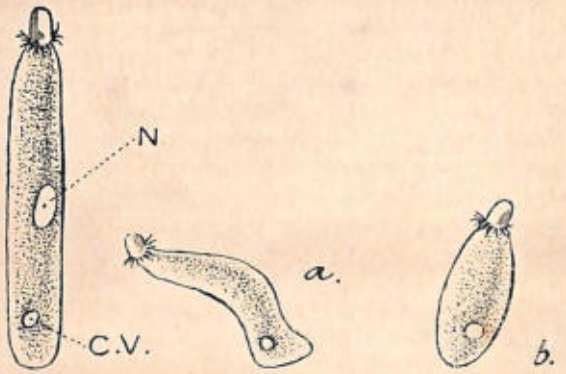


Fig. 29.—*Lacrymaria vermicularis* (O. F. Müll.), fully extended ; *a*, moderately extended ; *b*, fully contracted. *N*, macronucleus ; *C.V.*, contractile vacuole. (After Bhatia.)

short and thick, and bearing a single circlet of cilia which are usually directed backwards. Oral aperture at the summit of the apical portion. Surface of the body smooth or with short, close, fine cilia arranged in longitudinal or spiral rows. Contractile vacuole single, spherical, postero-terminal. Macronucleus oval, subcentral, obliquely directed.

Dimensions.—Length about 120 μ.

Remarks.—Body is subcylindrical, or bottle-shaped if the apical lobe is taken into consideration, flexible and contractile; the statement that it is two and a half times as long as broad (Kent, 1880–2, p. 519) appears to refer to the contracted state of the animal; in the fully extended condition it is four to six times as long as broad. Apical portion in advance of the annular furrow is short and cylindrical and bears at its base a single circlet of cilia which are directed backwards, the rest of the body is generally described as finely ciliate, though I found it glabrous, as was described by Ehrenberg and other early writers. The nucleus is oval in outline, and the single contractile vacuole is situated near the posterior end.

Kahl (1930–5) shows his examples to be spirally striated and the body bearing cilia.

Habitat.—Fresh water: PUNJAB, Lahore.

Genus **ENCHELIS** O. F. Müller, 1773.

Enchelis O. F. Müller, 1773, p. 33.
Enchelys Nitzsch, 1817, p. 125; Ehrenberg, 1838, p. 209; Claparède & Lachmann, 1858–61, pp. 294, 309–12; Fromentel, 1874, p. 187; Kent, 1880–2, p. 509; Roux, 1901, p. 23; Schoenichen, 1927, p. 180; Kahl, 1930–5, p. 96.

Animalcules free-swimming. Body elongated or egg-shaped, with anterior end narrowed, drawn out and obliquely truncate and posterior end rounded. Mouth antero-terminal, pharynx absent, anus postero-terminal. Cilia short, fine, with a fringe of larger cilia encircling the oral region. Contractile vacuole single and terminal or numerous and arranged in a longitudinal row. Macronucleus subcentral, spherical or oval. Inhabiting marsh and stagnant water and in infusions.

33. **Enchelis arcuata** Claparède & Lachmann. (Fig. 30.)

Enchelys arcuata, Claparède & Lachmann, 1858–61, p. 311, pl. xvii, fig. 4; Kent, 1880–2, p. 510, pl. xxvii, fig. 14; Schewiakoff, 1896, p. 130, pl. i, fig. 10.
†*Enchelys arcuata*, Bhatia, 1916, p. 179.
Enchelys arcuata, Lepsi, 1926 *a*, p. 38, fig. 39; Schoenichen, 1927, p. 180, pl. xii, fig. 3; Kahl, 1930–5, p. 96, fig. 12, *21*.

Body pyriform, attenuate anteriorly. Cilia of general surface very short and fine. Contractile vacuoles several, arranged in an arcuate manner along the margin of the body. Macronucleus elongate-oval.

Dimensions.—Length about 80 μ.

Remarks.—Body is rounded posteriorly, attenuated anteriorly. Length 80 μ, maximum width 30 μ. The animal

is broadest at one-fourth of the length of the body from the posterior end, and begins to taper rapidly in the anterior fourth. Anterior end is obliquely truncate and is occupied by the mouth. Cilia covering the whole body are very fine, rather longer ones surrounding the oral end.

Habitat.—Infusion of leaves : PUNJAB, Lahore.

Fig. 30.

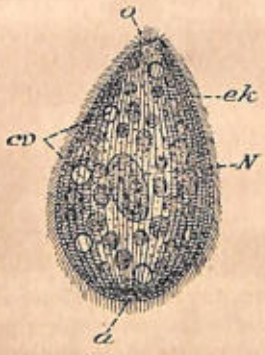


Fig. 32.

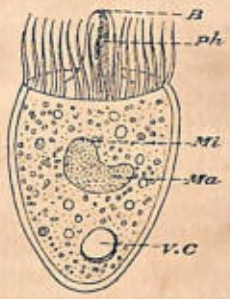


Fig. 31.

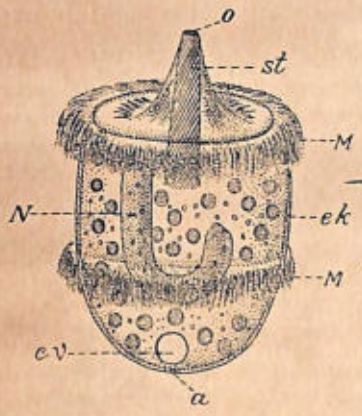


Fig. 33.

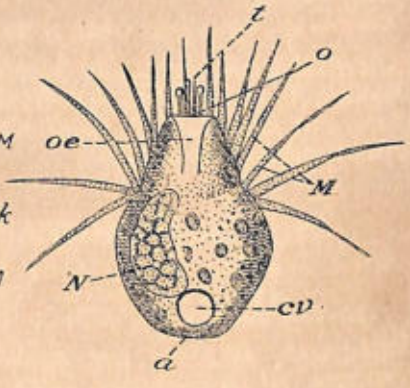


Fig. 30.—*Enchelis arcuata* Clap. & Lach. *a*, anus ; *cv*, contractile vacuole ; *ek*, ectoplasm ; *N*, macronucleus ; *o*, oral aperture. (After Schewiakoff.)

Fig. 31.—*Didinium nasutum* (O. F. Müll.). *M*, wreath of cilia ; *st*, seizing organ with trichocysts. Other lettering as in fig. 30. (After Schewiakoff.)

Fig. 32.—*Didinium balbiani* (Fabre-Dom.). *B*, mouth ; *Ma*, macronucleus ; *Mi*, micronucleus ; *ph*, pharynx ; *v.c.*, contractile vacuole. (After Roux.)

Fig. 33.—*Mesodinium pulex* (Clap. & Lach.). *a*, anus ; *cv*, contractile vacuole ; *M*, membranellæ ; *N*, macronucleus ; *o*, oral aperture ; *oe*, pharynx ; *t*, tentacles. (After Schewiakoff.)

34. **Enchelis** sp.

†*Enchelys* sp., Sandon, 1927, p. 172, Chart III.

Habitat.—Farm and garden soil: South India, Coimbatore.

35. **Enchelis** sp.

†*Enchelys* sp., Chaudhuri, 1929, p. 54, Table III.

Habitat.—Soil from cultivated fields: Punjab, Lahore, Lyallpore; Bengal, Sibpore.

Genus **CHÆNEA** Quennerstedt, 1867.

Chænea, Quennerstedt, 1867, p. 15.
Chœnia, Kent, 1880–2, p. 521.
Chœnia, Schewiakoff, 1896, p. 154; Roux, 1901, p. 29.
Chœnia, Schoenichen, 1927, p. 182.
Chœnea, Kahl, 1930–5, p. 103.

Body elongated, somewhat cigar-shaped. Cilia fine, arranged spirally. Mouth slit-like, at the anterior extremity, often surrounded by a brush-like tuft of larger cilia.

36. **Chænea** sp.

Chœnia sp., Chaudhuri, 1929, p. 60.

In his Table IV Chaudhuri mentions a species of this genus as having been recorded by Sandon from South India and Burma, but reference to Sandon's monograph shows that he did not record it from India.

Genus **TRACHELOCERCA** Ehrenberg, 1840.

Trachelocerca, Ehrenberg, 1840, p. 316; Cohn, 1866, p. 264; Kent, 1880–2, p. 514; Bütschli, 1887–9, p. 1684; Calkins, 1926, pp. 381, 403; Lepsi, 1926 *a*, p. 33; Kahl, 1930–5, p. 116.

Elongated, more or less flexible, plump to very slender vermiform or flask-shaped form, not flattened. Oral cone 2–4-lobed; with circlet of cilia and no constriction marking off the anterior portion.

Remarks.—This genus is distinguished from the closely-related *Lacrymaria* by the absence of a groove marking off a neck-like constriction, and from *Chœnea* by the anterior end not being narrowed into a neck-like portion and by the body not showing spiral striations during contraction.

37. **Trachelocerca** sp.

Trachelocerca sp., Simmons, 1891, p. 4.

Habitat.—Pond water: Bengal, Calcutta.

2. Family DIDINIIDÆ Poche, 1913.

Body spheroid or ellipsoid. Cytostome round, situated at the summit of an apical truncated cone, which is surrounded at its base by a ciliary girdle, with one or more ciliary girdles situated more posteriorly. Rest of the body uniformly ciliated or naked.

Key to Indian Genera.

Body with one or two circlets of membranelles; rest of the body without cilia.....	DIDINIUM St., p. 93.
Body with an equatorial furrow containing one or more girdles of cirri; cytostome surrounded by small tentacles.....	MESODINIUM St., [p. 95.

Genus **DIDINIUM** Stein, 1859.

Didinium Stein, 1859 *a*, p. 5; Kent, 1880–2, p. 638; Schewiakoff, 1889, p. 15; 1896, p. 178; Roux, 1901, p. 32; Schoenichen, 1927, p. 187; Kahl, 1930–5, p. 123.

Animalcules free-swimming, large, ovoid, flat or deepened in front. From the middle of the anterior end a conical process projects forward, at the summit of which lies the mouth-opening, which is capable of being widened considerably. Cytopharynx provided with fine rods. Body provided with one or more girdles of membranelles, which frequently break up into separate cilia; rest of surface without cilia. Contractile vacuole and anal aperture posterior. Macronucleus horseshoe-shaped. Multiplication by transverse fission.

38. **Didinium balbiani** (Fabre-Domergue). (Fig. 32.)

Monodinium balbiani, Fabre-Domergue, 1888, pp. 35–9, pl. iv, figs. 43–50.
Didinium balbiani, Bütschli, 1887–9, p. 1688, pl. lviii, figs. 4 *a–b*; Schewiakoff, 1889, pp. 15–17, pl. ii, figs. 14–21; 1896, pp. 181–2, pl. ii, fig. 39, pl. vii, fig. 196; Roux, 1901, p. 32, pl. ii, fig. 1.
†*Didinium balbiani*, Bhatia, 1922, p. 29.
Didinium balbiani, Penard, 1922, p. 56, fig. 59.
†*Didinium balbiani*, Gulati, 1925, p. 746–7, fig. 6.
Didinium balbiani, Lepsi, 1926 *a*, p. 40, fig. 83; Schoenichen, 1927, p. 187, pl. xii, fig. 10; Kahl, 1930–5, p. 125, pl. xviii, fig. 24.

Body ovate, rounded and narrower posteriorly, with the anterior broader end produced into a conical projection. A single ciliary wreath near the base of the proboscis only. Contractile vacuole large and posterior. Macronucleus band-like and curved, micronucleus situated close to one end. Locomotion not so rapid as in *D. nasutum*.

Dimensions.—Length 60–100 μ.

Remarks.—The pellicle is said to be provided with very weak longitudinal striations, differing in number, according to the observations of different authors, from 6 to 12, wide apart according to Faure-Fremiet and close together according to Schewiakoff. According to Faure-Fremiet isolated trichocysts are found in the ectoplasm. Endoplasm colourless, granular. This species is widespread, planktonic or on the surface of plants, rarely among detritus.

Habitat.—In the surface layer of clear swamp-water near the River Ravi : PUNJAB, Lahore.

39. **Didinium nasutum** (O. F. Müller). (Fig. 31.)

Vorticella nasuta, O. F. Müller, 1773, pp. 102–4; 1786, pp. 268–70, pl. xxxvii, figs. 20–4.
Didinium nasutum, Stein, 1859*a*, p. 5; 1867, pp. 124, 148, 168; Engelmann, 1862, pp. 375–6; Balbiani, 1873, pp. 363–94, pl. xviii; Kent, 1880–2, pp. 638–9, pl. xxxii, figs. 50–7; Maupas, 1888*a*, pp. 191–2; 1889, pp. 276–7, pl. xvi, figs. 27–8; Bütschli, 1887–9, p. 1686, pl. lviii, fig. 3; Schewiakoff, 1896, p. 182, pl. ii, fig. 40; Thon, 1905, pp. 281–321, pls. xii–xiii, & figs. 1–3; Prandtl, 1906, pp. 229–58, pls. ix–x & 12 figs.
†*Didinium nasutum*, Bhatia, 1916, p. 180.
Didinium nasutum, Penard, 1922, p. 55, fig. 58.
†*Didinium nasutum*, Gulati, 1925, p. 746, fig. 5.
Didinium nasutum, Bullington, 1925, p. 269; Lepsi, 1926*a*, p. 40, fig. 84; Calkins, 1926, pp. 154, 178, 216, figs. 88, 89; Schoenichen, 1927, p. 187; Kahl, 1930–5, p. 125, fig. 18, *20* & *22*; Beers, 1935, pp. 133–55.

Body oval or barrel-shaped, rounded posteriorly, the anterior border produced into a conical projection. One wreath of cilia near the base of the proboscis, the other posterior to the middle of the body. Ectoplasm without distinct trichocysts. Contractile vacuole large, debouching upon the anal aperture. Macronucleus band-like, curved. Devours large Infusoria ; revolves impetuously.

Dimensions.—Length 100–180 μ.

Remarks.—Specimens found by me at Lahore measured on an average 123 μ by 84 μ. Apparently this species is subject to large variations of size, as the dimensions given by different authors differ very widely. Kent, for example, gives the length as 1/300 of an inch (83 μ), while Conn and Edmondson state it to be 100–175 μ. The animalcule is often found attached to a *Paramecium* by its snout-like process.

Besides the principal contractile vacuole situated posteriorly I found three or four subsidiary ones scattered in different parts of the body. These were carried towards the principal vacuole by circulation of the protoplasm and absorbed into it one by one. In one case two of these vacuoles reached the

principal vacuole at about the same time; the one that touched it first was absorbed into it, the other had to wait for its turn.

Habitat.—Pond water, in the dusty upper surface of water or amidst decaying vegetation: PUNJAB, Lahore.

Genus **MESODINIUM** Stein, 1862.

Mesodinium, Stein, 1862 *b*, p. 162; 1867, p. 148; Kent, 1880–2, p. 635.
Acarella, Kent, 1880–2, p. 636.
Mesodinium Bütschli, 1887–9, p. 1688; Schewiakoff, 1896, p. 183; Roux, 1901, pp. 32–3; Calkins, 1926, p. 404; Sandon, 1927, p. 175; Reichenow, 1929, p. 1170.

Body ovate or pear-shaped, divided into two unequal parts by an equatorial furrow, anterior conical and posterior spherical. In the groove are situated one or more girdles of larger cilia, which are united in groups to form membranelles. The remaining part of the body is naked. Cytostome at the anterior end of the snout often surrounded by small tentacles. Cytopharynx more or less elongated, conical, provided with rods. Anus posterior. Contractile vacuole in the close neighbourhood of the anus. Macronucleus spherical or ovoid. Locomotion irregular, quick.

40. **Mesodinium pulex** (Claparède & Lachmann). (Fig. 33.)

Halteria pulex, Claparède & Lachmann, 1858–61, p. 370, pl. xiii, figs. 10–11.
Acarella siro, Cohn, 1866, pp. 293–4, 301, pl. xv, figs. 32–4.
Mesodinium pulex, Stein, 1867, p. 162.
†*Halteria pulex*, Carter, 1869, pp. 259–60, pl. xvii, fig. 23.
Mesodinium pulex, Kent, 1880–2, p. 636, pl. xxxii, fig. 44.
Acarella siro, Kent, 1880–2, pp. 636–7, pl. xxxii, fig. 45; Mereschkowsky, 1882, pp. 1232–4; 1883, pp. 276–9.
Mesodinium pulex, Maupas, 1882, pp. 1381–4; 1883, pp. 516–8; Gourret & Roeser, 1886, pp. 491–3, pl. xxx, fig. 13; Bütschli, 1887–9, pl. lviii, fig. 5; Schewiakoff, 1896, pp. 185–6, pl. ii, fig. 42; Penard, 1922, pp. 58–61, figs. 62, 63; Lepsi, 1926, p. 40, fig. 90; Kahl, 1930, p. 127, fig. 18, 7, 8.

Body egg-shaped, globose posteriorly, conical and tapering as it approaches the anterior projecting snout; two wreaths of cirrose membranelles developed on an annular groove, those of the anterior spread in different directions, those of the posterior directed spirally backwards to the left; the rest of the surface of the body naked. Mouth at the anterior end, surrounded by 4 to 8 forwardly directed tentacles. Pharynx more or less elongated, conical, provided with rods. Anus posterior. Contractile vacuole postero-lateral. Endoplasm

with large, colourless food-particles. Macronucleus of two spherical parts. Locomotion irregular, swift.

Pelagic or among detritus in salt or fresh water.

Dimensions.—Length 20–30 μ, or according to some up to 40 μ.

Remarks.—Claparède and Lachmann, who described this species under the title *Halteria pulex*, showed it as possessing three long bristle-like processes in advance of the mouth. Stein regarded these simply as three forwardly-directed locomotive cirri, but Kent interpreted them as an optical misinterpretation of the everted attenuate proboscis. Kahl has shown that these tentacles are provided distally with suckers and serve to attach the organism during intervals of rest. According to him the tentacles are not always recognizable. The macronucleus is shown as a single rounded body by Kent and by Blochmann, and as kidney-shaped by Schewiakoff. According to Penard there are always two small macronuclei, one to the right and the other to the left of the median line, a little way behind the transverse furrow.

Habitat.—Fresh water : Bombay.

3. Family COLEPIDÆ Claparède & Lachmann, 1858.

Body barrel-shaped or pointed posteriorly, covered with an ectoplasmic armour of regularly arranged plates. Anterior end of the body truncated, surrounded by the teeth-like ends of the plates. Cilia arranged in longitudinal rows, those near the mouth more strongly developed. Cytostome apical, surrounded by cirri-like structures. Cytopharynx wide, funnel-shaped, provided with rod-apparatus.

Genus **COLEPS** Nitzsch, 1817.

Coleps, Nitzsch, 1817, p. 69 ; Ehrenberg, 1838, p. 317 ; Dujardin, 1841, p. 565 ; Claparède & Lachmann, 1858–61, p. 364 ; Fromentel, 1874, p. 191 ; Kent, 1880–2, p. 506 ; Bütschli, 1887–9, p. 1686 ; Schewiakoff, 1896, p. 166 ; Roux, 1901, p. 30 ; Noland, 1925, pp. 3–13 ; Schoenichen, 1927, p. 185 ; Kahl, 1930–5, p. 131.

Animalcules free-swimming, small to medium-sized, more or less barrel-shaped. Anterior end truncate, surrounded by teeth-like projections. Cuticular surface usually longitudinally and transversely furrowed, and thus divided into numerous symmetrical quadrangular facets forming a coat of mail ;

quadrangular facets smooth and indurated, the narrow intervening furrows soft and clothed with cilia. Mouth apical, terminal, surrounded with cilia of slightly larger size than those of the general surface; pharynx wide, funnel-shaped, and provided with rod-apparatus; anal aperture postero-terminal. Contractile vacuole single and terminal. Macronucleus rounded, with a micronucleus lying close to it. Posterior end of the body rounded and generally provided with spines.

Divides by transverse fission. Locomotion rapid, constantly revolving and often changing the direction. Frequently containing zoochlorellæ. Marine and fresh water.

Key to Indian Species.

1 (4). With posterior spines	2.	
2 (3). Three posterior spines; 20 longitudinal rows of plates; body fairly plump: length 40–65 μ		[p. 97. *C. hirtus* (O. F. Müll.),
3 (2). Four posterior spines: length 60–70 μ.		*C. uncinatus* Clap. & [Lach., p. 100.
4 (1). Without posterior spines: length about 52 μ		*C. kenti* Bhatia, p. 98.

41. **Coleps hirtus** (O. F. Müller). (Fig. 34.)

Cercaria hirta, O. F. Müller, 1786, p. 128, pl. xix, figs. 17–18.
Coleps hirtus, Nitzsch, 1817, p. 4; Ehrenberg, 1830, p. 42; 1831, p. 100; 1838, p. 317, pl. xxxiii, fig. 1, pl. xxxv, fig. 1; Dujardin, 1841, pp. 566–7, pl. xvi, fig. 10; Claparède & Lachmann, 1858–61, p. 366; Pritchard, 1861, p. 616, pl. xxiv, figs. 284–6; Engelmann, 1862, p. 350; Stein, 1867, p. 118; Fromentel, 1874, p. 311, pl. xxii, fig. 25; Kent, 1880–2, p. 506, pl. xxvii, figs. 3, 4; Maupas, 1885, pp. 337–67, pl. xvii; 1888*a*, p. 236; 1889, p. 271, pl. xvi, fig. 13; Bütschli, 1887–9, pp. 1686–7, pl. lviii, fig. 1; Schewiakoff, 1893, p. 38; 1896, pp. 169–70, pl. ii, fig. 35; Roux, 1901, p. 30, pl. i, fig. 19.
†*Coleps hirtus*, Bhatia, 1916, p. 180; Ghosh, 1921, p. 7; Gulati, 1925, p. 747, fig. 4.
Coleps hirtus, Noland, 1925, pp. 6–7, pl. i, fig. 3; Bullington, 1925, p. 266; Lepsi, 1926*a*, p. 41, fig. 86; Calkins, 1926, pp. 128, 374, figs. 65, 164; Sandon, 1927, p. 175; Schoenichen, 1927, p. 186, pl. xii, fig. 9.
†*Coleps hirtus*, Bhatia & Mullick, 1930, p. 391.
Coleps hirtus, Kahl, 1930–5, p. 134, fig. 19, *1*, *2*.

Body barrel-shaped, about twice as long as broad, rounded posteriorly, slightly narrower and truncate in front; anterior margin denticulate, posterior extremity provided with three spines. Cuticular surface divided into quadrangular areas. Colour whitish or light brown. Contractile vacuole single, posteriorly situated. Macronucleus spherical, subcentral.

Dimensions.—Length 40–65 μ.

Remarks.—Specimens of this cosmopolitan species are quite commonly met with in ponds, and whenever encountered are found in abundance. Individuals exhibit considerable differences in size and appearance. Specimens taken in

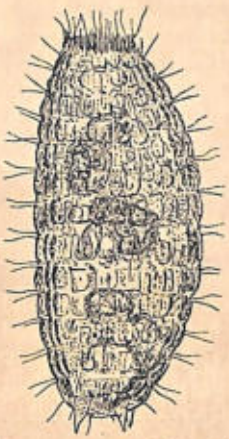


Fig. 34.—*Coleps hirtus* (O. F. Müll.). (After Noland.)

Lahore are generally 40μ by 20μ in size, but those found in Srinagar were larger, measuring from 48 to 60μ in length.

Habitat.—Pond water: KASHMIR, Srinagar; PUNJAB, Lahore; BENGAL, Calcutta.

42. **Coleps kenti** Bhatia. (Fig. 35.)

Coleps hirtus (part), Kent, 1880–2, p. 507.
†*Coleps kenti*, Bhatia, 1922, p. 28.
Coleps striatus, Kahl, 1930–5, p. 137, fig. 19, *20*, *21*.

Body barrel-shaped, only one and one-third as long as broad, rounded posteriorly, broad and truncate anteriorly, not provided with apical projections and posterior spines. Cuticular surface divided into quadrangular areas by longitudinal and transverse furrows, the latter dividing the body into four chief girdles. Contractile vacuole and anal aperture posterior. Macronucleus spherical, subcentral.

Dimensions.—Length 52μ, width 39μ.

Remarks.—This species differs from *C. hirtus* in being proportionately much broader and in the absence of apical projections and posterior spines. Kent also had observed forms "in which no cusps whatever were developed at the posterior extremity, the size, quadrangular corrugation, and deeper longitudinal lines of furrows being, in common

with all other structural details, identical with what obtains in *C. hirtus*. . . . While the comparative length and breadth range in most instances in the proportion of two to one, much shorter and almost subspherical specimens were not infrequently encountered." He, however, thought that this well-marked variety should perhaps be properly referred to the genus *Plagiopogon*. But the genus *Plagiopogon* was founded by Stein for *Coleps*-like forms which, though not possessing apical or posterior spines, are only longitudinally furrowed, and the surface is neither marked off into quadrangular areas nor bears a coat of mail, as *Coleps* does. The form encountered by me is practically the same as that described by Kent, and regarded by him as a distinct variety of or a most closely allied species to *C. hirtus*, except that I did not find

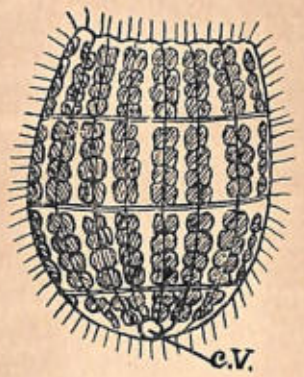


Fig. 35.—*Coleps kenti* Bhatia. *C.V.*, contractile vacuole. (After Bhatia.)

the proportion of length to breadth as two to one. For the reason mentioned above I would not refer Kent's form and mine to *Plagiopogon*, but consider that they merit separate specific distinction.

Noland (1925) in his monograph on the genus *Coleps* has overlooked this species. In the species recognized by Noland a number of posterior spines are always present, but in *C. kenti* there are no posterior spines, though the body is covered with a coat of mail. Referring to Kent's original description, Noland thinks that, if it is not a *Plagiopogon*, it is the simplest type of *Coleps* yet observed. Kahl (1930–5) considers my species as synonymous with *Coleps striatus* Smith, 1897, and *Coleps inermis* Perty, 1852. I have not access to the original works of Smith and Perty, but on comparing my figure with those of *C. striatus* and *C. inermis*,

as reproduced by Kahl, I find that my form is quite distinct. It is proportionately broader and more clearly marked into quadrangular facets.

Habitat.—Pond water : PUNJAB, Lahore.

43. **Coleps uncinatus** Claparède & Lachmann. (Fig. 36.)

Coleps uncinatus, Claparède & Lachmann, 1858–61, p. 366, pl. xii, fig. 9 ; Kent, 1880–2, p. 507, pl. xxvii, fig. 6 ; Schewiakoff, 1896, p. 171 ; Roux, 1901, p. 30, pl. i, fig. 20.
†*Coleps uncinatus*, Bhatia, 1922, p. 29.
Coleps uncinatus, Noland, 1925, p. 8, fig. 1 *b* ; Lepsi, 1926 *a*, p. 41 ; Schoenichen, 1927, p. 186, fig. 712 ; Kahl, 1930–5, p. 135, fig. 19, *11*.

Body ovate, slightly flattened ventrally, two and a half times as long as broad ; the anterior margin bearing two spines

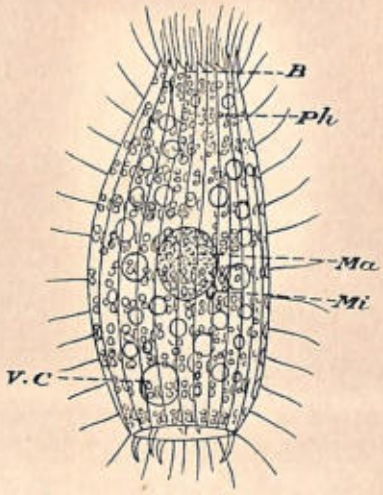


Fig. 36.—*Coleps uncinatus* Clap. & Lach. *B*, mouth ; *Ma*, macronucleus ; *Mi*, micronucleus ; *Ph*, pharynx ; *V.C*, contractile vacuole. (After Roux.)

on the more flattened ventral side ; four acuminate spines developed at the posterior extremity. Contractile vacuole single, posteriorly situated. Macronucleus discoidal, central ; micronucleus situated close by. Rare and living in mud.

Dimensions.—Length 60–70 μ, width 28–33 μ.

Remarks.—The average size of my specimens was 70 μ by 28 μ, and the body was elongated oval and provided with four posterior spines. On staining with acetic methyl-green the spherical macronucleus and the small micronucleus situated close by it were observed. On the ventral anterior margin

are two spines or hooks which, according to Claparède and Lachmann (1858–61), are recurved, but are shown by Roux (1901) as straight and pointing forward. In the latter case, according to Noland (1925), they do not differ materially from the longer teeth that may be seen at the lateral angles of the mouth of nearly all species of *Coleps*.

Habitat.—Pond water : PUNJAB, Lahore.

44. **Coleps** sp.

Coleps sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

4. Family SPATHIDIIDÆ Kahl, 1930.

Body oval or cylindrical, with truncated anterior end. Cilia arranged in longitudinal rows. Cytostome anterior, slit-like, surrounded by a laterally compressed, more or less prominent, padded margin, which bears trichocysts.

Genus **SPATHIDIUM** Dujardin, 1841.

Spathidium, Dujardin, 1841, p. 457 ; Bütschli, 1887–9, p. 1680 ; Roux, 1901, p. 23 ; Hickson, 1903, pp. 397, 398 ; Penard, 1922, p. 23 ; Lepsi, 1926 *a*, p. 39 ; Calkins, 1926, p. 404 ; Schoenichen, 1927, p. 180 ; Reichenow, 1929, p. 1171 ; Kudo, 1931, p. 350 ; Kahl, 1930–5, p. 149.

Animalcules free-swimming, medium-sized to large ; body nearly purse-shaped, flexible, anterior end truncated and generally wholly taken up by the slit-like mouth ; margins of the mouth padded and thickened. Without pharynx. Cilia fine, short, in longitudinal rows, somewhat longer on the thickening round the mouth. Contractile vacuole terminal or varying in number and position. Anus at the posterior end. Macronucleus round to elongated and rosary-shaped. Micronuclei one to many. Cysts spherical.

45. **Spathidium moniliforme** Bhatia. (Fig. 37.)

†*Spathidium spathula* var. *moniliforme*, Bhatia, 1920, p. 259.
Spathidium spathula, Penard, 1922, p. 23, fig. 16.
†*Spathidium spathula*, Gulati, 1925, p. 745, pl. i, fig. 2.
Spathidium moniliforme, Kahl, 1930–5, p. 158, fig. 22, *3*.

Body elongated, flask-shaped, flexible but not deformable ; anterior end obliquely truncate and occupied almost completely by the narrow and elongated slit-like mouth ; margins

of the oral portion padded and provided with longer cilia. Ciliary lines on the general surface of the body close and provided with fine and short cilia. Trichocysts small, fusiform and more numerous round the mouth. Large contractile vacuole at the posterior end of the body. Macronucleus elongated, consisting of a number of beads, which are sometimes disjointed.

Dimensions.—Length up to 260 μ.

Remarks.—The animals were found in large numbers. The body was flask-shaped, flexible though not very contractile; the anterior end was narrower than the middle of the body, obliquely truncate and occupied almost completely by the narrow and elongated slit-like mouth. The margins of the oral portion were padded. The general surface of the body



Fig. 37.—*Spathidium moniliforme* Bhatia. *C.V.*, contractile vacuole; *N*, macronucleus; *O*, mouth. (After Bhatia.)

appeared to be striate. Cytoplasm was granular and the anterior part of the body somewhat clearer and more transparent. Ciliation was uniform, with somewhat longer cilia round the anterior end. The movements of the animal were slow, the anterior part of the body occasionally bending slightly.

This form differs from *S. spathula* O. F. Müller in its much smaller size and in the character of the nucleus. The animals measured only 105 μ by 20 μ, instead of the usual size of the species, which is given as 180–240 μ. The macronucleus consisted of a long chain of small beads, which was bent upon itself. In the generic characters given by Bütschli the nucleus is said to be round to elongated and rosary-shaped, but in the figure of *S. spathula* is shown as consisting of three

large beads only (plate lviii, fig. 10). E. André (1916), under the name *S. spathula* var. *plurinucleata*, described a form containing a large number of small, separate, rounded nuclei. The form here described differs from the latter in that these small, separate, rounded nuclei are not irregularly scattered but are parts of an elongated rosary which is bent upon itself. The form was originally described by me as a new variety of *S. spathula*, but Kahl (1930) in his recent monograph considers *S. plurinucleata* André and *S. moniliforme* Bhatia to be distinct species and *S. spathula* as described by Penard to be identical with the latter. The size of the form described by Penard is mentioned as 240–260 μ long and 35–60 μ wide, and Penard has stated that the beads of the macronucleus are sometimes disjointed. Gulati (1925) found specimens which were proportionately very much wider than mine, measuring 112 μ by 85 μ.

Habitat.—Pond water : PUNJAB, Lahore.

5. Family BÜTSCHLIIDÆ Poche, 1913.

Parasites in the gut of the Ungulate mammals. Ciliation over the whole body or reduced to a single zone at the anterior end. Cytostome circular, situated at the anterior end of the body ; generally an anus at the posterior end. One or more contractile vacuoles.

Remarks.—This family includes a large number of genera, most of which have been incompletely studied, and it is uncertain if all of them will, on further examination, be found to belong to this family.

Genus **BÜTSCHLIA** Schuberg, 1888.

Bütschlia, Schuberg, 1888, pp. 369, 371 ; Bütschli, 1887–9, p. 1690 ; Hickson, 1903, p. 400 ; Wenyon, 1926, pp. 1188–9 ; Reichenow, 1929, p. 1171.

Body egg-shaped ; very minute cilia cover the general surface with a special pre-oral crown of longer cilia, and in some species an additional tuft of longer cilia at the posterior extremity. Cytostome terminal, leading to a short pharynx. A large spherical macronucleus and a single contractile vacuole present.

Three species are known from the stomach of cattle and one from the cæcum of the horse.

46. **Bütschlia parva** Schuberg. (Fig. 38.)

Bütschlia parva, Schuberg, 1888, p. 372, pl. xii, figs. 1 & 2; Wenyon, 1926, p. 1189, fig. 504, *1*; Reichenow, 1929, p. 1171, fig. 1158.
†*Bütschlia parva*, Kofoid & MacLennan, 1933, p. 28.

Form oval, often nearly spherical. Anterior end almost evenly truncated. Cytostome in the middle of the anterior end, leading to a short gullet. The entire surface of the body is covered with short and fine cilia, which are arranged in moderately spaced, longitudinal rows; specially long cilia cover the anterior end of the body. There is a large spherical macronucleus and a single contractile vacuole. The endo-

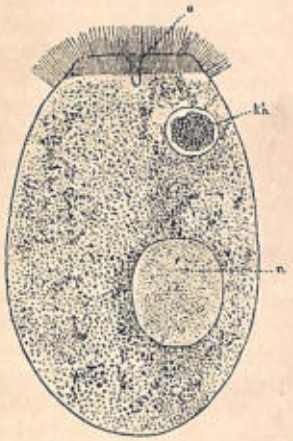


Fig. 38.—*Bütschlia parva* Schuberg. *kh*, excretory mass; *n*, macronucleus; *o*, mouth. Very fine cilia covering the whole body not shown. (From Reichenow, after Schuberg.)

plasm contains near the anterior end another vacuole, which is filled with strongly refractile, excretory particles. Parasitic in the rumen of cattle and sheep.

Dimensions.—Up to 50μ in length.

Remarks.—Schuberg (1888), who first described this species, could detect only the longer cilia covering the anterior end of the body, but later observers state that, in addition, the whole body is covered with fine cilia.

Habitat.—Stomach of *Bos indicus*: locality not noted (Coonoor or Colombo).

2. Tribe PLEUROSTOMATA Schewiakoff, 1896, emend. Kahl, 1930.

Gymnostomatous Ciliates with the cytostome slit-like, running from the anterior pole along the compressed ventral border of the body, or round and situated at the base of a proboscis.

Identification Table of Families.

1 (6).	Cytostome slit-like	2.
2 (5).	Cytostomial slit ciliated	3.
3 (4).	Cytostomial slit on the convex ventral border of the anterior part of the body	[Bütsch., p. 105. **Amphileptidæ**
4 (3).	Cytostomial slit on the concave ventral border of the anterior part of the body....	[p. 119. **Loxodidæ** Bütsch.,
5 (2).	Cytostome in an unciliated groove extending backward from the anterior end; near the posterior end is a ciliated groove which may serve as an organ of attachment	[Grandori. **Amphibotrellidæ***
6 (1).	Cytostome round, at the base of a proboscis.	**Trachelidæ** [Ehrbg., p. 115.

1. Family AMPHILEPTIDÆ Bütschli, 1889.

Body lanceolate, more or less laterally compressed, showing two broad lateral surfaces, and dorsal and ventral borders. The ventral border is convex and the dorsal sigmoid. Cilia fine, on all sides of the body, or confined to one lateral surface. Cytostome slit-like, along the convex ventral border of the anterior part of the body, provided with trichocysts. Macronucleus bipartite or quadripartite, rarely undivided and band-shaped.

Key to Indian Genera.

1 (3).	Both sides of the body normally ciliated..	2.
2.	Oral cleft not reaching to the middle of the body. Body without hyaline trichocyst zone. Proboscis moderately long	[& Lachm., p. 106. AMPHILEPTUS Clap.
3 (1).	Only the right side of the body normally ciliated	4.
4 (5).	Body ventrally with flat trichocyst zone, dorsally with similar zone or with trichocyst warts, proboscis poorly developed..	[p. 112. LOXOPHYLLUM Duj..
5 (4).	Ventral and dorsal borders without trichocyst zone, left side quite unciliated, proboscis well developed	[p. 106. LITONOTUS Wrzes.,

Genus **AMPHILEPTUS** Claparède & Lachmann, 1859.

Amphileptus, Claparède & Lachmann, 1858–61, p. 347; Kent, 1880–2, p. 523; Bütschli, 1887–9, p. 1690; Roux, 1901, p. 34; Penard, 1922, p. 64; Lepsi, 1926 *a*, p. 34; Calkins, 1926, p. 405; Schoenichen, 1927, p. 189; Reichenow, 1929, p. 1172; Kahl, 1930–5, p. 182.

Body elongated, contractile, only little of the anterior part of the body flattened; posterior part narrower and pointed. Cilia fine, thickly arranged on all sides of the body along regular longitudinal rows. Cytostome slit-like, along the convex border of the proboscis. No cytopharynx. Trichocysts often present. Locomotion mostly slow, creeping hither and thither, or rotating on the long axis. Feeding on animal detritus.

47. **Amphileptus** sp.

Amphileptus sp., Simmons, 1891, p. 4.

Habitat.—Pond water: BENGAL, Calcutta.

Genus **LITONOTUS** Wrzesniowski, 1870.

Amphileptus (part), Ehrenberg, 1838, p. 354.
Loxophyllum (part), Claparède & Lachmann, 1858–61, pp. 357–64.
Leionota, Wrzesniowski, 1869, p. 33.
Litonotus, Wrzesniowski, 1870, p. 495.
Dileptus (part), Fromentel, 1874, pp. 176–7.
Litonotus, Kent, 1880–2, p. 742.
Lionotus, Bütschli, 1887–9, p. 1691; Roux, 1901, pp. 35–6; Penard, 1922, p. 64; Lepsi, 1926 *a*, p. 35; Calkins, 1926, p. 405; Schoenichen, 1927, p. 190; Reichenow, 1929, p. 1172; Kahl, 1930–5, p. 185.

Body elongated, strongly flattened, chiefly at the anterior end, often curved in a S-shaped manner, anteriorly drawn out into a more or less elongated neck, posterior end narrow and pointed. The right flattened surface with longitudinal rows of cilia, the left side of the body without cilia. Mouth slit-like, more or less elongated along the convex border of the anterior portion, with a row of stronger cilia along the left oral border and a row of trichocysts along the right oral border. Pharynx absent. Contractile vacuole single and terminal, or multiple and arranged in one or two rows. Anus at the posterior end or at the base of the tail-like portion. Macronucleus bipartite, the two halves connected by a thread, or sometimes band-shaped or multipartite. Body flexible, contractile, often transparent. Locomotion slow, gliding on the ciliated side.

Remarks.—Wrzesniowski erected the genus *Litonotus* for the reception of those species, previously referred to *Loxophyllum* or *Amphileptus*, which he demonstrated to be ciliate only on the lower or " ventral " surface. If, however, we regard the edge bearing the slit-like mouth as ventral, the ciliate surface should be referred to as right and the unciliated one as left.

Bütschli (1889) wrongly changed the name to *Lionotus* with the remark " falslich zuerst Litonotus genannt." The name as given by Wrzesniowski, the author of the genus, is *Litonotus*, and must be followed, as both *Leionota* and *Lionotus* are preoccupied.

Key to Indian Species.

1 (4). With single contractile vacuole.....	2.	
2 (3). Lanceolate, macronucleus consisting of two spherical lobes united to one another: 80–100 μ in length		[p. 107. *L. fasciola* (Ehrbg.).
3 (2). Lanceolate, macronucleus reniform: 90 μ in length.....		[p. 109. *L. infusionus* Ghosh.
4 (1). With several contractile vacuoles in a dorsal and a ventral row; posterior end of the body pointed; with trichocysts..	5.	
5 (6). Macronucleus of two spherical or oval parts, united together by a thread, or discrete: 200–300 μ in length.....		[Stokes, p. 110. *L. pleurosigma*
6 (5). Macronucleus bilobed, lobes in contact with one another: 170 μ in length		[p. 111. *L. similis* Ghosh.

48. **Litonotus fasciola** (Ehrenberg) Wrzesniowski. (Fig. 39.)

Amphileptus fasciola, Ehrenberg, 1838, p. 356, pl. xxxviii, fig. 17; Dujardin, 1841, p. 485, pl. xi, fig. 17.
†*Amphileptus fasciola*, Carter, 1856 *b*, p. 225.
Loxophyllum fasciola, Claparède & Lachmann, 1858–61, pp. 361–2.
Amphileptus fasciola, Stein, 1867, pp. 24, 64, 67, 118, 119.
Leionota fasciola, Wrzesniowski, 1869, p. 33.
Litonotus fasciola, Wrzesniowski, 1870, pp. 500–1, pls. xxii–xxiii, figs. 29–32.
Dileptus fasciola, Fromentel, 1874, p. 290, pl. xviii, fig. 8.
Litonotus fasciola, Kent, 1880–2, p. 743–4, pl. xlii, figs. 5–11.
Amphileptus massiliensis, Gourret & Roeser, 1886, pp. 471–2, pl. xxix, figs. 2, 3.
Lionotus fasciola, Bütschli, 1887–9, pp. 1372, 1388, 1461, 1691, pl. lix, fig. 6.
Loxophyllum fasciola, Maupas, 1888 *a*, p. 248; 1889, pp. 278–84, pl. xvi, figs. 29–42.
Lionotus fasciola, Schewiakoff, 1889, pp. 19–22; 1896, p. 202, pl. ii, figs. 49–50; pl. vi, fig. 158; pl. vii, figs. 176, 197; Roux, 1901, p. 36, pl. ii, fig. 3.
†*Loxophyllum fasciola*, Bhatia, 1920, p. 260.
†*Lionotus fasciola*, Ghosh, 1921, p. 8.
Lionotus fasciola, Penard, 1922, p. 64, fig. 68; Lepsi, 1926 *a*, p. 44, fig. 99; Schoenichen, 1927, p. 190, pl. xii, fig. 15.
Lionotus fasciola, Kahl, 1926, pp. 292–3, fig. K, ; 1930–5, p. 194, fig. 28, 7.
†*Lionotus fasciola*, Bhatia & Mullick, 1930, p. 393.

Body lanceolate, flexible but not contractile ; the neck-like portion scarcely equalling in length one-half of the entire body, curved at its extremity towards the right, gradually narrowing towards the end, and not sharply distinguished from the body; posterior end obtusely pointed. Mouth-cleft along the convex border of the neck ; the cilia situated along the mouth-cleft, of larger size than on the remaining surface ; trichocysts along the left oral border. Contractile vacuole single, situated

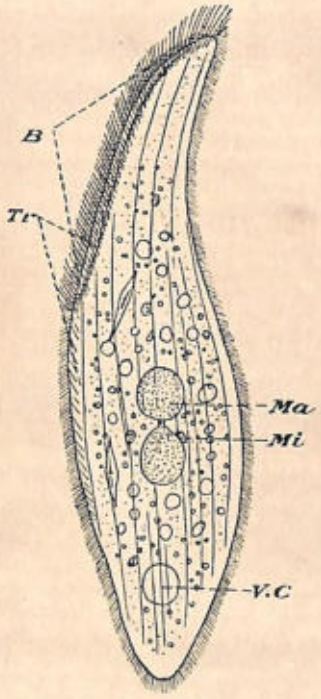


Fig. 39.—*Litonotus fasciola* (Ehrbg.). *B*, mouth-cleft ; *Ma*, macronucleus ; *Mi*, micronucleus ; *Tr*, trichocysts ; *V.C*, contractile vacuole. (After Roux.)

near the base of the short tail-like prolongation. Macronucleus bipartite, subcentral, each portion spheroidal, and connected by a cord-like structure ; micronucleus between the two portions of the macronucleus. Locomotion slow, alternately swimming backwards and forwards.

Dimensions.—Length 80–100 μ.

Remarks.—Examples of this species were found in large numbers in water from a drain at Lahore. They were of

somewhat smaller size than usual, and measured 94 μ by 31 μ, the neck portion being 31 μ, *i. e.*, one-third of the entire length. Locomotion was characteristic, slowly swimming forwards or backwards. Very much smaller specimens were found in pond water at Srinagar (Kashmir).

Habitat.—Dirty water : KASHMIR, Srinagar ; PUNJAB, Lahore ; BOMBAY ; BENGAL, Calcutta.

49. **Litonotus infusionus** Ghosh. (Fig. 40.)

†*Lionotus infusionus*, Ghosh, 1920 *a*, pp. 146–7, fig. 3 ; 1921 *a*, p. 7.
Lionotus infusionus, Kahl, 1930–5, p. 195.

Body lanceolate, widest in the middle and tapering to a rounded end posteriorly. Dorsal surface strongly convex in the middle, ventral slightly so, with a median ridge extending from the middle of the body to the posterior end. Anterior beak twisted and bent to the left side and towards the ventral



Fig. 40.—*Litonotus infusionus* Ghosh. (After Ghosh.)

aspect. Cytostome slit-like, occupying about one-third the body-length. Cilia in longitudinal meridional rows, those along the left margin of the cytostome longer than the others. Trichocysts usually in a row along the right margin of the beak. Contractile vacuole single, large, oval and postero-terminal. Macronucleus reniform, placed obliquely in the anterior half of the body. Micronucleus small, spherical, in the notch of the macronucleus.

Dimensions.—Length 90 μ, width 20 μ.

Habitat.—Hay infusions and pond water among *Epistylis* and *Carchesium* colonies : BENGAL, Calcutta.

50. **Litonotus pleurosigma** Stokes. (Fig. 41.)

Litonotus pleurosigma, Stokes, 1884 *b*, p. 124.
†*Loxophyllum fasciola* subsp. *punjabensis* Bhatia, 1916, pp. 181–2, fig. 3.
Lionotus pleurosigma, Penard, 1922, pp. 68–9, fig. 74.
Hemiophrys (*Lionotus*) *pleurosigma*, Kahl, 1926, pp. 293–5, fig. L_1; 1930–5, p. 186–7, fig. 28, *3*.

Body elongate, transparent, flexible, but scarcely contractile, posterior end drawn out into a tail-like prolongation or only pointed, tapering gradually towards the anterior extremity, which is curved. Oral cleft along the convex border. Cuticular surface longitudinally striate ; cilia more conspicuous on the neck-region. Contractile vacuoles multiple, variable in number, arranged in two rows. Macronucleus bipartite, spheroidal,

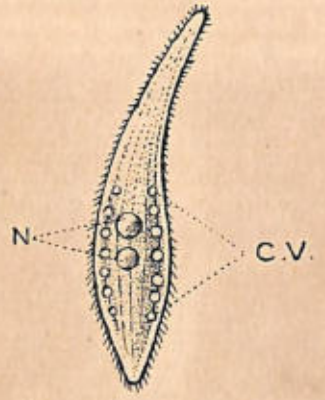


Fig. 41.—*Litonotus pleurosigma* Stokes. *C.V.*, contractile vacuoles ; *N*, macronucleus. (After Bhatia.)

subcentral ; micronucleus between the two parts of the macronucleus.

Dimensions.—Length up to 300μ.

Remarks.—The animal showed slow locomotion, now moving forwards, then suddenly in a backwards direction. The length of a specimen was 147μ and the maximum width 42μ. When I made the acquaintance of this form I did not have Stokes's work at my disposal, and it appeared to resemble most closely *Litonotus varsoviensis* Wrz. (Kent, 1880–2, p. 744, pl. xlii, fig. 4), from which, however, it differed in the number of contractile vacuole asnd their arrangement in two longitudinal rows instead of one containing five contractile vacuoles only. At the time I considered that both my form and

L. varsoviensis should be regarded as distinct subspecies of *L. fasciola*, which some writers had removed from the genus *Litonotus*, reserved for species with a very long neck (in some being even longer than the body), and had again placed in *Loxophyllum*, to which indeed it originally belonged: the name *punjabensis* was given to the subspecies to indicate its special peculiarities.

Recent workers have, however, more accurately defined *Litonotus*, and *L. fasciola* has again been placed under that genus by Roux, Penard and others; and Kahl, in his recent monograph, has referred my form to *Litonotus pleurosigma* Stokes, a view which I accept. Kahl states that the neck often possesses an apical group of trichocysts, and the trichocysts are also distributed in the plasma. The trichocysts were not noticed by me.

Habitat.—Stagnant water: PUNJAB, Lahore.

51. **Litonotus similis** Ghosh. (Fig. 42.)

†*Lionotus similis*, Ghosh, 1921 *a*, p. 8, fig. 3.
Hemiophrys (*Lionotus*) *similis*, Kahl, 1930–5, p. 188.

Body broadly lanceolate, widest behind the middle, more tapering anteriorly than posteriorly. Anterior end pointed



Fig. 42.—*Litonotus similis* Ghosh.

and curved to one side. Cytostome extending beyond the anterior one-third of the length of the body. Longitudinal ciliary rows faint. Trichocysts scattered. Contractile vacuoles 5–6 in number and placed in two rows along both the margins. Micronucleus by the side of the macronucleus.

Dimensions.—Length 170μ, width 52μ.

Remarks.—According to Ghosh this species differs from *L. fasciola* Ehrbg. in having scattered trichocysts, a smaller cytostome, and numerous contractile vacuoles, but agrees with it in having a bilobed macronucleus. It resembles *L. diaphanes* Wrzesn. in having scattered trichocysts, but differs from it in the arrangement of the contractile vacuoles and in the shape of the macronucleus. Kahl (1930) thinks that it is probably identical with *L. pleurosigma*. The macronucleus does not, however, consist of two discrete parts; and the contractile vacuoles, though stated to be 5–6 in two rows, are actually shown in the figure as 4 in the ventral and 2 in the dorsal row.

Habitat.—Vegetable infusions: BENGAL, Calcutta.

52. **Litonotus** sp.

Lionotus sp., Chaudhuri, 1929, p. 54.

Habitat.—Soils from CENTRAL INDIA, Indore, and CEYLON, Colombo.

Genus **LOXOPHYLLUM** (Dujardin, 1841), emend. Wrzesniowski, 1869.

Loxophyllum (part), Dujardin, 1841, pp. 467, 487; (part) Claparède & Lachmann, 1858–61, pp. 357–64.
Loxophyllum, Fromentel, 1874, p. 178; Kent, 1880–2, pp. 527–8; Bütschli, 1887–9, p. 1692; Roux, 1901, p. 38; Penard, 1922, p. 71; Lepsi, 1926*a*, p. 35; Calkins, 1926, p. 405; Schoenichen, 1927, p. 191; Reichenow, 1929, p. 1172; Kahl, 1930–5, pp. 195, 197.

Body contractile and flexible; flattened, leaf-like, pointed at the anterior and posterior ends. Anterior portion bent towards the dorsal border. Cilia in longitudinal rows on the right surface of the body, left surface without cilia. Mouth slit-like, along the convex border of the anterior portion, as in the preceding genus. Recognizable from the preceding genus by the possession of a hyaline zone along the ventral border, extending up to the posterior end and usually provided with trichocysts; with a similar zone extending along the dorsal border, or narrow and with trichocysts collected in warty bundles. Locomotion gliding.

Key to Indian Species.

Body small, up to 250 μ. Macronucleus bipartite ..... *L. helus* (Stokes), [p. 113.
Body large, up to 700 μ. Macronucleus multipartite or rosary-shaped ..... *L. meleagris* (O. F. [Müll.), p. 114.

53. **Loxophyllum helus** (Stokes). (Fig. 43.)

Litonotus helus, Stokes, 1884, p. 124; 1888, p. 268, pl. ix, fig. 19.
Loxophyllum helus, Penard, 1922, p. 73, fig. 78; Kahl, 1926, pp. 295–6, fig. M_1; 1930–5, pp. 199–200, fig. 30, *17*.
†*Loxophyllum helus*, Bhatia & Mullick, 1930, p. 393.

Body elongate, lanceolate, flattened, anterior end prolonged into a short neck which is curved towards the dorsal edge, posterior end acuminate, very contractile. Mouth slit-like along the convex border of the neck. Hyaline zone narrow, provided with fine trichocysts along the ventral border and the posterior end. The dorsal border is raised into a number

Fig. 43.



Fig. 44.

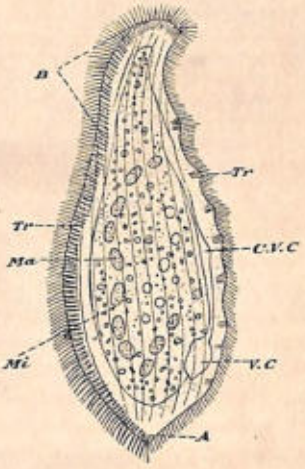


Fig. 43.—*Loxophyllum helus* (Stokes). (After Kahl.)
Fig. 44.—*Loxophyllum meleagris* (O. F. Müll.). *A*, anus; *B*, cytostome; *C.V.C*, feeder canal of the vacuole; *Ma*, macronucleus; *Mi*, micronucleus; *Tr*, trichocysts; *V.C*, contractile vacuole. (After Roux.)

of papillæ, underneath each of which is a bundle of trichocysts. The right side of the body is flattened and covered over by cilia arranged along numerous closely approaching longitudinal lines. The left side is bulging and marked by only a few furrows, but does not bear any cilia. Contractile vacuole posterior, subterminal, sometimes with accessory vacuoles. Macronucleus consists of two ellipsoid portions with a micronucleus lying between them.

Dimensions.—Length 109–130 μ, and up to 250 μ when fully extended.

Remarks.—A few specimens, showing the characters of the species as given above, were met with. The length of the organisms was only 124 μ. Scarce.

Habitat.—Pond water : KASHMIR, Srinagar.

54. **Loxophyllum meleagris** (O. F. Müller). (Fig. 44.)

Kolpoda meleagris, O. F. Müller, 1786, pp. 99–101, pl. xiv, figs. 1–6, pl. xv, figs. 1–5.
Amphileptus meleagris, Ehrenberg, 1838, p. 357, pl. xxxviii, fig. 4.
Loxophyllum meleagris, Dujardin, 1841, pp. 488–9, pl. xiv, fig. 6 ; Claparède & Lachmann, 1858–61, pp. 358–61, pl. xvi, fig. 9 ; Stein, 1859 *d*, pp. 61–3, 89 ; 1867, pp. 10, 64, 67, 80, 81, 82, 90, 104 ; Pritchard, 1861, p. 639 ; Wrzesniowski, 1869, pp. 44–5, 48, pl. iv, figs. 28–30 ; Fromentel, 1874, p. 294, pl. xx, fig. 7 ; Kent, 1880–2, p. 528, pl. xxvii, fig. 52 ; Bütschli, 1887–9, p. 1692, pl. lx, fig. 2, *a*, *b* ; Schewiakoff, 1896, p. 209, pl. iii, fig. 55 ; Roux, 1901, p. 38, pl. ii, fig. 8 ; Penard, 1922, pp. 71–3, fig. 77.
†*Loxophyllum meleagris*, Gulati, 1925, p. 747, pl. i, fig. 8.
Loxophyllum meleagris, Lepsi, 1926 *a*, p. 43, fig. 105 ; Calkins, 1926, p. 380, fig. 167 ; Schoenichen, 1927, p. 192, fig. 719 ; Kahl, 1930–5, p. 202, fig. 30, *12*.

Body very flexible. Form very variable, from lanceolate to broadly leaf-shaped, narrow anteriorly and curved towards the dorsal aspect. Ventral border broad, uniformly provided with trichocysts. Dorsal border crenulate, the projections provided with groups of trichocysts. Contractile vacuole single, dorsal, subterminal, with a distinct canal running near the dorsal border and presenting several ampullæ. Ciliary lines close, with short, thick cilia. Macronucleus rosary-shaped or consisting of separate small oval masses. Micronuclei corresponding in number to the parts of the macronucleus.

Dimensions.—Length 300–400 μ ; sometimes much larger, up to 700 μ (according to Penard).

Habitat.—Stagnant water : PUNJAB, Lahore.

2. Family TRACHELIIDÆ Ehrenberg, 1840.

Elongated or ovoid or almost spheroid forms, provided with a short or long proboscis. Body covered with uniform cilia. Special cilia along the ventral border of the trunk. Cytostome round, situated at the base of the proboscis. Cytopharynx provided with trichocysts or trichites. Contractile vacuoles numerous. Macronucleus multipartite or band-shaped.

Key to Indian Genera.

1.	Anterior end of the body runs out into a trunk or finger-like process. Free-living	2.
2 (3).	Form lanceolate, posteriorly drawn out into a tail-like process or at least pointed, rounded only in a form found in moss ...	[p. 115 DILEPTUS Duj.,
3 (2).	Form oval to spherical, posteriorly rounded or only slightly pointed.....	[p. 117. TRACHELIUS Schr.,

Genus **DILEPTUS** (Dujardin, 1841), emend. Wrzesniowski, 1870.

Dileptus, Dujardin, 1840, p. 285; 1841, pp. 404–7.
Amphileptus (part), Claparède & Lachmann, 1858–61, pp. 347–8; Fromentel, 1874, p. 176; Kent, 1880–2, p. 523.
Dileptus, Bütschli, 1887–9, p. 1693; Schewiakoff, 1896, p. 219; Roux, 1901, p. 41; Penard, 1922, p. 79; Lepsi, 1926 *a*, p. 35; Calkins, 1926, p. 405; Schoenichen, 1927, p. 192; Reichenow, 1929, p. 1172; Kahl, 1930–5, pp. 204–5.

Animalcules free-swimming, medium sized to very large. Body not compressed, greatly elongated and very contractile; posterior end usually tapering; neck long, very movable, more or less bent dorsalwards. Mouth a round opening situated at the base of the neck. Cilia on all sides fine, with a row of stronger cilia along the ventral border of the proboscis. Along the ventral border of the proboscis is a row of trichocysts, which are also found in the upper surface of the body. Contractile vacuoles numerous, in several rows along the back. Anal aperture situated at the base of the pointed tail. Macronucleus elongated, band-shaped or rosary-shaped; micronuclei numerous and lying close to the parts of the macronucleus. Locomotion quick and graceful, the neck constantly bending forwards and backwards. Fresh water and marine.

55. **Dileptus anser** (O. F. Müller). (Fig. 45.)

Vibrio anser, O. F. Müller, 1773, p. 46; 1786, pp. 73–4, pl. x, figs. 7–11.
Amphileptus anser, Ehrenberg, 1838, p. 355, pl. xxxviii, fig. 4.
Amphileptus margaritifer, Ehrenberg, 1838, p. 355, pl. xxxvii, fig. 5.
Dileptus anser, Dujardin, 1841, pp. 407–9, pl. vii, fig. 17.
Amphileptus anser, Claparède & Lachmann, 1858–61, p. 352.
Dileptus anser, Stein, 1859*d*, pp. 61–4, 80, 81, 90; 1867, pp. 67, 75, 81, 82.
Amphileptus anser, Pritchard, 1861, p. 636, pl. xxiv, figs. 312–13; Fromentel, 1874, p. 286, pl. xviii, figs. 9, 9 *a*; Kent, 1880–2, p. 525, pl. xxvii, figs. 39 & 40.
Dileptus anser, Bütschli, 1887–9, p. 1693, pl. lix, fig. 4, *a–g*; Schewiakoff, 1889, pp. 22–4, pl. iii, figs. 31–3; 1896, pp. 221–2, pl. iii, fig. 61, pl. vii, fig. 181; Roux, 1901, p. 42, pl. ii, fig. 11.
†*Dileptus gigas*, Bhatia, 1922, p. 29.
Dileptus anser, Lepsi, 1926*a*, p. 44, fig. 113; Calkins, 1926, pp. 61, 116, figs. 24, 58.
Dileptus gigas, Schoenichen, 1927, p. 192, pl. xii, fig. 17.
Dileptus anser, Kahl, 1930–5, p. 205, fig. 31, *17*.

Body elongated, brownish-yellow or greyish-white, posterior end with a pointed tail-like projection; the neck more or less



Fig. 45.—*Dileptus anser* (O. F. Müll.). *B*, cytostome; *Ma*, macronucleus; *Tr*, trichocysts; *V.C*, contractile vacuoles. (After Roux.)

elongated, strongly compressed, one-half to as long as the body. Cilia of the body short, fine, with stronger adoral cilia on the ventral border of the proboscis. Mouth at the base of the neck surrounded by a swollen margin without cilia.

Cytopharynx funnel-shaped, longitudinally striated. Trichocysts on the ventral surface of the neck. Contractile vacuoles numerous, in a dorsal row. Anal aperture on the surface at the base of the tail. Macronucleus elongated, sausage-shaped or moniliform. Very voracious, devouring large animalcules.

Dimensions.—Length 200–400μ, rarely up to 600μ.

Remarks.—The body and the neck showed movements which are characteristic of the species. Specimens were smaller than the size usually recorded for the species : they measured on an average 200μ only. The ratio between the length of the neck and that of the rest of the body in the specimens that came under my observation was 2 to 3. The cilia covering the body were very fine and close-set, and the neck showed a narrow groove along which the stronger adoral cilia were situated. The body did not show any longitudinal striations, and the endoplasm was finely granular. The row of contractile vacuoles extended into the proboscis also. The tail was obtusely pointed, and not drawn out into a distinct prolongation.

The original descriptions of *D. anser* and *D. gigas* were not available to me in 1922, and, the two species having been merged into one by Eyferth-Schoenichen (1909), I referred my examples to *D. gigas*. Schoenichen (1927) still regards the two as synonyms. Kahl (1930–5) has stated the distinctions clearly, and the form is now correctly referred to *D. anser*.

Habitat.—River water : PUNJAB, Lahore.

Genus **TRACHELIUS**, Schrank, 1803, emend. Claparède & Lachmann, 1858–61.

Trachelius, Schrank, 1803, p. 20.
Trachelius (part), Ehrenberg, 1838, p. 320.
Trachelius, Claparède & Lachmann, 1858–61, pp. 345–7 ; Fromentel, 1874, p. 182 ; Kent, 1880–2, p. 522 ; Bütschli, 1887–9, p. 1692 ; Schewiakoff, 1896, p. 216, Roux, 1901, p. 41 ; Hickson, 1903, p. 400 ; Minchin, 1912, p. 439 ; Penard, 1922, p. 80 ; Calkins, 1926, p. 405 ; Lepsi, 1926 *a*, p. 35 ; Schoenichen, 1927, p. 192 ; Reichenow, 1929, p. 1172 ; Kahl, 1930–5, p. 210.

Body elongated oval or spherical, with rounded posterior end and relatively short and plump neck, which is curved dorsalwards. Body flexible, neck mobile. Endoplasm wide-meshed. Ventral surface flattened, sometimes with a depression in its middle. Mouth on ventral surface at the base of the neck. Cilia uniform on all sides. A row of stronger cilia extends back from the anterior extremity of the neck, surrounds the mouth and is continued forward again to the anterior extremity Cytopharynx long, conical, provided with

rods. Anus posterior, ventral. Contractile vacuoles numerous. Macronucleus central, ovoid. Micronucleus close by. Movements swift, rotating round the long axis. Feeding on diatoms, algæ and infusoria.

56. **Trachelius gutta** (Cohn). (Fig. 46.)

Amphileptus gutta, Cohn, 1866, p. 269, pl. xv, fig. 50 ; Kent, 1880–2, p. 527.
Trachelius gutta, Hamburger & Bruddenbrock, 1911, pp. 33–4, fig. 29.
†*Trachelina gutta*, Ghosh, 1920 *a*, pp. 144–5, fig. 1 ; 1921 *a*, p. 8.
Trachelius gutta, Lepsi, 1926 *a*, p. 44.

Body elongate-pyriform, rounded and widest posteriorly ; anterior extremity pointed, curved towards the dorsal aspect. Cytostome situated on the ventral surface at a distance of

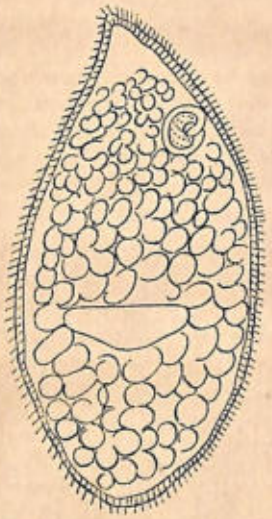


Fig. 46.—*Trachelius gutta* (Cohn). (After Ghosh.)

about one-third of the length of the body from the anterior extremity. Cytopharynx a smooth, conical, corneous tube, with its long axis in the direction of the curvature of the neck. Cuticular surface striate longitudinally, densely clothed with short, fine, even cilia ; cilia on the anterior or oral regions not specially differentiated. Endoplasm with numerous large, spherical water-vacuoles. Contractile vacuole single, postero-terminal. Macronucleus in the form of numerous scattered,

refringent corpuscles. Locomotion constant in a forward direction, rotating on its long axis.

Dimensions.—Length 120–125 μ.

Remarks.—The form described by Ghosh (1920*a*) differs from the description, as given above, in the following respects:—The cytostome is at one-fourth of the length of the body from the anterior end ; contractile vacuoles are two in number ; macronucleus is irregularly and elongately oval and placed in the posterior half of the body ; anterior portion forms a broad proboscis and is devoid of spherical granules. Length 214 μ, breadth 101 μ. Organism is capable of changing its shape from an elongated pyriform to a nearly spherical form. Ghosh considers it to be a new variety of *T. gutta*, but from his description and figure it is impossible to decide if the form has been correctly identified.

Habitat.—Putrefying vegetable infusions : Bengal, Calcutta.

3. Family LOXODIDÆ Bütschli, 1889.

Body elongated, more or less laterally flattened, anteriorly terminating in a beak-like process which is curved ventralwards, posteriorly pointed or rounded. Cilia rather long, distributed along longitudinal lines, on the right surface of the body only. The dorsal and ventral borders bear numerous, short, immobile, tactile bristles. Cytostome slit-like, situated on the concave ventral border of the anterior part of the body. Contractile vacuole absent or single. Macronuclei two or more.

This family contains only one genus.

Genus **LOXODES** Ehrenberg, 1830, emend. Claparède & Lachmann, 1858.

Loxodes, Ehrenberg, 1830, p. 42 ; 1838, p. 323 ; Claparède & Lachmann, 1858–61, p. 339.
Drepanostoma, Engelmann, 1862, p. 382.
Loxodes, Fromentel, 1874, p. 182 ; Kent, 1880–2, p. 748 ; Bütschli, 1887–9, p. 1694 ; Schewiakoff, 1896, p. 212 ; Roux, 1901, p. 39 ; Minchin, 1912, pp. 439, 448 ; Penard, 1922, p. 77 ; Calkins, 1926, p. 405 ; Lepsi, 1926*a*, p. 35 ; Schoenichen, 1927, p. 193 ; Reichenow, 1929, p. 1172 ; Kahl, 1930–5, p. 212.

Large to very large, elastic but persistent in form, flattened and leaf-like, anteriorly with a beak bent ventralwards, posterior end pointed or rounded. The right surface is slightly convex, distinctly longitudinally striated and ciliated, the cilia being delicate, moderately long, and closely arranged in longitudinal

rows ; the left surface is flat and naked*. The ectoplasm appears to be more or less brown, owing to closely situated brown granules. Along the dorsal border lie a variable number (5–25) of strongly refractile bodies known as Müller's corpuscles. In the ventral border of the beak is a narrow cleft, the cytostome extending as a slit along the whole curvature of the blade of the sickle which characterizes the anterior part of the animal ; there is no true cytopharynx (what is generally represented as cytopharynx and looks like the handle of the sickle is merely an internal fold). The endoplasm is vacuolated. Contractile vacuole absent or single. A row of non-contractile vesicles may also be present. Anus situated on the unciliated surface in the posterior quarter of the body. The macronuclei are two in number or numerous, small and spherical, each with a strong membrane and a central nucleolus, and arranged along the length of the animal in a more or less regular row ; the micronuclei are in the neighbourhood of the macronuclei. Locomotion moderately quick.

Key to Indian Species.

1 (6). Two macronuclei ..... 2.
2 (3). The macronuclei lie so close to one another that the single micronucleus is flattened between the two.

* Great divergencies are met with in the recorded descriptions by different authors of the various forms included in this genus. In the first place, it may be pointed out that all the German authors speak of the borders as being ventral and dorsal and the flattened and convex surfaces as right and left respectively, while English, French and American writers refer to the borders as being situated on the left and right and the two surfaces as ventral and dorsal. As regards the nuclei, Wrzesniowski has demonstrated "a racemose development of the numerous spherical endoplasts or nuclei, with their attached endoplastules. In many instances the endoplastule, instead of being fixed to the endoplast, is found attached separately to the cord or funiculus, while in other cases it may be entirely absent" (Kent, 1880-2, p. 749, and pl. i, fig. 14). Bütschli, in his description of the genus, states : "Ein bis sehr zahlreiche kleine runde Ma.Ni (je nach der Grosse der Thiere) durch den gresammten Korper zerstreut und unverbunden. Zahl der Mi.Ni ähnlich verschieden." Schewiakoff (1893) remarks as follows :—"Unterscheidet sich von den bisher unter diesem Namen beschriebenen Formen durch einen ovalen, in der Korpermitte gelegnen, fein-netzigen *Makronucleus*, dem ein kleiner mikronucleus anliegt und durch die Lage der contractilen vacuole. Letztere liegt nicht terminal, sondern rechtseiting in der vorderen Körperhälfte unweit des Mundendes. Diese Unterschiede halte ich für unzureichend zur Aufstellung einer neuen Art." Conn (1918) states "Nuclei may be two or more." Penard (1922) says that nuclei are numerous, small and spherical. There would thus seem to be at least three distinct types of nuclear apparatus : (1) a single macronucleus as described by Schewiakoff ; (2) two macronuclei as described by Conn ; and (3) numerous macronuclei, either connected by a thread or not, as described by Wrzesniowski, Bütschli and the present writer.

3 (2).	The macronuclei lie wide apart.....	4.
4 (5).	Two micronuclei, attached to the posterior pole of the anterior and the anterior pole of the posterior macronucleus; posterior end of the body pointed ventralwards; no contractile vacuole: length up to 200 μ.....	[mann), p. 123. *L. striatus* (Engel-
5 (4).	Two micronuclei lying close behind each macronucleus, posterior end rounded; contractile vacuole postero-terminal: length 130–170 μ.....	[& Mullick, p. 121. *L. bahaduri* Bhatia
6 (1).	Macronuclei and micronuclei numerous...	7.
7.	Posterior end of the body more or less pointed ventralward; contractile vacuole single, central, with a row of non-contractile vesicles arranged along the ventral border	[sp. nov., p. 121 *L. punjabensis*,

57. **Loxodes bahaduri** Bhatia & Mullick. (Fig. 47.)

†*Loxodes bahaduri*, Bhatia & Mullick, 1930, p. 392, fig. 1.

Body elongated and laterally compressed, elastic, though preserving a definite oval shape. The anterior end pointed and curved towards the ventral border. The ventral border of the anterior portion marked by a groove, at the bottom of which the cytostome is situated. Cytopharynx absent. The borders are uniformly ciliated. Cytoplasm colourless and more or less vacuolated. Contractile vacuole single, postero-terminal, and a few small non-contractile vesicles arranged along the dorsal border. Two spherical macronuclei with micronucleus lying close behind each.

Dimensions.—Length from 130 to 170 μ.

Remarks.—This species has some resemblance to *L. magnus* Stokes (as described by Kahl), from which it differs, however, by its smaller size, proportionately narrower body, number and structure of the macronuclei and the possession of a definite contractile vacuole, which was observed to contract after long intervals. The dimensions of *L. magnus* are given as 400–600 μ, but our specimens did not exceed 170 μ.

Habitat.—Pond water: KASHMIR, Srinagar.

58. **Loxodes punjabensis,** sp. nov. (Fig. 48.)

†*Loxodes rostrum*, Bhatia (not O. F. Müll.), 1920, p. 260.

Body flexible, flattened, highly vacuolated; the anterior extremity curved slightly ventralwards and terminating in a beak-like projection; along the ventral border of the beak is a slit-like cytostome; cytopharynx absent; the posterior extremity is also bent slightly in the same direction as the anterior end. Contractile vacuole single with a row of much

smaller non-contractile vacuoles along one border of the body. Macronuclei many, with laterally attached micronuclei. Animalcules swim evenly or rotate on their axis and creep over foreign objects.

Dimensions.—Length up to 150 μ.

Remarks.—Specimens found at Lahore were originally wrongly referred to *Loxodes rostrum*. *Loxodes rostrum* (O. F. Müller) is shown by Roux as possessing numerous macronuclei.

Fig. 47.



Fig. 48.

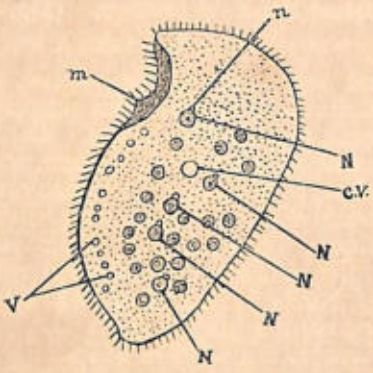


Fig. 49.

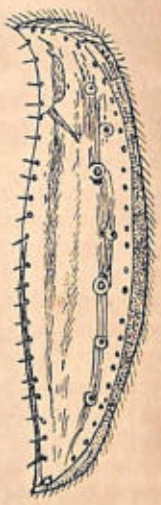


Fig. 47.—*Loxodes bahaduri* Bh. & M. (After Bhatia and Mullick.)
Fig. 48.—*Loxodes punjabensis*, sp. nov. *c.v.*, contractile vacuole; *m*, cytostome; *N*, macronuclei; *n*, micronucleus; *V*, non-contractile vacuoles.
Fig. 49.—*Loxodes striatus* (Engelm.). Two somewhat larger spherical bodies are macronuclei, and the other five are statoblasts. (After Kahl.)

and by Kahl as possessing only two macronuclei with a micronucleus situated between them. Kahl's description and figure of *Loxodes magnus* Stokes resemble very closely those given by Roux for *L. rostrum*; and he thinks this form has been wrongly designated as *L. rostrum* by other authors as well.

My form differs from *L. rostrum* (O. F. Müll.) (as described by Kahl) in possessing many macronuclei, one contractile and many non-contractile vacuoles, and in the absence of the cytopharynx and the marginal setæ. It shows some resemblance to *L. magnus* Stokes (as described by Kahl), but differs from it in (1) a smaller size and greater proportional width, (2) the presence of a single contractile and a number of non-contractile vacuoles, and (3) the absence of cytopharynx and the marginal setæ. The size of *L. magnus* is stated to be 400–600 μ. My specimens measured 126–150 μ in length and 44–63 μ in width. Kahl (1930–5) has enumerated and distinguished in this genus four species and two new varieties of *L. magnus*. The present form differs from them all: it is, therefore, now recognized as a distinct species.

In the forms that came under my observation the body was flexible, but persistent in form and flattened. In addition to the characters noted above, the marginal cilia were short, fine and close-set, and there were no marginal setæ or spines. The cilia bordering the adoral groove were somewhat larger than the marginal cilia The cytostome measured 32 μ in one specimen and 42 μ in another—that is, about one-fourth of the entire length of the body. The surface of the body did not show any longitudinal striations, but the deeper layer was longitudinally furrowed. The endoplasm was granular and vacuolated, and numerous chloroplasts were scattered in it; the colour of the part of the body that was free from them was greyish.

The single contractile vacuole was situated about the middle of the body, and numerous, very much smaller non-contractile vesicles were arranged in a row along the ventral border.

The macronuclei were spherical, of the vesicular type, irregularly distributed in the posterior three-fourths of the body, and were not connected by any cord-like filament or funiculus. The micronuclei were not detected.

Habitat.—Pond water: PUNJAB, Lahore.

59. **Loxodes striatus** (Engelmann). (Fig. 49.)

Drepanostoma striatum, Engelmann, 1862, pp. 382–3, pl. xxxi, fig. 7.
Loxodes striatus, Penard, 1917, pp. 471–6, figs. 5–12; 1922, p. 79, fig. 83.
†*Loxodes striatus*, Bhatia & Mullick, 1930, pp. 392–3.
Loxodes (*Drepanostoma*) *striatus*, Kahl, 1930–5, p. 215, fig. 33, *3*.

Body elongated, lanceolate and colourless or brownish: flexible, with its right surface slightly convex and marked with longitudinal lines, along which very fine cilia are evenly

distributed; the left surface is flattened and naked. Anterior end curved towards the ventral border. Cytostome cleft-like along the curved anterior part. Along the dorsal border 4 to 6 statoblasts are described by Penard. No contractile vacuole. Two spherical macronuclei, each provided with a strong nuclear membrane and a large centrally placed nucleolus. Two micronuclei are placed close to the nuclear membrane, attached to the posterior pole of the anterior and the anterior pole of the posterior macronucleus.

Dimensions.—Length up to 250 μ.

Remarks.—The statoblasts described by Penard were not noticed, though a few non-contractile vacuoles were present along the dorsal border. The stiff tactile bristles described as occurring along the ventral border were also not present. The length of our specimens varied from 142 to 190 μ.

Habitat.—Pond water : KASHMIR, Srinagar.

60. **Loxodes** sp.

Loxodes sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

3. Tribe **HYPOSTOMATA** Schewiakoff, 1896, emend. Kahl, 1931.

Gymnostomatous Ciliates in which the cytostome lies in the anterior half of the flattened ventral surface ; the cytopharynx usually provided with a rod-apparatus.

Identification Table of Families.

1 (2).	Ciliation complete ; the dorsal surface may be somewhat more sparsely ciliated than the ventral	[p. 125. **Nassulidæ** Bütsch.,
2 (1).	Ciliation incomplete, cilia absent from the dorsal surface, at the most only a few bristles present	3.
3 (6).	Free-living forms	4.
4 (5).	No style from the posterior end of the ventral side	[Claus., p. 131. **Chlamydodontidæ**
5 (4).	A style arising from the posterior end of the ventral surface	[& Lachm. **Dysteriidæ*** Clap.
6 (3).	Parasitic forms on Amphiopods and Isopods ; enclosed in an imperforate shell, the form segments into a number of tomites which escape and show a type of ciliature different from the trophont	[Chat. & Lw. **Pilisuctoridæ***.

1. Family NASSULIDÆ Bütschli, 1889.

Body ciliated all over, the dorsal surface may be somewhat more sparsely ciliated than the ventral. Cytostome situated in the anterior half of the flattened ventral surface. Cytopharynx almost always provided with a rod-apparatus.

Key to Indian Genera.

1 (2). The opening of the rod-apparatus lies deep at the base of an outer portion, the outer opening of which is narrowed by a second membrane ..... [p. 125. NASSULA Ehrgb.,

2 (1). The opening of the rod-apparatus lies in the upper surface or at the bottom of a flat depression, not opening to the outside ..... 3.

3 (4). The rod-apparatus opens in a strong depression, the anterior margin of which bears a membranous structure of cilia. Slender, oval, more or less flattened, small Infusoria, sometimes with striking trichocyst layer..... [p. 128. CYCLOGRAMMA Perty,

4 (3). The rod-apparatus opens without a distinct depression in the surface. Mostly distinctly flattened, without trichocysts ..... 5.

5 (6). The left margin of the body shows anteriorly no beak-like structure or a very weakly developed one. Opening of the rod-apparatus median ..... [Blochm., p. 129. CHILODONTOPSIS

6 (5). The left margin of the body shows a distinct projecting beak-like structure in the neighbourhood of the mouth. The opening of the rod-apparatus directed to the right..... [Bhatia, p. 130. ORTHODONELLA

Genus **NASSULA** Ehrenberg, 1833.

Nassula, Ehrenberg, 1833, p. 303; 1838, p. 338; Dujardin, 1841, p. 494.

Liosiphon, Ehrenberg, 1853, pp. 186, 193.

Nassula, Claparède & Lachmann, 1858–61, p. 324; Fromentel, 1874, p. 168; Kent, 1880–2, p. 494; Bütschli, 1887–9, p. 1694; Roux, 1901, p. 42; Hickson, 1903, pp. 397, 400; Minchin, 1912, p. 430; Penard, 1922, p. 85; Lepsi, 1926*a*, p. 36; Calkins, 1926, p. 404; Wenyon, 1926, p. 1175; Schoenichen, 1927, p. 194; Reichenow, 1929, p. 1173; Kahl, 1930–5, p. 216.

Animacules of medium size to very large. Body flexible and contractile, generally egg-shaped to elongated, mostly with distinctly flattened ventral and strongly bulging dorsal side, with both the anterior and the posterior ends rounded.

Cytostome situated on the ventral surface of the body at some distance from the anterior end. From the cytostome a row of strong cirri usually extends to the back along a depression of the body lying on the left side. Cilia uniform. Body striations faint and weakly spiral. Cytopharynx provided with well-developed rod-apparatus; the opening of the tubular rod-apparatus lies at the base of an outer portion, the outer opening of which is narrowed by a second membrane. Anal aperture always terminal. Contractile vacuoles one or more; when single usually in the middle region of the body, sometimes, however, up to four in number, lying partly on the dorsal and partly on the ventral side. Often with a complex covering of trichocysts. Macronucleus mostly spherical and central, rarely band-shaped; with one or more micronuclei lying close by. The body is sometimes colourless, mostly, however, it is red, blue or brown. Feeds on *Oscillaria* and Diatoms, and the body is consequently found to contain red, blue or violet food-vacuoles. Cysts spherical. Locomotion uniform and constant.

Key to Indian Species.

1. Body oval, without a flexible anterior prolongation; cytopharynx without rod-apparatus; contractile vacuole central ..... *N. ambigua* St., [p. 126.
2. Body ovate, with a flexible anterior prolongation; cytopharynx with a rod-apparatus; contractile vacuole posterior ..... *N. stramphii* (Ehrbg.), p. 127.

61. **Nassula ambigua** Stein. (Fig. 50.)

Nassula ambigua, Stein, 1854, pp. 248–9, pl. vi, figs. 42–4.
Liosiphon ambiguus, Stein, 1859 *d*, p. 72, fig. 88.
Nassula ambigua, Claparède & Lachmann, 1858–61, p. 329; Kent, 1880–2, p. 495, pl. xxvi, fig. 41; Schewiakoff, 1896, p. 236.
†*Nassula ambigua*, Gulati, 1925, p. 748, pl. i, fig. 10.
Nassula ambigua, Lepsi, 1926 *a*, p. 44, fig. 116; Schoenichen, 1927, p. 195, fig. 722; Kahl, 1930–5, p. 220.

Body oval, rounded at both extremities; about one and a half times as long as broad, evenly ciliate; beautifully coloured with red and green particles. Cytopharynx a horny tube, ciliated anteriorly, and without rod-apparatus. Contractile vacuole single, spherical, central. Macronucleus rounded or oval.

Dimensions.—Up to 160 μ in length.

Remarks.—Gulati, who described this species from Lahore, gives the size as 80 μ by 50 μ and shows the macronucleus as rounded.

Habitat.—Pools: PUNJAB, Lahore.

62. **Nassula stramphii** (Ehrenberg). (Fig. 51.)

Liosiphon stramphii Ehrenberg, 1853, pp. 184–6, 193.
Nassula stromphii Kent, 1880–2, p. 496.
†*Nassula stromphii* Bhatia, 1916, p. 182.

Body ovate, with a distinct large prolongation of the anterior region beyond the cytostome, anterior portion flexible; colour green owing to the ingestion of algæ as food-particles. Cilia uniform. Cytopharynx tubular, with a cylindrical fascicle of rod-like teeth. Contractile vacuole large, posteriorly situated, with pinkish contents*, with two or more smaller vacuoles irregularly distributed. Macronucleus oval, subcentral and eccentric.

Fig. 51.

Fig. 50.



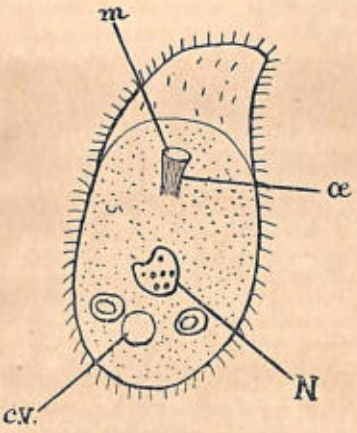


Fig. 52.



Fig. 50.—*Nassula ambigua* Stein. (After Gulati.)
Fig. 51.—*Nassula stramphii* (Ehrbg.). *c.v*, contractile vacuole; *m*, cytostome; *N*, nucleus; *œ*, cytopharynx. (After Bhatia.)
Fig. 52.—*Cyclogramma rubens* Perty. (After Gulati.)

Dimensions.—Length 57 μ, width 36 μ.

Remarks.—The row of stronger cirri, extending from the mouth and so characteristic of the other species of the genus, is absent in this form.

Habitat.—Ditch water: PUNJAB, Lahore.

63. **Nassula** sp.

†*Nassula* sp., Carter, 1855.

Habitat.—Fresh water: Bombay.

* The pink tinge is probably apparent rather than real, and is a contrast effect of the green body.

Genus **CYCLOGRAMMA** Perty, 1852.

Cyclogramma, Perty, 1852, p. 146; Stein, 1859 *d*, p. 61.
Acidophorus, Stein, 1859 *a*, p. 59.
Nassula (part), Claparède & Lachmann, 1858–61, p. 324; Kent, 1880–2, p. 494; Bütschli, 1887–9, p. 1694; Roux, 1901, p. 42.
Cyclogramma, Kahl, 1930–5, p. 224.

Comprising a few small species, generally referred to *Nassula*, and agreeing with that genus in form, pigmentation, trichocysts, position, and function of the centrally-situated vacuole. The structure of the cytopharynx, however, is characteristic. The strong rod-apparatus opens into a pear-shaped depression on the ventral and left side. Along the anterior margin of the depression is a short row of small membranellæ, which are recognizable with difficulty. The trichocysts are more strongly developed than in *Nassula*.

64. **Cyclogramma rubens** Perty. (Fig. 52.)

Cyclogramma rubens, Perty, 1852, p. 146, pl. iv, fig. 10, *a–g*; Stein, 1859 *d*, pp. 61–2.
Acidophorus rubens, Stein, 1859 *a*, p. 59.
Nassula rubens, Claparède & Lachmann, 1858–61, p. 330, pl. xvii, fig. 8; Kent, 1880–2, p. 495; Schewiakoff, 1896, p. 233; Roux, 1901, p. 43, pl. ii, fig. 13.
†*Nassula rubens*, Gulati, 1925, p. 747, pl. i, fig. 9.
Nassula rubens, Schoenichen, 1927, p. 195, fig. 720.
Cyclogramma rubens, Kahl, 1930–5, p. 224, fig. 34, *24*.

Body elongate, cylindrical, three times as long as broad, equally rounded at both extremities, brick-red or rose-coloured. Preoral depression little developed, forming a membranoid structure in front of the cytopharynx. Cytopharynx slightly dilated anteriorly, with an armature of separate rod-like teeth. Trichocysts thick and abundant. Contractile vacuole single, spherical, subcentral. Macronucleus large, spherical, with a number of chromatin masses. Micronucleus small and rounded. Feeding on blue algæ.

Dimensions.—Length up to 90 μ.

Remarks.—The form encountered by Gulati differed from the above description in the ratio of the length to the width of the body. His specimens measured 90 μ by 50 μ, whereas the length recorded by other authors for this species is 50–75 μ. Gulati shows the micronucleus as lying near the pharyngeal tube, while Kahl shows it near the macronucleus The slight preoral depression, described by Kahl, was not found by Gulati.

Habitat.—Pond water: PUNJAB, Lahore.

Genus **CHILODONTOPSIS** Blochmann, 1895.

Chilodontopsis, Blochmann, 1895, p. 94; Roux, 1901, p. 45; Schœnichen, 1927, pp. 194, 196; Kahl, 1930–5, p. 225.

Strongly flattened, or ventrally flattened and dorsally slightly bulging, elongate, with colourless plasma. Ciliated on both surfaces. Rod-apparatus without anteriorly prolonged tube; cytostome with a weakly developed ring-shaped membrane. Mostly with postoral row of cilia extending from the left side of the cytopharynx or right across the ventral surface (not forming composite structures as in *Nassula*).

Remarks.—The genus is intermediate between *Nassula*, which it resembles in ciliation and the presence of a postoral row of cilia, and *Chilodonella*, which possesses a similar rod-apparatus and form and is also colourless.

65. **Chilodontopsis bengalensis** (Ghosh). (Fig. 53.)

†*Chlamydodontopsis bengalensis*, Ghosh, 1921 *a*, p. 8, fig. 4.
Chilodonella bengalensis, Kahl, 1930–5, p. 225.

Body elongated oval; anterior end slightly narrower and terminating in a point curved towards the left side; posterior

Fig. 53.

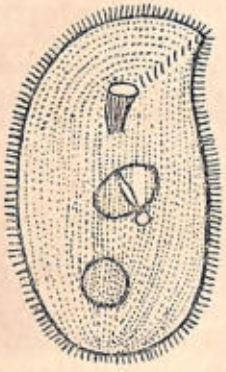


Fig. 54.

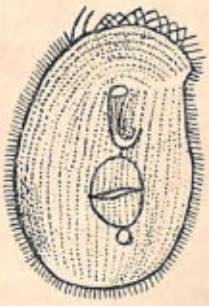


Fig. 53.—*Chilodontopsis bengalensis* (Ghosh). (After Ghosh.)
Fig. 54.—*Orthodonella banerjeei* (Ghosh). (After Ghosh.)

end rounded. Body flattened on the ventral and convex on the dorsal surface. Cytostome on the ventral surface at one-fourth of the length of the body from the anterior end. Cytopharynx short and conical, with a rod-apparatus. Ciliary striations of the right side curve round to become continuous with those of the left side in front of the cytostome. An

adoral row of stout cilia extending from the anterior beak to the cytostome. Contractile vacuole single, spherical, near the posterior end. Macronucleus oval, central or more posteriorly situated, with a single micronucleus close to it.

Dimensions.—Not recorded.

Remarks.—Ghosh has wrongly referred this species to *Chlamydodontopsis* instead of *Chilodontopsis* Blochm. Kahl is of the opinion that the form is probably referable to *Chilodonella*. According to Ghosh, the species differs from *Chilodontopsis depressa* Perty in shape, shape of the cytopharynx, character of the macronucleus and the shape of the contractile vacuole. The macronucleus is described and figured with a transverse septum in the middle What is described as a transverse septum is probably only a cleft, as described for *Chilodontopsis* (*Nassula*) *oblonga*, which species it closely resembles.

Habitat.—Vegetable infusion : Bengal, Calcutta.

Genus **ORTHODONELLA** (nom. nov.)
(= Orthodon Gruber, 1884).

Orthodon, Gruber, 1884, p. 524 ; Bütschli, 1887–9, p. 1695 ; Calkins, 1926, p. 404 ; Lepsi, 1926 *a*, p. 36 ; Kahl, 1930–5, p. 228.

Lanceolate or elongate-oval, dorso-ventrally flattened, with a more or less prominent beak-like projection at the anterior end. Opening of the rod-apparatus directed to the right. Contractile vacuole single, postero-terminal or in the middle of the body. Macronucleus oval, central ; micronucleus lying close to it.

Remarks.—As the name *Orthodon* is preoccupied for a genus of Pisces (C. F. Girard, 1856) I have altered it to *Orthodonella*.

66. **Orthodonella banerjeei** (Ghosh). (Fig. 54.)

†*Orthodon banerjeei*, Ghosh, 1921 *a*, pp. 8–9, fig. 5.
Orthodon banerjeei, Kahl, 1930–5, p. 229.

Body oval, narrowed anteriorly, broad and rounded posteriorly. Anterior end curved to a blunt beak towards left side. Body flattened on the ventral and convex on the dorsal surface. Cytostome at one-fourth of the body-length from the anterior end. Cytopharynx elongated, conical, with the posterior end bent forward. A rod-apparatus present. A few cilia at the extreme anterior margin of the body longer and stouter than those over the rest of the body. Contractile vacuole absent (?). Macronucleus broadly oval, with a transverse partition in the middle, and situate in the posterior half

of the body. Micronucleus near the posterior end of the body.

Dimensions.—Not recorded.

Remarks.—Kahl is of the opinion that this species also is a *Chilodonella*. As regards the presence or absence of cilia on the convex dorsal surface, the size of the organism, and the presence or absence of the contractile vacuole, the description given by Ghosh is incomplete. The cytopharynx is directed to the right in *Orthodonella*, but this is not so in the figure given by Ghosh.

Habitat.—Tank water : BENGAL, Calcutta.

2. Family CHLAMYDODONTIDÆ Claus, 1874.

Body not provided with cilia on the dorsal surface, at the most only a few bristles may be present. Cilia confined to the ventral surface. Cytostome situated in the anterior half of the ventral surface. Adoral cilia, when present, always as a feebly developed preoral membrane-like structure, never as a postoral row. Cytopharynx with a rod-apparatus. Posterior end of the ventral surface not provided with styles.

Key to Indian Genera.

1. Ciliated ventral surface narrowed to a strip, wider anteriorly and pointed posteriorly : the unciliated dorsal surface extending inwards on both sides behind the mouth . . PHASCOLODON Stein, [p. 131.
2. Ventral surface ciliated ; dorsal surface convex, anterior third or fourth and generally the lateral margins free from this convexity ; dorsally with a transverse row of bristles on the anterior flattened part . . . . . CHILODONELLA Strand, [p. 132.

Genus **PHASCOLODON** Stein, 1859.

Phascolodon, Stein, 1859 *a*, p. 2 ; 1859 *d*, p. 109 ; Kent, 1880–2, pp. 745–6 ; Bütschli, 1887–9, pp. 1697–8 ; Lepsi, 1926 *a*, p. 36 ; Schoenichen, 1927, pp. 193, 198 ; Kahl, 1930–5, p. 232.

Small to medium sized. Ventral surface longitudinally striated and ciliated, narrowed behind the mouth by extension on both sides of the dorsal unciliated surface ; hinder end pointed. Cytostome in the anterior part of the ventral surface. Cytopharynx funnel-shaped, enclosing a bundle of rods. Contractile vacuoles two. Locomotion, swimming and rotating on the long axis.

67. **Phascolodon** sp. (Fig. 55.)

†*Phascolodon* sp., Chaudhuri, 1929, p. 54, pl. ii, figs. 14, 15, 16.

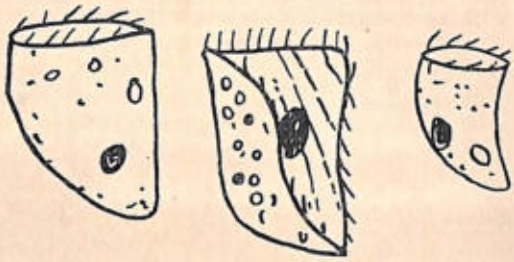


Fig. 55.—*Phascolodon* sp. (After Chaudhuri.)

Habitat.—In soil : CEYLON, Colombo.

Genus **CHILODONELLA** Strand, 1926
(=CHILODON Ehrenberg, 1833).

Chilodon, Ehrenberg, 1833, p. 287 ; 1838, p. 336 ; Dujardin, 1841, p. 490 ; Stein, 1859 *d*, p. 110 ; Claparède & Lachmann, 1858–61, p. 332 ; Kent, 1880–2, p. 746 ; Bütschli, 1887–9, pp. 1695–6 ; Roux, 1901, p. 46 ; Lepsi, 1926 *a*, p. 36 ; Calkins, 1926, p. 404.
Chilodonella, Strand, 1926, p. 31.
Chilodon, Schoenichen, 1927, pp. 194, 196.
Chilodonella, Kahl, 1930–5, pp. 234–5.

Animalcules free-swimming, small to medium-sized or large, persistent in shape, but more or less flexible, subovate, strongly flattened dorso-ventrally. Anterior end produced on the left side into a beak-like projection. The dorsal region convex, the ventral surface flat or slightly concave and with fine longitudinal striations. Posterior end broad, rounded, only rarely pointed. From the cytostome a curved striation bearing somewhat thicker cilia or bristles extends to the beak. Cytostome median, in the anterior half of the body, followed by a straight or spirally curved cytopharynx, which is provided with fine well-developed rod-apparatus. Contractile vacuoles variable, either single, terminal, or median, or 2, 3, up to numerous, increasing in number with the size of the individual. Anal aperture postero-terminal. Macronucleus central, oval, showing characteristic structure ; micronucleus single, lying close to macronucleus. Inhabiting salt and fresh water : Penard (1922) has recorded two species as ecto-commensals on *Asellus* or *Gammarus*, freshwater Crustacea.

Remarks.—The name of the genus has been altered by Strand, as the name *Chilodon* is preoccupied, Ehrenberg having already (1831) given it to a genus of Mollusca.

Key to Indian Species.

1 (2). Contractile vacuole single, cytopharynx short and straight ..... *C. rhesus* (Ghosh.), [p. 135.
2 (1). Contractile vacuoles more than one .... 3.
3 (4). Contractile vacuoles several, scattered. Cytopharynx long and straight ..... *C. cucullulus* (O. F. [Müll.), p. 133.
4 (3). Contractile vacuoles three, largest posterior. Cytopharynx spirally curved behind ..... *C. spiralidentis* (Bhatia [& Mull.), p. 135.

68. **Chilodonella cucullulus** (O. F. Müller). (Fig. 56.)

Kolpoda cucullus, Müller, 1773, p. 58; 1786, p. 105, pl. xv, figs. 7–11, p. 185, pl. xxvi, figs. 13–16.
Loxodes cucullio, O. F. Müller, 1786, p. 106, pl. xv, figs. 12–15.
Loxodes cucullulus, Ehrenberg, 1830, pp. 42, 53, 56, 63, 78, pl. iv, fig. 3; 1831, pp. 109, 150.
Chilodon cucullulus, Ehrenberg, 1833, pp. 169, 174, 176, 287, 322, pl. ii, fig. 1 *a–g*; 1837, pp. 164, 166; 1838, pp. 336–7, pl. xxxv, fig. vi.
Loxodes cucullulus, Dujardin, 1841, p. 451, pl. xiii, fig. 9.
Loxodes cucullio, Dujardin, 1841, p. 452.
Chilodon cucullulus, Dujardin, 1841, p. 491, pl. vi, fig. 6; Stein, 1854, pp. 126–38, 192, 242, 249, pl. iii, figs. 51–69; 1859 *d*, pp. 110–14, pl. i, figs. 6–23; 1867, pp. 20, 41, 44, 49, 59–61, 69, 70, 118.
†*Chilodon cucullulus*, Carter, 1856 *b*, pp. 128, 132, 248, pl. vii, figs. 82–3
Chilodon cucullulus Claparède & Lachmann, 1858–61, pp. 334–7; Engelmann, 1862, pp. 350, 368, 387, pl. xxviii, fig. 4; Kent, 1880–2, pp. 746–7, pl. xlii, figs. 16–22; Bütschli, 1887–9, pp. 1695–6, pl. lx, fig. 8, pl. lxi, fig. 1; Schewiakoff, 1893, p. 40; 1896, p. 245, pl. iii, fig. 73, pl. vii, fig. 199; Roux, 1901, pp. 46–7, pl. ii, fig. 16.
†*Chilodon steini*, Bhatia, 1922, p. 30.
Chilodon cucullatus, Hollis, 1922, pp. 3–7, figs. 1–5.
Chilodon cucullulus, Penard, 1922, pp. 90–2, figs. 94, 95.
†*Chilodon cucullus*, Gulati, 1925, p. 748, pl. i, fig. 11.
Chilodon cucullulus, Lepsi, 1926 *a*, p. 46, fig. 128; Wenyon, 1926, p. 1176, fig. 496; Schoenichen, 1927, p. 197, pl. xii, fig. 20; Reichenow, 1929, pp. 276, 277, 358, 1173, fig. 307.
†*Chilodon cucullulus*, Bhatia & Mullick, 1930, p. 394.
Chilodonella cucullulus, Kahl, 1930–5, p. 235, fig. 38, *1–3*.

Body asymmetrical, dorso-ventrally flattened, elongate, elliptical, deformable. Anterior extremity produced into a lamellar beak-like projection, curving towards the left. Posterior end of the body rounded. Ventral surface flattened and bearing longitudinal ciliary lines, those on the right half curved and running on to the beak, those on the left half running straight. Dorsal surface convex. Cytostome ventral, situated in the anterior third of the body. Cytopharynx straight, wider anteriorly and narrowing posteriorly, containing a number of longitudinal rods. From the anterior end of the cytopharynx a line of bristles extends to the beak.

Contractile vacuoles numerous. Macronucleus oval, with a small micronucleus close to it.

Dimensions.—Length 130–150 μ, sometimes up to 300 μ.

Remarks.—Specimens found at Lahore were much smaller than the size usually given for the species, an average specimen measuring only 90 μ by 42 μ. The body was strongly asymmetrical, flattened and flexible, and the animal moved with a gliding and undulating movement. The longitudinal striations were fine but well marked, and the ciliation was fine and close. The oblique line of bristles, which generally extends from the beak to the cytopharynx, was not present in the specimens that came under my observation. Numerous small vesiculæ were distributed in all parts of the body, including the beak. The macronucleus was large, oval and

Fig. 56. Fig. 57. Fig. 58.

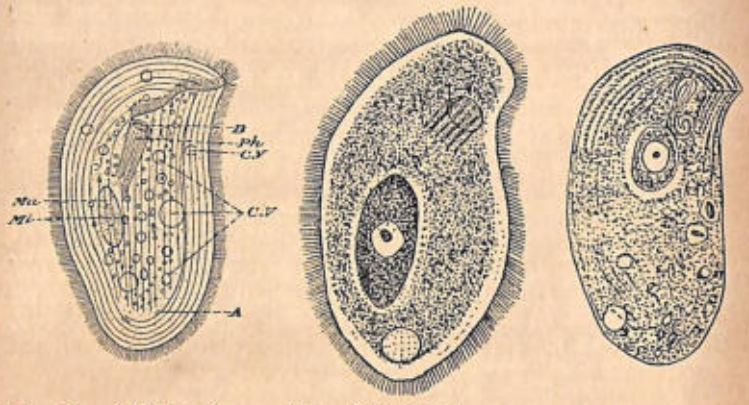


Fig. 56.—*Chilodonella cucullulus* (O. F. Müll.). *A*, anus; *B*, cytostome; *C.V*, contractile vacuole; *Ma*, Macronucleus; *Mi*, micronucleus; *ph*, cytopharynx. (After Roux.)
Fig. 57.—*Chilodonella rhesus* (Ghosh). (After Ghosh.)
Fig. 58.—*Chilodonella spiralidentis* (Bh. & Mull.). (After Bhatia and Mullick.)

finely granular, containing a large central vesicular body. The micronucleus could not be made out. The body did not contain any diatoms, but round, disc-shaped or oval green algæ. In 1922 I referred the form to *C. steini*, but that species is now generally merged into *C. cucullulus*.

Specimens found by Bhatia and Mullick at Srinagar (Kashmir) also measured about 90 μ in length. Contractile vacuoles were three in number, two being in the middle, and the third, which was largest, postero-terminal. The large oval macronucleus shows a characteristic structure in permanent preparations. There is a narrow compact layer of

nucleoplasm extending along the nuclear membrane. There is a large spherical nucleolus, surrounded by chromatin granules, which are specially aggregated on two sides of the nucleolus like two caps.

Habitat.—Pond water : KASHMIR, Srinagar ; PUNJAB, Lahore ; BOMBAY, Bombay.

69. **Chilodonella rhesus** (Ghosh). (Fig. 57.)

†*Chilodon* sp., Knowles, 1928, p. 522.
†*Chilodon rhesus*, Ghosh, 1929 *b*, pp. 15–16, fig. 1.

Body flattened and elongately ovate, length less than twice the breadth, widest behind the middle. Anterior end somewhat tapering, rounded, and slightly bent to the left. Dorsal surface convex, ventral surface flattened and ciliated ; no dorsal row of cilia. Cilia longest in the anterior portion. Cytostome circular and situated towards the left side at one-fourth or one-fifth of the body-length from the anterior end. Cytopharynx short, truncate, and directed towards the left, with a distinct rod-apparatus. Ectoplasm thick ; endoplasm coarsely granular. Contractile vacuole spherical and postero-terminal. Macronucleus large, oval, central or somewhat behind the middle. The macronucleus consists of a large clear area, with a small mass of chromatin in the centre, the clear area being surrounded by dense chromatin granules which fill up the rest of the macronucleus. Micronucleus not detected. Intestinal parasite.

Dimensions.—Length 50–65 μ, width 26–42 μ.

Remarks.—The species differs from others in the absence of an adoral row of cilia, in its short pharynx, and a very short and straight rod-apparatus.

Habitat.—In the intestine of the common Bengal monkey, *Macacus rhesus* : BENGAL, Calcutta.

70. **Chilodonella spiralidentis** (Bhatia & Mullick). (Fig. 58.)

†*Chilodon spiralidentis*, Bhatia & Mullick, 1930, pp. 394–5, fig. 2.

Body flattened, oval, nearly twice as long as broad. Dorsal surface convex, ventral surface flat and uniformly ciliated. Cilia arranged along parallel lines, which run straight in the left half and curve round to the anterior end in the right half of the body. Anterior extremity of the body produced into a flattened beak slightly curving to the left. Cytostome situated some distance behind the anterior end, followed by a cytopharynx which is wider in front and the narrow portion of which is spirally curved. Cytoplasm vacuolated. Contractile

vacuoles three, the largest near the posterior end. Macronucleus somewhat oval and surrounded by a clear space. The nuclear membrane has a wavy zone of nucleoplasm adhering to it all round. There is a large, centrally placed nucleolus with a dark central karyosome. Chromatin granules are compactly arranged in two masses on the anterior and posterior sides of the nucleolus and less densely laterally.

Dimensions.—Length 97 μ.

Remarks.—The movement is usually gliding, but sometimes the animal swims forward and rotates on its axis. The length of the animal is 97 μ and the maximum width 53 μ.

The species, as defined above, shows some resemblance to *C. cucullulus* (Müller) and *C. uncinatus* (Ehrbg.). It resembles *C. cucullulus* in the arrangement of the ciliary lines and the structure of the nucleus, but differs from it in the form of the cytopharynx, which is spirally curved. It resembles *C. uncinatus* in having the cytopharynx spirally curved, but differs from that species in the structure of the nucleus, the number and disposition of the contractile vacuoles, and its larger size.

Habitat.—Pond water : KASHMIR, Srinagar.

71. **Chilodonella** sp.

†*Chilodon* sp., Chaudhuri, 1929, p. 54, pl. iii, fig. 7.

Remarks.—Chaudhuri gives no description, and the organism cannot be identified from the rather crude diagram given by him.

Habitat.—Soils : BENGAL, Sibpore ; CENTRAL INDIA, Indore.

72. **Chilodonella** sp.

†*Chilodon* sp., Simmons, 1889, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

2. Suborder *TRICHOSTOMATA* Bütschli, emend. Kahl.

HOLOTRICHA with body usually covered entirely with cilia. A well-developed peristomial depression or groove, the surface of which is ciliated, leads to the cytostome, and causes a spiral twisting of the body. Cytostome is kept permanently open and the food is brought in by a whirlpool. Cytopharynx tubular, not containing a rod-apparatus. Both the cytostome and the cytopharynx are provided with specially thickened cilia, which are not united to form membranes but help to direct the current, containing food particles, down the cytopharynx.

Remarks.—Bütschli used the term TRICHOSTOMATA to include all groups of CILIATA other than the GYMNOSTOMATA. He divided the order TRICHOSTOMATA into the suborders ASPIROTRICHA (including all the HOLOTRICHA except GYMNOSTOMA) and SPIROTRICHA (including HETEROTRICHA, OLIGOTRICHA, HYPOTRICHA and PERITRICHA). Calkins (1926) applied the term TRICHOSTOMINA to those HOLOTRICHA in which there is always a ciliated peristomial groove and special cilia, which may be free or united to form membranes, in the cytostome or the cytopharynx. This group had been previously designated as HYMENOSTOMATA by Delage and Hérouard (1896), Schewiakoff (1896), Hickson (1901) and Minchin (1912). Kahl (1926, 1930–5) still further restricted the term TRICHOSTOMATA to a suborder of HOLOTRICHA in which there is a ciliated peristomial groove and the oral and pharyngeal cilia are not united to form membranes, and he also restricted the term HYMENOSTOMATA to those in which the oral and pharyngeal cilia are united to form membranes. Reichenow (1929) has followed Kahl in this usage of these terms.

Identification Table of Families.

A. *Fresh-water*:

1 (2). Small, ovoid Infusoria, with a ciliated peristomial groove, which surrounds half of the anterior end, and a projection provided with bristles extending beyond it. They secrete a delicate gelatinous test; swim backwards ... **Marynidæ** * Poche.
2 (1). Other forms, building no test ..... 3.
3 (4). Small, generally strongly flattened laterally, with delicate, coat-of-mail-like pellicle. Cilia sparse, particularly on the right flattened side,

where they form a semicircular or sickle-shaped uninterrupted dorsal keel, and 2–9 interrupted rows on the plane surface. Cytostome on the compressed ventral surface, membranoid structures generally recognizable with difficulty. Two contractile vacuoles. [p. 153.

4 (3). Other forms, differently ciliated ..... **Trichopelmidæ** Kahl,

5 (6). Small to very small Infusoria with long tail-like process; the body cilia occupy only the anterior half in 3–4 transverse spirals ..... [Kahl).

6 (5). Without a tail-like process and differently ciliated ..... [(=**Sciadostomidæ***

7 (10). A zone of special cilia extends spirally from the mouth to the hinder end .. **Trimyemidæ*** Kahl

8 (9). Spiral zone extends from the anterior right to the posterior left (optical)... 7.

9 (8). Spiral zone extends from the anterior left to the posterior right (optical) .. 8.

10 (7). Without special spiral row ..... **Spirozonidæ*** Kahl.

11 (12). On the ventral side a ciliated transverse groove runs to the cytostome.. **Trichospiridæ*** Kahl.

12 (11). Without ventral transverse groove ... 11.

13 (14). Cytostome in the first fourth in a shallow oval longitudinal groove, the walls of which are provided with uniformly thick cilia ..... [p. 139.
Plagiopylidæ Schew..

14 (13). Cytostome deepened in a funnel-like manner ..... 13.

15 (16). From the anterior end a broad peristomial groove runs backwards and to the right up to the middle of the body, at the bottom of which lies the characteristic oral funnel (vestibule). Oral funnel with a strong ciliary field .... **Clathrostomidæ*** Kahl.

16 (15). Without a depression extending backwards from the anterior end ..... 15.

17. Oral funnel with tunnel-shaped passage, with a ciliary field at the lower and another at the upper side of the funnel. Free-living, mostly moss-inhabiting forms ..... [p. 145.
Parameciidæ Kent,

17.

[p. 141.
Colpodidæ Poche,

Incertæ sedis:

1. Form oval or lanceolate, strongly flattened, posteriorly drawn out. Cytostome a very short ciliated groove near the anterior end ..... [Madsen.
Entorhipidiidæ*

2. Form obovate, with a posterior bunch of gelatinous threads fixing the body to the substratum, and with a stiff bristle arising from the posterior end of the body. Cytostome in the centre of the ventral surface ..... [(=**Centrostomatidæ***).
Lagenellidæ* Grand.

3. Form elongate, very contractile. Cytostome a long, simple, and narrow groove, lying along the ventral margin near the anterior end ..... **Geleiidæ*** Kahl.

B. *Parasitic*:

1	(6). Entire body covered with cilia.....	2.
2	(3). Cytostome ventral, connected by a groove with the anterior end, or numerous small cytostomes along the whole length of the groove; parasites of mammals.....	[Chatt. & Per.). [(=**Nicollellidæ** * **Pycnothrichidæ*** Poche
3	(2). Cytostome ventral, not connected by a groove with the anterior end.....	4.
4	(5). Cytostome ventral, near the posterior end; concretion vacuole absent; parasites in the stomach of ruminants.	[p. 156. **Isotrichidæ** Bütsch.,
5	(4). Cystostomial groove on the ventral surface between it and the anterior end of the body is a frontal field covered with longer cilia; concretion vacuole present; parasites in the cæcum of horse	[da Cunha **Paraisotrichidæ** *
6	(1). Cilia over certain regions of the body only	7.
7	(8). Peristome occupies entire anterior end; cilia limited to the peristomial field and adjacent part of the body; parasites in the cæcum of guinea-pigs ...	[da Cunha. **Cyathodinidæ** *
8	(7). Cytostome not terminal; tufts of cilia above and below cytostome and in posterior anal region; parasites in the stomach of ruminants	[Hsiung, p. 160. **Blepharocoridæ**

* In addition to the families enumerated above, Protohallidæ da Cunha & Muniz (1927) and Sulcigeridæ Gajewskaja (1933) may be mentioned, each based on a single species.

1. Family PLAGIOPYLIDÆ Schewiakoff, 1896.

Dorso-ventrally flattened, oval to ovoidal forms. Without a tail-like process of the body and without a special spiral zone of cilia. On the ventral side of the body a ciliated groove runs transversely across to the cytostome. Cytostome followed by a short ciliated cytopharynx.

Genus **PLAGIOPYLA** Stein, 1860.

Plagiopyla, Stein, 1860 *a*, pp. 57, 58–9; Kent, 1880–2, p. 538; Bütschli, 1887–9, p. 1704; Roux, 1901, p. 76; Penard, 1922, p. 186; Lepsi, 1926 *a*, p. 51; Calkins, 1926, p. 406; Schoenichen, 1927, p. 219; Kahl, 1930–5, p. 264.

Body elongated oval, flattened. On the anterior fourth of the ventral surface a peristomial groove runs transversely across from the right margin of the body, and is provided along both margins with thicker cilia, which are, however,

not united to form membranelles. At its end is the cytostome, followed by a short ciliated cytopharynx. Macronucleus rounded, with a small rounded micronucleus close to it.

73. **Plagiopyla (?) carteri** Kent. (Fig. 59.)

†*Plagiopyla* (?) *carteri*, Kent, 1880–2, p. 538, pl. xxvi, fig. 69.

Body elliptical, cylindrical, equally rounded at the two extremities, about twice as long as broad. Cytostome nearly mid-way between the centre and the anterior extremity of the body, enclosing a minute, lunate, undulating membrane, followed by a conically-pointed tubular cytopharynx; anal aperture lateral, on the same surface as the mouth, but nearer the posterior extremity. Cuticular cilia short, disposed in even longitudinal rows. Contractile vacuole lateral, subcentral. Macronucleus undetermined.

Dimensions.—Length 200 μ.

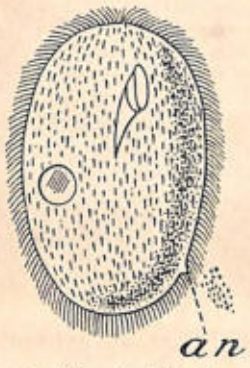


Fig. 59.—*Plagiopyla* (?) *carteri* Kent. *an*, anal aperture. (After Kent.)

Remarks.—The form figured and briefly described by H. J. Carter in his manuscript notes under the title of *Paramœcium* ? was described as a new species by Kent, and was tentatively referred to *Plagiopyla*. It does not, however, seem to belong to this genus, as there is no peristomial groove running transversely across from the right margin of the body. Further, the cytopharynx as figured does not show any cilia, but a lunate membrane. Kent himself was doubtful and thought that the form would perhaps be more rightly referred to the genus *Ophryoglena*. But in my opinion the form cannot even be referred to *Ophryoglena*, as the characteristic deeply-sunk oral groove is wanting.

Habitat.—Fresh water: Bombay, Bombay.

2. Family COLPODIDÆ Poche, 1913, emend. Kahl, 1926.

The body cilia run in rows arranged in a concentric manner round the convex oral margin on the ventral surface and diagonally on the dorsal surface. Body is without a depression extending backwards from the anterior end. A funnel-shaped groove, in the anterior half of the body, runs across one of the surfaces of the body. Both upper and lower sides of the funnel bear ciliary fields. These cilia are (according to Kahl) not united into membranes. Cytostome followed by a short cytopharynx leading to a food vacuole. Alveolar layer of the ectoplasm always contains short trichocysts or trichocyst-like, round, shining bodies. Contractile vacuole single, posterior. Macronucleus spherical or slightly oval and contains a nucleolus.

Genus **COLPODA** O. F. Müller, 1773.

Kolpoda, Müller, 1773, pp. 56–7.
Colpoda, Gmelin, 1791, p. 3894; Ehrenberg, 1838, p. 346.
Kolpoda (part), Dujardin, 1841, p. 478.
Colpoda, Claparède & Lachmann, 1858–60, p. 270; Kent, 1880–2, p. 512; Rhumbler, 1888, pp. 549–601; Bütschli, 1887–9, p. 1707; Schewiakoff, 1896, p. 306; Roux, 1901, p. 57; Enriques, 1908 *a*, p. 272, 1908 *b*, pp. i–xv; Calkins, 1926, p. 406; Lepsi, 1926 *a*, p. 53; Schoenichen, 1927, p. 207; Sandon, 1927, p. 183; Kahl, 1930–5, p. 273.

Body kidney-shaped, laterally flattened. Dorsal surface strongly convex, ventral plain or convex, provided with a deep depression in the anterior part or in the middle. Anterior end rounded, twisted from left to right and curved on the ventral face. Posterior end uniformly enlarged and rounded. Cilia long, fine, and closely arranged in longitudinal rows. Cytostome in the ventral depression, oval, usually described as provided with an undulating membrane. Cytopharynx absent or rudimentary, described by Roux as short, curved and provided with a narrow undulating membrane. According to Kahl undulating membranes, as also the lip-like projection described by Enriques, are absent, these investigators having wrongly interpreted the projecting marginal cilia as such. Anus posterior. Contractile vacuole single, posterior. Macronucleus variable in form. The organism divides after encystment into two or four daughter organisms. Locomotion rapid, with changes of aspect. Feeding on bacteria.

Key to Indian Species.

8 to 10 frontal dentations, macronucleus with lobate karyosome	*C. cucullus* O. F. Müll., [p. 142.
6 to 7 frontal dentations, macronucleus with lobate karyosome	*C. maupasi* Enriques, [p. 143.
6 to 7 frontal dentations, macronucleus with non-lobate karyosome	*C. steinii* Maupas, [p. 144.

74. **Colpoda cucullus** O. F. Müller. (Fig. 60.)

Kolpoda cucullus, O. F. Müller, 1773, p. 58 ; 1786, p. 102, pl. xiv, figs. 7–14.
Colpoda cucullus, Ehrenberg, 1838, pp. 347–8, pl. xxxix, fig. 5.
Kolpoda cucullus, Dujardin, 1841, pp. 479–81, pl. iv, fig. 29 ; pl. xiv, fig. 5 (*1*).
Colpoda cucullus, Stein, 1854 *d*, pp. 15–25, 34–5, 131, 204, pl. iii, figs. 1–31 ; 1867, p. 48 ; Claparède & Lachmann, 1858–60, p. 270 ; Kent, 1880–2, pp. 512–3, pl. xxvii, figs. 19–23 ; Maupas, 1883, pp. 430–6, pl. xix, figs. 1–6 ; Rhumbler, 1888, pp. 549–601, pl. xxxvi, figs. 1–57 ; Bütschli, 1887–9, p. 1707, pl. lxii, fig. 7 ; Schewiakoff, 1893, p. 48 ; 1896, p. 307, pl. iv, fig. 111.
†*Colpoda cucullus*, Daday, 1898, p. 8.
Colpoda cucullus, Roux, 1901, p. 58, pl. iii, fig. 11 ; Enriques, 1908 *b*, pp. vi–vii, figs. 1, 2.
†*Colpoda cucullus*, Bhatia, 1916, p. 182 ; Ghosh, 1921 *a*, p. 9, fig. 6 ; Gulati, 1925, p. 749, pl. ii, fig. 16.
Colpoda cucullus, Lepsi, 1926 *a*, p. 62, figs. 216–19 ; Wenyon, 1926, p. 1179, fig. 498 ; Schoenichen, 1927, p. 207, pl. xii, fig. 32.
†*Colpoda cucullus*, Sandon, 1927, p. 183, pl. vi, fig. 1 ; Madhava Rao, 1928, p. 114, pl. iii, fig. 4 ; Chaudhuri, 1929, p. 60, pl. ii, figs. 10, 11, 12.
Colpoda cucullus, Reichenow, 1929, pp. 1175–6, 1187, fig. 1159 ; Kahl, 1930–5, p. 277, fig. 47, *1–3*.

Body strongly kidney-shaped, with a well-marked depression, the ventral side with strong furrows which give the anterior end a curved appearance. Frontal dentations 8 to 10. Colour yellowish or brown owing to large number of food-vacuoles being filled with algæ. Cytopharynx absent, or short and curved. Cilia of the oral region projecting in a tuft-like manner. Contractile vacuole large, single, posterior. Macronucleus oval, central, with a lobed karyosome. Reproduction occurs in cysts, and just before excystation cysts contain two or four individuals actively rotating.

Dimensions.—Length very various, from 40–120 μ, average 80 μ. Cysts on an average about 35 μ in diameter.

Remarks.—*C. cucullus* is one of the commonest soil Ciliates. It is larger than the two other species, and the part behind the mouth is very swollen and almost globular. Reproduction often occurs in the cysts, which are about 35 μ in diameter.

Habitat.—In soil : Kashmir, Punjab, Sind, Bombay, Mysore, Madras, Hyderabad, Central Provinces, United

PROVINCES, ORISSA, BENGAL, ASSAM, and BURMA. In vegetable infusions : PUNJAB, Lahore, and BENGAL, Calcutta. In fresh water : CEYLON.

Fig. 60. Fig. 61. Fig. 62.

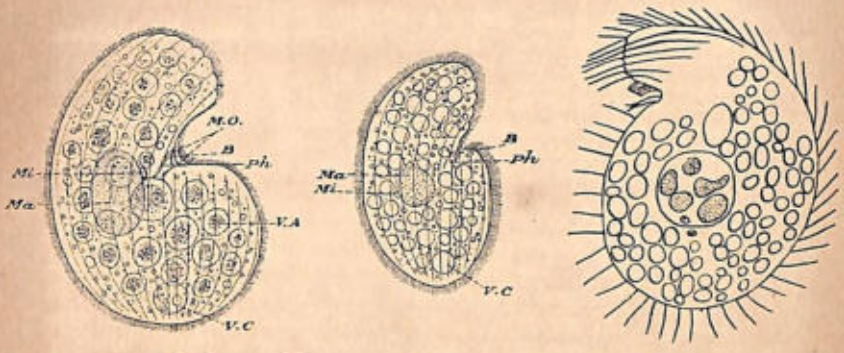


Fig. 60.—*Colpoda cucullus* O. F. Müll. *B*, cytostome ; *Ma*, macronucleus ; *Mi*, micronucleus ; *M.O.*, undulating membrane ; *ph*, cytopharynx ; *V.A*, food-vacuole ; *V.C*, contractile vacuole. (After Roux.)
Fig. 61.—*Colpoda steinii* Maupas. Lettering as in fig. 60. (After Roux.)
Fig. 62.—*Colpoda maupasi* Enriques. (After Sandon.)

75. **Colpoda maupasi** Enriques. (Fig. 62.)

Colpoda maupasi, Enriques, 1908*b*, pp. vii–xi, figs. 3–5, 9 ; Wenyon, 1926, p. 1180.
†*Colpoda maupasi*, Sandon, 1927, p. 183, pl. i, fig. 24, pl. vi, fig. 2.
Colpoda maupasi, Kahl, 1930–5, p. 279, fig. 47, *12*.

Body oval and cylindrical, more elongated than *C. steinii*, with the anterior end more rounded. Frontal dentations 6 to 7. Left margin with small, but distinct, semicircular excavation. Macronucleus spherical, with a lobate karyosome, and with a micronucleus lying close to it.

Dimensions.—Length 35–70 μ. Cysts smaller, about 15–20 μ in diameter.

Remarks.—According to Enriques this species cannot be induced to conjugate readily like *C. steinii*. The cysts, which are smaller than in the other two species, are enclosed in a thick, structureless, mucilaginous outer layer, which is not so corrugated as the outer wall in the other species. In older cysts this outer layer condenses into a relatively thin and highly refringent wall.

Habitat.—In soils : BENGAL, Pusa, and MADRAS, Madras and Coimbatore.

76. **Colpoda steinii** Maupas. (Fig. 61.)

Colpoda steinii, Maupas, 1883, pp. 436–43, pl. xix, figs. 7–14; Bütschli, 1887–9, p. 1707, pl. lxii, fig. 8; Schewiakoff, 1896, p. 308, pl. iv, fig. 112; Roux, 1901, p. 58, pl. iii, fig. 12.
Colpoda steini, Enriques, 1908 *a*, p. 272; 1908 *b*, pp. xi–xiii, figs. 6–8, 10.
Colpoda steinii, Lepsi, 1926 *a*, p. 62, figs. 220–2.
Colpoda steini, Wenyon, 1926, pp. 1179–80, fig. 498; Schoenichen, 1927, p. 208, fig. 733.
†*Colpoda steinii*, Sandon, 1927, p. 183, pl. vi, fig. 3.
†*Colpoda steini*, Madhava Rao, 1928, p. 114, pl. iv, fig. 3.
†*Colpoda steinii*, Chaudhuri, 1929, p. 60, pl. ii, figs. 1–9, pl. iv, figs. 9, 12; Bhatia & Mullick, 1930, p. 395.
Colpoda steini, Kahl, 1930–5, p. 279, fig. 47, *13*, and p. 281, fig. 46, *14*.

Body oval and cylindrical, relatively more elongated than in the preceding species, anteriorly more narrowed. Frontal dentations 6 to 7. Ventral surface nearly flat. Posterior end less broad. Ventral depression less pronounced than in *C. cucullus*. Colour deep grey. Cytostome situated at the bottom of the depression and followed by a short tubular cytopharynx. Large food vacuoles often present. Contractile vacuole single, in the posterior region of the body. Macronucleus central, spherical or oval, with a non-lobate karyosome, and with a micronucleus close to it.

Dimensions.—Length 25–60 μ, width 9–15 μ. Cysts smaller than in *C. cucullus*, being about 25 μ in diameter.

Remarks.—*C. steinii* is also one of the commonest soil ciliates. It is smaller than *C. cucullus*, and is not inflated behind, so that the ventral surface is quite flat except for the notch which leads to the mouth. The anterior end is also more pointed than in *C. cucullus*. Reproduction takes place in cysts. The specimens found at Srinagar possessed a tuft of longer cilia at the posterior end of the body, and measured about 53 μ in length.

Habitat.—In soil: Behar, Pusa; Assam, Cinnamara; Bombay, Poona; Kanara; Madras, Coimbatore; Burma, Hmawbi (*Sandon*); Mysore (*Madhava Rao*); N.W.F. Province, Peshawar; Punjab, Ghora Gali, Lahore, Delhi; United Provinces, Dehra Dun; Bombay, Bombay, Dharwar; Central India, Indore; Central Provinces, Nagpur; Hyderabad; Madras, Madras; Burma, Rangoon; Ceylon, Colombo (*Chaudhuri*). In pond water: Kashmir, Srinagar.

77. **Colpoda** sp.

Colpoda sp., Knowles, 1927, p. 522.

Habitat.—In cultures of *Paramecium*: Bengal, Calcutta.

3. Family PARAMECIIDÆ Kent, 1881, emend. Kahl, 1931.

Body elongate and cigar-shaped or shorter and plumper, finely ciliate throughout, usually with longer cilia at the posterior end. From the anterior end of the body a broad peristomial groove runs backwards and to the right, to the middle of the body. Cytostome at the bottom of the peristomial groove, followed by a funnel-shaped cytopharynx. Oral funnel with a strong ciliary field, a row of very fine cilia being attached to the dorsal wall of the cytopharynx. Contractile vacuoles, usually two, with radiating canals. Macronucleus oval, with one, two, or numerous micronuclei.

Genus **PARAMECIUM** Hill, 1752, emend. Stein, 1860.

Paramæcium, Hill, 1752 ; Müller, 1773, p. 54.
Paramecium, Gmelin, 1791, p. 3895 ; Rafinesque-Schmaltz, 1814, p. 89 ; Ehrenberg, 1838, p. 349 ; Dujardin, 1841, p. 481 ; Claparède & Lachmann, 1858–61, p. 263 ; Fromentel, 1876, p. 183.
Paramæcium, Kent, 1880–2, p. 483 ; Bütschli, 1887–9, pp. 1710–1, pl. lxiii ; Schewiakoff, 1896, p. 334.
Paramecium, Roux, 1901, p. 67 ; Woodruff, 1921 *a*, pp. 171–180 ; Calkins, 1926, p. 407 ; Wenyon, 1926, pp. 1163, 1175.
Paramæcium, Lepsi, 1926 *a*, p. 50 ; Schoenichen, 1927, p. 211 ; Sandon, 1927, p. 185.
Paramecium, Wenrich, 1928 *b*, pp. 275–82, pls. xxvi–xxvii.
Paramæcium, Reichenow, 1929, pp. 1175–7.
Paramecium, Kahl, 1930–5, p. 289.

Animalcules free-swimming, medium-sized to large, ovate or elongate, asymmetrical, more or less flexible but persistent in shape, finely ciliate throughout, usually with a group of longer cilia at the posterior end ; the cilia of the oral region not differing in size or character from those of the general surface of the body, a complete layer of trichocysts abundantly developed. An oblique peristomial groove developed on the ventral surface, at the posterior extremity of which, at or about the middle of the ventral surface of the body and to the right of the median line, the cytostome is situated ; cytopharynx moderately long, with a row of very fine cilia attached to its dorsal wall ; a membranelle present according to some, absent according to others. One or more, commonly two, contractile vacuoles, usually with radiating canals. Macronucleus oval, central or subcentral, with one, two, or numerous micronuclei. One species coloured green owing to the presence of zoochlorellæ. Locomotion quick and uniform, with frequent pauses, and sometimes rotating on its longitudinal axis. Fresh water or marine, very common.

Remarks.—Maier (1903), Minchin (1912), Lühe (1913), Bourne (1921) and various other authors described one or more undulating membranes attached to the dorsal wall of the cytopharynx. Bozler (1924), v. Gelei (1926–7) and Kahl (1930–5) showed that there are no undulating membranes, but only free cilia attached to the wall of the cytopharynx, thus necessitating the transfer of the genus from HYMENOSTOMATA to TRICHOSTOMATA. More recently v. Gelei (1934) has published a thorough study of the detailed structure of the cytopharynx of *Paramecium*, and comes to the conclusion that the cytopharynx consists of three sections, viz., the vestibule, the pharynx and the œsophagus. The first bears free cilia, the second possesses membranes showing a characteristic Hymenostomatous structure, and the third part contains fibres or elements which can be compared with the rods in the gullet of GYMNOSTOMATA. On the strength of these observations, he remarks that *Paramecium* can neither be placed among HYMENOSTOMATA nor among TRICHOSTOMATA, but should be placed in a new suborder lying between the two, for which he proposes the name TRICHOHYMENOSTOMATA.

Woodruff (1921) pointed out that in this genus the species fall into two groups according to the shape of the body, namely: (*a*) The "*aurelia* group," with cigar-shaped bodies, round in cross-section and tapering to a point at the posterior end, and (*b*) the "*bursaria* group," broadly elliptical in cross-section and rounded at the posterior end. In either group two types of micronuclear structure may be found, viz., (*a*) the "*caudatum* type," in which the micronucleus is a relatively large, rather compact mass of chromatin, and (*b*) the "*aurelia* type," in which the micronuclei are small and distinctly vesicular in organization. On the basis of these facts Wenrich (1928) has recognized eight well-defined species, and he considers that no description of a species can be considered complete unless it includes a description of the type and number of micronuclei.

Key to Indian Species.

1 (4). Body cigar-shaped, widest near or a little posterior to the middle and tapering towards both ends, but more pointed at the posterior end; round in cross-section posterior to the cytostome; length usually more than three times the width.. 2.

2 (3). Length usually between 120 and 180 μ; posterior end narrowed but less sharply pointed (about 90°) than in the other species; two contractile vacuoles; two small vesicular micronuclei..... [p. 147. *P. aurelia* Ehrbg.,

3 (2). Length commonly between 200 and 300 μ; posterior end more pointed than in

P. aurelia; normally two contractile vacuoles; single micronucleus relatively large and compact ..... [p. 150.

4 (1). Body somewhat compressed dorso-ventrally, rounded posteriorly; usually not more than three times as long as wide .. *P. caudatum* Ehrbg., 5.

5. Body usually containing small green algæ (zoochlorellæ); usually 120–160 μ in length; cyclosis relatively rapid; single micronucleus relatively large and compact. [p. 148. *P. bursaria* (Ehrbg.).

78. **Paramecium aurelia** Ehrenberg. (Fig. 63, A & B.)

Paramæcium aurelia, Ehrenberg, 1833, pp. 172, 176, 179, 323, pl. iii, fig. 1; 1838, pp. 350–1, pl. xxxix, fig. 6.
Paramecium aurelia, Dujardin, 1841, pp. 480–3, pl. viii, figs. 5, 6.
Paramæcium aurelia, Stein, 1854, pp. 239–40, 240–3; 1859 *a*, p. 58; 1859 *d*, pp. 52, 58, 61–2, 77, 78, 87, 97–101; 1861, p. 65; 1867, pp. 9, 24, 31, 39, 41–4, 47, 48, 50, 53, 58–9, 65, 67, 75–6, 88–92, 95–9, 118–9, 121.
†*Paramecium aurelia*, Carter, 1856 *b*, pp. 115–32, 221–49, pl. vi, figs. 65–9.
Paramæcium aurelia, Claparède & Lachmann, 1858–61, pp. 49–50, 54–5, 263–5; vol. ii, pp. 199–200, 256, 259–61, 264, 291, pl. xi, figs. 8–17; Balbiani, 1860, pp. 1192–3; 1861, pl. ix, figs. 23, 24; Pritchard, 1861, p. 634, pl. xxv, figs. 329–32; Engelmann, 1862, pp. 349, 368, 387, 391; 1876, pp. 604–9; Fromentel, 1874, p. 296, pl. xvi, fig. 8; Mereschkowsky, 1879, p. 254; Maupas, 1883, pp. 607–61, pl. xx. fig. 18, pl. xxi, figs. 14, 15; 1886 *a*, pp. 1569–72; 1886 *b*, pp. 482–4; 1888 *a*, p. 234, pl. x, fig. 12; 1889, pp. 215–28, pls. xii, xiii, figs. 1–33; Schewiakoff, 1896, pp. 339–40, pl. v, fig. 126.
Paramecium aurelia, Roux, 1901, p. 67, pl iv, fig. 3; Woodruff, 1911 *b*, pp. 223–37; Lepsi, 1926 *a*, p. 58, fig. 229; Calkins, 1926, p. 541, fig. 226; Wenyon, 1926, pp. 55, 64, 114, 131, figs. 34 & 37; Schoenichen, 1927, p. 211, fig. 735; Wenrich, 1928, p. 279, pl. xxxvi. fig. 3.
Paramæcium aurelia, Reichenow, 1929, p. 1177, figs. 1160 B & 1143.
†*Paramecium aurelia*, Bhatia & Mullick, 1930, p. 396.
Paramecium aurelia, Kahl, 1930–5, p. 291, fig. 48, *3*, *4*.

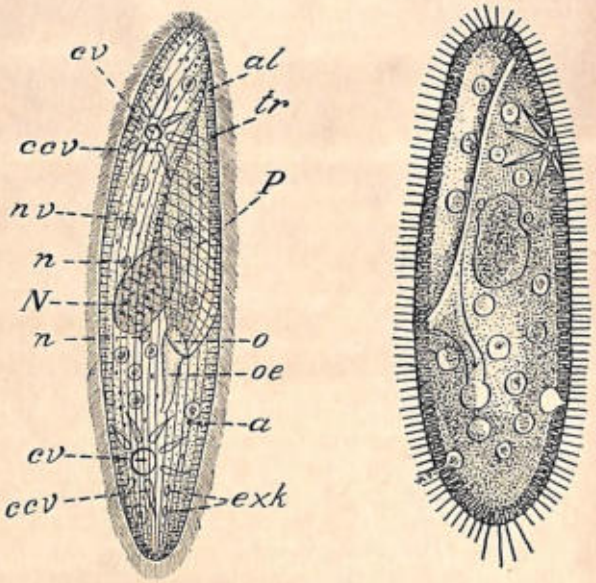
Body elongated, ellipsoid, rounded at both extremities, posteriorly drawn into a tapering but less pointed end, which is generally not provided with the posterior tuft of cilia. Cilia over the body uniform. Peristomial groove about two-thirds of the body, running obliquely. Trichocysts well developed. Contractile vacuoles two, with radiating canals, situated along the right border. Anus ventral, in the posterior part of the body. Macronucleus oval, with two small vesicular micronuclei. Common in infusions and stagnant water.

Dimensions.—Length 75–290 μ, usually between 120 and 180 μ, width 15–50 μ.

Remarks.—Smaller in size and less pointed at the posterior end than *P. caudatum*. In specimens examined at Srinagar

and Lahore there was no tuft of longer cilia at the posterior end. In the stained preparations two vesicular micronuclei are seen, situated one on each side of the macronucleus.

Habitat.—Fresh water: KASHMIR, Srinager; PUNJAB, Lahore; BOMBAY, Bombay.



A. B.

Fig. 63.—A. *Paramecium aurelia* Ehrbg. *a*, anus; *al*, alveolar layer; *cv*, contractile vacuole; *ccv*, radiating canals; *exk*, excretory granules; *N*, macronucleus; *n*, micronucleus; *nv*, food-vacuole; *o*, cytostome; *oe*, cytopharynx; *P*, peristomial groove; *tr*, trichocysts. (After Schewiakoff.) B. *Paramecium aurelia* Ehrbg., showing micronuclear structure. (After Wenrich.)

79. **Paramecium bursaria** (Ehrenberg) Focke. (Fig. 64, A & B.)

Loxodes bursaria, Ehrenberg, 1833, pp. 238–45, pl. iv, figs. 6–16; 1838, pp. 324–5, pl. xxxiv, fig. 3.

Paramecium bursaria, Focke, 1836, pp. 786–7; 1843, p. 227.

Loxodes bursaria, Cohn, 1851, pp. 260–78, pl. vii, figs. 1–6; 1854 *b*, pp. 422–8, pl. xxii, figs. 1–3.

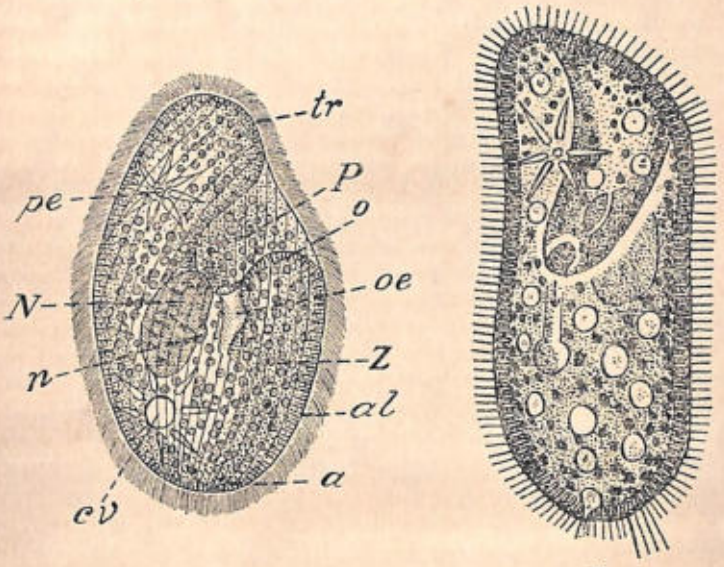
Paramecium bursaria, Claparède & Lachmann, 1858–61, pp. 265–6, 344; vol. ii, pp. 193–7, 256, 266, pl. x, figs. 20–4; Stein, 1859 *d*, pp. 16, 43–4, 52, 57, 88, 97; 1867, pp. 41–4, 50, 53–5, 58–9, 65, 76, 89, 91–2, 95, 98, 118–19, 121; Engelmann, 1862, pp. 348–9, 368, 387, 391; 1876, pp. 609–11; Kent, 1880–2, pp. 486–7, pl. xxvi, figs. 31, 32; Bütschli, 1887–9, pp. 1710–11, pl. lxiii, figs. 2 *a–d*, 3 *a*, *b*, *d–g*, 5 *a–c*; Maupas, 1883,

pp. 607–61 ; 1886 *a*, p. 1573 ; 1888 *a*, pp. 234–5, pl. xii, fig. 16 ; 1889, pp. 224–38, pls. xiii, xiv, figs. 1–21 ; Schewiakoff, 1893, pp. 52–3 ; 1896, pp. 341–2, pl. v, fig. 128, pl. vii, fig. 204 ; Roux, 1901, p. 68, pl. iv, fig. 5 ; Hamburger, 1904, pp. 199–239, pls. vii–ix & 2 figs. ; Lepsi, 1926 *a*, p. 58, fig. 231 ; Calkins, 1926, p. 385, fig. 170 ; Schoenichen, 1927, pp. 211–12, pl. xii, fig. 41 ; Wenrich, 1928, p. 280, pl. xxxxvii, fig. 5 ; Reichenow, 1929, p. 1177, fig. 1160 *c*.

†*Paramecium bursaria*, Bhatia & Mullick, 1930, p. 396.

Paramecium bursaria, Kahl, 1930–5, p. 293, fig. 48, *13*.

Body oval, flat, little more than twice as long as broad ; rounded and wide posteriorly, narrowest and obliquely truncate at the anterior extremity. Peristomial groove flat, infundibulate, very wide anteriorly, extending obliquely backwards



A. B.

Fig. 64.—A. *Paramecium bursaria* (Ehrbg.). *a*, anus ; *al*, alveolar layer ; *cv*, contractile vacuole ; *N*, macronucleus ; *n*, micronucleus ; *o*, cytostome ; *oe*, cytopharynx ; *P*, peristomial groove ; *pe*, excretory pore ; *tr*, trichocysts ; *Z*, zoochlorellæ. (After Schewiakoff.) B. *Paramecium bursaria* (Ehrbg.), showing micronuclear structure. (After Wenrich.)

from left to right to beyond the centre of the body. Cytostome situated at the posterior extremity of the groove, followed by a distinct cytopharynx. Trichocysts abundantly developed ; under the trichocyst coat the cortical and endoplasmic layers mostly coloured green owing to the presence of numerous zoochlorellæ. Contractile vacuoles two in number,

spherical or stellate. Anal aperture postero-terminal. Macronucleus oval, with a simple, relatively large and compact micronucleus lying close to it. In marsh water, common among plants in standing water.

Dimensions.—Length 90–306 μ, usually 120–160 μ.

Remarks.—This species can be readily recognized by its size (usually 120–160 μ in length), rounded posterior end, green colour due to the presence of numerous small green algæ or zoochlorellæ, and rapid cyclosis. In combination with these characters staining will show a relatively large single micronucleus of the *caudatum*-type, and thus make identity certain.

The specimens found at Lahore were typical in every respect except that they were of a somewhat smaller size than is usual for this species. One specimen measured 84 μ by 40 μ and another 95 μ by 42 μ. The body was oval and obliquely truncate anteriorly. The contractile vacuoles were two in number, spherical and without any radiating canals in some individuals and stellate in others. The macronucleus was kidney-shaped and the micronucleus was situated in the notch.

The species was also commonly met with at Srinagar (Kashmir). The form was, as usual, dorso-ventrally flattened and the posterior end rounded. Cytoplasm full of small green algæ and showed rapid cyclosis. Peristomial groove rather small in length as compared with the size of the animal. Macronucleus large, central, kidney-shaped. Micronucleus single, of massive type, and lying in the depression of the macronucleus. Some of the specimens were extraordinarily large, one measuring as much as 306 μ in length.

Habitat.—In stagnant water : KASHMIR, Srinagar ; PUNJAB, Lahore.

80. **Paramecium caudatum** Ehrenberg. (Fig. 65, A & B.)

Paramæcium aurelia, O. F. Müller, 1773, p. 54 ; 1786, p. 86, pl. xii, figs. 1–14.

Paramecium caudatum, Ehrenberg, 1833, pp. 268, 323, pl. iii, fig. 2 ; 1838, pp. 351–2, pl. xxxix, fig. 7 ; Dujardin, 1841, p. 483, pl. viii, fig. 7 ; Stein, 1867, p. 44.

Paramecium aurelia, Kent, 1880–2, pp. 483–6, pl. xxvi, figs. 28–30.

Paramecium caudatum, Maupas, 1886 *a*, p. 1572 ; 1886 *b*, pp. 482–4 ; 1888 *a*, pp. 230–3, pl. x, figs. 10, 11 ; 1889, pp. 181–215, pls. lxiii, figs. 1–64 ; Bütschli, 1887–9, pp. 1710–11, pl. lxiii, figs. 1 *a–k*, 3 *c*.

Paramæcium caudatum, Schewiakoff, 1893, p. 52 ; 1894, pp. 39–56, pl. iii, figs. 1–8 ; 1896, pp. 340–1, pl. v, fig. 127 ; pl. vii, figs. 169–70, 187, 192, 202–3.

Paramecium caudatum, Roux, 1901, p. 68, pl. iv, fig. 4 ; Schuberg, 1905, pp. 70–2, 93–7, 102–4.

Paramæcium caudatum, Khainsky, 1911, pp. 1–60, pls. i–iii & 2 text-figs.

Paramecium caudatum, Woodruff, 1911 *b*, pp. 223–37.

†*Paramæcium caudatum*, Bhatia, 1916, p. 183 ; 1923, pp. 69–72.
†*Paramœcium caudatum*, Ghosh, 1921 *a*, p. 10 ; Thapar & Chaudhury, 1923, pp. 64–8.
Paramecium caudatum, Dembowski, 1923, pp. 25–54, pls. ii, iv, & 3 text-figs ; Bozler, 1924, pp. 163–215, pl. viii & 10 text-figs. ; Lepsi, 1926 *a*, p. 58, fig. 230 ; Calkins, 1926, pp. 53, 162, 496, figs. 21, 85, 206 ; Wenyon, 1926, pp. 26, 79, 131, figs. 29, 45, 70 ; Schoenichen, 1927, p. 211, pl. xii, fig. 40 ; Wenrich, 1928, p. 279, pl. xxxvi, fig. 2.
Paramœcium caudatum, Reichenow, 1929, p. 1176, fig. 1160 A.
†*Paramecium caudatum*, Bhatia & Mullick, 1930, p. 396.
Paramecium caudatum, Kahl, 1930–5, p. 291, fig. 48, *1*, *2*.

Body elongated, cylindrical, but somewhat flattened, at least three times as long as broad, anterior end broader and rounded, posterior end gradually tapering and usually provided with a tuft of longer cilia. Trichocysts abundantly present. Contractile vacuoles two, stellate, situated about one-third or one-fourth the length of the body from either end. Macronucleus egg-shaped, with a single compact micronucleus lying close by it. One of the commonest species in standing water.

Dimensions.—Length 120–330 μ, usually 200–300 μ.

Remarks.—Very common at all times of the year in stagnant water and in infusions of dry leaves. Examples also grow well in a mucilage of *Ispaghul*-seeds, and their movements are rendered slow. After being kept in this medium for two or three days, owing to the colouring matter of the seeds diffusing into the water, the nuclei and food-particles are found to be stained a beautiful reddish colour in the living animals.

The tuft of longer cilia usually described at the posterior end is generally not present in forms met with at Lahore. Bhatia (1916) found extra contractile vacuoles in this species, and discussing the significance of this (1923) suggested that the occasional occurrence of extra vacuoles in *Paramecium* is a case of reversion to an ancestral condition in which there may have been a continuous row of vacuoles, as is so often the case, for example, in certain species of *Enchelis*, *Loxophyllum*, *Dileptus* and *Chilodon* among GYMNOSTOMATA, and in several species of *Anoplophrya* and of other genera among ASTOMATA. The evolution of the radiating canals which drain a large area of cytoplasm may possibly have been the cause of the number becoming restricted to two. Dimitrowa (1928) and Lepsi (1929) have supported the view.

Habitat.—Pond water : KASHMIR, Srinagar ; PUNJAB, Lahore ; UNITED PROVINCES, Lucknow ; BENGAL, Calcutta.

81. **Paramecium** sp.

Paramœcium sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

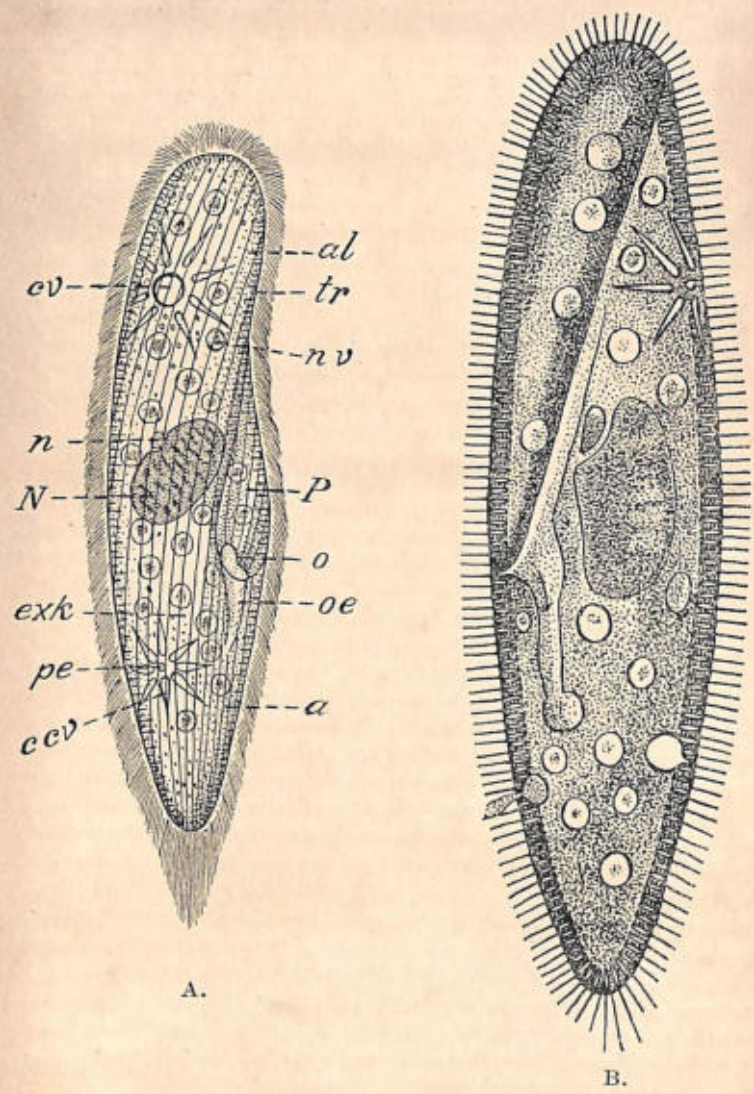


Fig. 65.—A. *Paramecium caudatum* Ehrbg. *a*, anus; *al*, alveolar layer; *cv*, contractile vacuole; *ccv*, radiating canal; *exk*, excretory granules; *N*, macronucleus; *n*, micronucleus; *o*, cytostome; *oe*, cytopharynx; *P*, peristomial groove; *pe*, excretory pore; *tr*, trichocysts. (After Schewiakoff.) B. *Paramecium caudatum* Ehrbg., showing micronuclear structure. (After Wenrich.)

4. Family TRICHOPELMIDÆ Kahl, 1931 (=LEPTOPHARYNGIDÆ Kahl, 1926).

Small forms without test, generally strongly flattened laterally, with delicate pellicle resembling a coat-of-mail. Cilia sparse, particularly on the right flattened side, where they form a semicircular or sickle-shaped uninterrupted dorsal keel, and 2 to 9 interrupted rows of cilia on the plane surface. Cytostome on the compressed ventral surface, membranoid structures recognizable with difficulty.

Genus **DREPANOMONAS** Fresenius, 1858 (=DREPANOCEROS Stein, 1878).

Drepanomonas, Fresenius, 1858, p. 216; Bütschli, 1887–9, p. 1710; Penard, 1922, p. 167; Lepsi, 1926*a*, p. 48; Kahl, 1930–5, p. 304.

Small to very small, very flattened, narrowly sickle-shaped or half-moon-shaped. Right margin keel-shaped, uniformly curved in a sickle-shaped manner or more elongated and broadly rounded at both anterior and posterior ends. Left margin elongated and slightly concave. Oral field small, groove-like, with small membranelle in the middle of the left margin; a cytopharynx observed in two species. Ventral surface with three ciliary rows, the two left ones interrupted in the middle; dorsal surface with only two ciliary rows or isolated cilia. In the oral groove or behind it are some isolated cilia. Often there is a deep longitudinal furrow on the dorsal surface. Contractile vacuole and macronucleus in the middle region of the body.

82. **Drepanomonas dentata** Fresenius. (Fig. 66.)

Drepanomonas dentata, Fresenius, 1858, pp. 216–17, pl. x, figs. 25–8.
Litonotus fasciola (young condition), Kent, 1880–2, p. 744.
Drepanomonas dentata, Bütschli, 1887–9, pl. lxiv, fig. 14; Mermod, 1914, p. 70.
†*Drepanomonas dentata*, Ghosh, 1920*a*, pp. 145–6, fig. 2; 1921*a*, p. 10, fig. 8.
Drepanomonas dentata, Penard, 1922, pp. 167–8, fig. 165; Lepsi, 1926*a*, p. 53, figs. 167, 168; Kahl, 1930–5, p. 304, fig. 50, *11*, *12*.

Body semilunar, laterally compressed, convex dorsally, concave on the ventral border, sharply pointed at either end. The ventral border bears in the middle a depression in which lies the cytostome, provided with a small undulating membrane. On each lateral surface there are two longitudinal ciliated

grooves which meet behind and lose themselves anteriorly in characteristic denticulations. A small contractile vacuole, with accessory vacuoles, close to the angle of the buccal depression. Macronucleus spherical, situated a little behind or above the mouth. On *Sphagnum* and in marshy water.

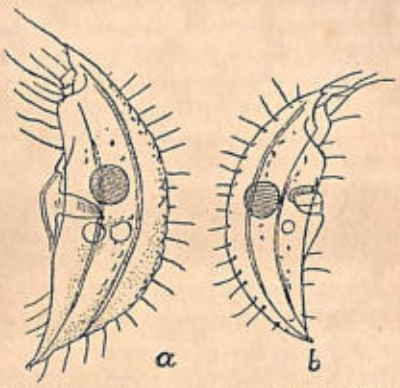


Fig. 66.—*Drepanomonas dentata* Fres.
a, left lateral aspect ; *b*, right lateral aspect. (After Penard.)

Dimensions.—Length 40–65 μ.

Remarks.—The form met with by Ghosh differed from the typical condition in that the dentations were broader and less numerous ; anterior end was rounded, without forming a beak ; there was a second oblique ridge on the surface near the postero-lateral margin ; and cytopharynx was narrow and comparatively long. Measurements are not given, and the figure given is very crude.

Habitat.—Vegetable infusions : Bengal, Calcutta.

Incertæ sedis.

Genus **OPISTHOSTOMUM** Ghosh, 1928.

Body oval. Peristome narrow, postero-terminal, surrounded by a large ventral lobe, a large left dorso-lateral lobe, and a small right dorso-lateral lobe. A single sinuous row of well-developed membranelles in the peristome.

83. **Opisthostomum bengalense** Ghosh. (Fig. 67.)

†*Opisthostomum bengalensis*, Ghosh, 1928, p. 383, figs. 2, 3.
Opisthostomum bengalense, Kahl, 1930–5, p. 311, fig. 49, *13*.

Body elongately and irregularly oval, less than twice as long as broad, broadly oval in transverse section. Anterior

end somewhat tapering and rounded. Posterior end with three lobes—a large ventral lobe, a somewhat triangular lobe on the dorso-lateral aspect and to the left, and a narrow elongated lobe on the right side somewhat projecting on the dorsal aspect. Peristome a long narrow excavation, apparently naked; a row of well-developed membranelles. Body uniformly ciliated, cilia on the left side very long. Macronucleus large, oval, and placed in the posterior half of the body. Micronucleus spherical, on the right side of the macronucleus.

Dimensions.—Length 78μ, width 48μ.

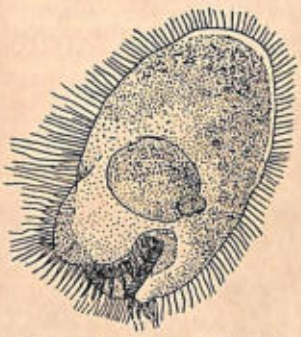


Fig. 67.—*Opisthostomum bengalense* Ghosh. (After Ghosh.)

Remarks.—Ghosh has referred the genus to HETEROTRICHA, to which it has no relationship. Kahl thinks that the form is much more related to *Mycterothrix*, family Marynidæ. He thinks that Ghosh has described the peristome as postero-terminal with reference to the direction of the swimming of the organism, but that it is really at the anterior pole, and the animal swims backwards, as does *Mycterothrix*. The form requires further study before its correct position can be determined.

Habitat.—Sewer water: BENGAL, Calcutta.

5. Family ISOTRICHIDÆ Bütschli, 1889.

Body with thick pellicle, and with a general and dense covering of cilia. Cytostome ventral, near the posterior end. Commensals or parasites in the rumen of Ruminantia.

Key to Indian Genera.

1. Body with rounded posterior and more pointed anterior end. Macronucleus with a nuclear stalk ..... ISOTRICHA St., p. 156.
2. Body more regularly ovoid. Macronucleus without a nuclear stalk ..... [p. 158. DASYTRICHA Schub.,

Genus **ISOTRICHA** Stein, 1858.

Isotricha, Stein, 1858, p. 69; 1861, p. 85; Kent, 1880–2, p. 497; Schuberg, 1888, p. 377; Bütschli, 1887–9, p. 1715; Schewiakoff, 1896, p. 373; Hickson, 1903, pp. 401, 403; Minchin, 1912, p. 439; Hegner & Taliaferro, 1924, p. 385; Calkins, 1926, p. 407; Wenyon, 1926, p. 1191; Knowles, 1928, p. 523; Reichenow, 1929, p. 1177; Kudo, 1931, p. 368.

Body somewhat flattened, ovoid, with rounded posterior and more pointed anterior ends, uniformly covered with cilia. Cytostome at the end which is posterior in locomotion or laterally placed. Contractile vacuoles many, distributed superficially in the central region of the body. Anal aperture at the anterior end. Macronucleus large, elongate, lying longitudinally in the posterior region or in the middle of the body, in a bag attached by a nuclear stalk. Micronucleus oval, close to the macronucleus. Parasitic in the rumen of cattle and sheep.

Remarks.—It is a matter of definition whether to refer to the cytostomial end as anterior or posterior. Bütschli (1887–9) and other authors, including Reichenow (1929), speak of the cytostome as situated at the posterior end and the animal swimming with the anterior end foremost. Others, including Wenyon (1926), regard the oral end as anterior and the animal as habitually swimming backward.

Key to Indian Species.

1. With cytostome at the posterior end of the body ..... *I. prostoma* St., p. 157.
2. With cytostome lateral, at some distance from the posterior end..... [p. 158. *I. intestinalis* St.,

84. **Isotricha prostoma** Stein. (Fig. 68.)

Isotricha prostoma, Stein, 1858, p. 88; Kent, 1880–2, p. 497; Schuberg, 1888, pp. 377–85, pl. xii, figs. 4–5; pl. xiii, figs. 10–13; Bütschli, 1887–9, pl. lxv, fig. 12; Schewiakoff, 1896, p. 375, pl. vi, fig. 142; Braune, 1913, p. 139; Hegner & Taliaferro, 1924, p. 385; Knowles, 1928, fig. 132, *13*; Reichenow, 1929, p. 1177, fig. 1162; Campbell, 1929, pp. 331–9, pls. x–xii; 1930, pp. 141–6, pls. xi, xii; Kudo, 1931, p. 368, fig. 159 *a*.

†*Isotricha prostoma*, Kofoid & MacLennan, 1933, p. 28; Kofoid & Christenson, 1934, p. 377; Das-Gupta, 1935, p. 159.

Form very flexible and elastic, but not contractile. Body elongated ovoid, with one end rounded and the other pointed. The body is somewhat flattened dorso-ventrally and is covered with cilia. Cytostome, with a short wide

Fig. 68.

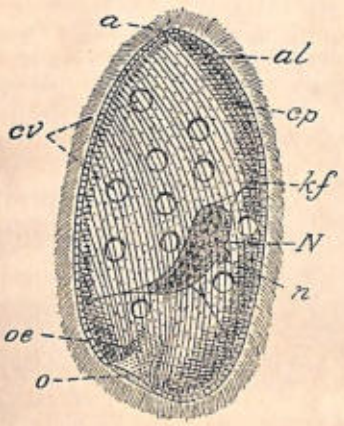


Fig. 69.

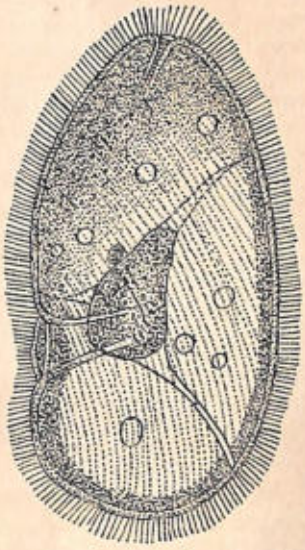


Fig. 68.—*Isotricha prostoma* Stein. *a*, anus; *al*, alveolar layer; *cp*, pellicle; *cv*, contractile vacuoles; *kf*, nuclear stalk; *N*, macronucleus; *n*, micronucleus; *o*, cytostome; *oe*, cytopharynx. (After Schewiakoff.)

Fig. 69.—*Isotricha intestinalis* Stein. (After Eberlein.)

cytopharynx provided with stronger cilia, situated at the end of the body, which is posterior in locomotion. Contractile vacuoles many, distributed superficially in the central region of the body. Anal aperture at the end which is forward in locomotion. Macronucleus large, elongate, lying longitudinally in the posterior region of the body in a bag attached

by a nuclear stalk to the wall of the organism. Micronucleus oval, close to the macronucleus. Parasitic in the rumen of cattle and sheep.

Habitat.—In the stomach of *Bos indicus* Linn. (locality not given); stomach of *Bos gaurus* H. Smith: Mysore; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

85. **Isotricha intestinalis** Stein. (Fig. 69.)

Isotricha intestinalis, Stein, 1858, p. 69; Kent, 1880–2, p. 497; Schuberg, 1888, pp. 385–6, pl. xiii, figs. 14–16; Bütschli, 1887–9, pl. lxv, figs. 10, 11; Hickson, 1903, pp. 401–3.
†*Isotricha intestinalis*, Jameson, 1925, p. 409.
Isotricha intestinalis, Wenyon, 1926, p. 1191, fig. 504, *8*; Reichenow, 1929, p. 1178.
†*Isotricha intestinalis*, Kofoid & Christenson, 1934, p. 377.

Body obovate, slightly flattened, longitudinally striate. Cytostome ventral, situated within a semilunar depression at some distance from the posterior end, and provided with a short cytopharynx. Cilia long, fine. Contractile vacuoles numerous, distributed chiefly in the posterior region. Macronucleus elongate oval, with a small, rounded micronucleus close to it. The whole nuclear apparatus is contained within a bag attached by a nuclear stalk to the inner layer of the cytoplasm. Dimensions not recorded.

Remarks.—This species was present in fair numbers in material from Ceylon, and the shape was markedly more rounded than is usually the case.

Habitat.—In the stomach of *Tragulus meminna* Milne-Edwards (mouse-deer): CEYLON; stomach of *Bos gaurus* H. Smith: Mysore.

Genus **DASYTRICHA** Schuberg, 1888.

Dasytricha, Schuberg, 1888, p. 386; Bütschli, 1887–9, p. 1716; Schewiakoff, 1896, p. 376; Hickson, 1903, p. 403; Braune, 1913, p. 145; Wenyon, 1926, p. 1191; Calkins, 1926, p. 407; Reichenow, 1929, p. 1178; Kudo, 1931, p. 369.

Body more regularly ovoid than in *Isotricha*. Macronucleus without a nuclear stalk. Parasitic in the rumen of cattle and sheep.

86. **Dasytricha ruminantium** Schuberg. (Fig. 70.)

Dasytricha ruminantium, Schuberg, 1888, pp. 386–91, pl. xiii, figs. 17–26; Schewiakoff, 1896, p. 377, pl. vi, fig. 144.
Isotricha ruminantium, Braune, 1913, p. 130.

Isotricha (*Dasytricha*) *ruminantium*, Dogiel, 1925 *b*, p. 286.
Dasytricha ruminantium, Wenyon, 1926, p. 1191, fig. 504, *9*.
Isotricha (*Dasytricha*) *ruminantium*, Dogiel & Fedorowa, 1927, pp. 75–82, figs. 1–11.
Dasytricha ruminantium, Reichenow, 1929, p. 1178; Kudo, 1931, p. 369, fig. 159 *c*.
†*Dasytricha ruminantium*, Kofoid & MacLennan, 1933, p. 28; Kofoid & Christenson, 1934, p. 377; Das-Gupta, 1935, p. 159.

Body regularly ovoid, uniformly covered with cilia. Cytostome at the posterior end of the body leading to a curved cytopharynx. Contractile vacuole single. Anal aperture at the anterior end of the body. Macronucleus a small, curved body, without a nuclear stalk. Micronucleus lying close to the macronucleus.

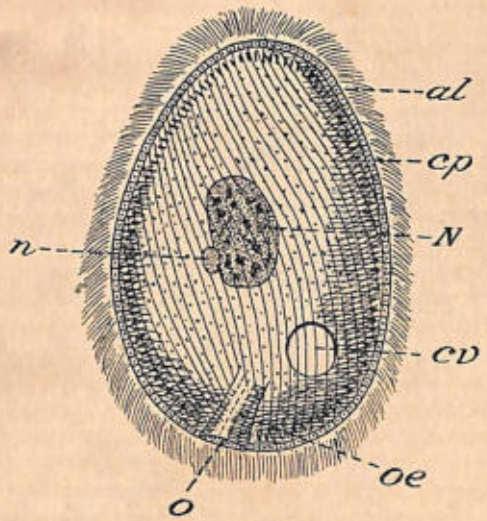


Fig. 70.—*Dasytricha ruminantium* Schub. *al*, alveolar layer; *cp*, pellicle; *cv*, contractile vacuole; *N*, macronucleus, *n*, micronucleus; *o*, cytostome; *oe*, cytopharynx. (After Schewiakoff.)

Dimensions.—Length 50–110 μ; width 25–65 μ.

Remarks.—Dogiel and Fedorowa (1927) have published a note on the reproduction in this species, and have referred it to the genus *Isotricha*.

Habitat.—In the stomach of *Bos indicus* (locality not given); stomach of *Bos gaurus* H. Smith: Mysore; rumen of *Capra hircus* Linn.: Bengal, Calcutta.

6. Family BLEPHAROCORIDÆ Hsiung, 1829.

Body cilation confined to certain regions only, tufts of cilia situated above and below the cytostome, and in the posterior anal region. Cytostome not terminal and not lying in a prominent depression. Contractile vacuole single, posterior. Macronucleus and micronucleus central. Parasites in the Ungulate Mammals.

Genus **BLEPHAROCORYS**, Bundle, 1895.

Blepharocorys, Bundle, 1895, pp. 305–9.
Charon, Jameson, 1925, p. 403 ; Wenyon, 1926, p. 1193.
Blepharocorys, Dogiel, 1926, pp. 61–4 ; 1934, p. 297.
Charonella, Bhatia, 1935, p. 13.

Body with a simple anterior projection and with an anterior and a posterior group of cilia, the posterior cilia in one or two compact bundles. The cytostome does not lie in a prominent depression, and opens into a cytopharynx which extends deep into the body. Attached to the left side of the cytopharynx is a well-developed ciliary membrane made up of stout cirri. No permanent anal opening. Contractile vacuole single, large, in the posterior part of the body. Macronucleus large, rounded and coarsely granular. Micronucleus oval and close to the macronucleus. In the paunch and rumen of cattle and sheep.

Remarks.—Jameson described *Charon* as a new genus, but that name being pre-occupied for an Arachnid genus of Karsch (1879), I changed the name to *Charonella*. Dogiel (1934) has, however, pointed out that *Charon ventriculi* Jameson and *Blepharocorys bovis* Dogiel are identical, and the form should be called *Blepharocorys ventriculi* (Jameson).

87. **Blepharocorys ventriculi** (Jameson). (Fig. 71.)

Charon ventriculi, Jameson, 1925*a*, pp. 403–5, 1 fig ; Wenyon, 1926, p. 1193.
Blepharocorys bovis, Dogiel, 1926, pp. 61–4, 1 fig.
†*Charon ventriculi*, Kofoid & MacLennan, 1933, p. 28.
Blepharocorys ventriculi, Dogiel, 1934, p. 297.

Body resembles the blade of a lancet, with one side convex the other nearly straight, more than twice as long as broad, very much compressed dorso-ventrally. Anterior end bluntly pointed and pinched into a projecting knob ; the posterior end tapers to a finer rounded point. Ventral surface flat or very slightly concave ; dorsal surface very slightly convex ;

right side straight; left side convex. Anterior end of the body covered with many cilia, including two tufts of cilia similar to those of posterior end, but less prominent. The anterior and posterior pairs of ciliary bundles consist of stiff, long cirri, which are only capable of bending near the tips. The anterior bundles are placed, one on each side of the body, at the base of the anterior knob on a level with the cytostome. The posterior bundles lie one on each side of the body, close to the end, and each is inserted in an oval socket. The posterior bundles are chiefly locomotory, moving in unison with slow, somewhat jerky strokes. Cytostome round or slightly pear-shaped, situated on the ventral surface of the body immediately behind the anterior ciliated



Fig. 71.—*Blepharocorys ventriculi* (Jameson). (After Jameson.)

tip, and opens at once into a prominent cytopharynx. Cytopharynx extends deep into the body, reaching at least halfway to the posterior end, and curving slightly to the right. Extending along the whole length of the left side of the cytopharynx is a well-developed ciliary membrane, made up of stout cirri, which seem to be fixed together and act as an undulating membrane. Contractile vacuole single, large, in the posterior part of the body. No permanent anal opening, but occasionally a temporary anus can be seen opening at the extreme posterior tip of the body. Macronucleus large, rounded, coarsely granular in structure, usually situated about the middle, near the end of the cytopharynx.

Micronucleus oval, lying in a depression in the macronucleus or close to it. Feeds on bacteria and fine organic particles.

Dimensions.—Length 24–36 μ, breadth 12–15 μ.

Habitat.—Very rare in the stomach of *Bos indicus* (locality not given).

3. Suborder *HYMENOSTOMATA* Hickson, emend. Kahl.

HOLOTRICHA in which the mouth is permanently open, and provided with membranes, formed by the fusion of rows of cilia, and free cilia in addition.

Remarks.—Previously the terms TRICHOSTOMINA and HYMENOSTOMATA were indiscriminately used to include all HOLOTRICHA in which the mouth was provided either with free cilia or with some of the cilia united to form membranes. Kahl (1926, 1930–5) has grouped these forms into two sub-orders, TRICHOSTOMATA (oral cilia free) and HYMENOSTOMATA (oral cilia united to form membranes). Reichenow (1929) has followed him in this usage of these terms.

Identification Table of Families.

1	(2). Oral aperture without a peristome....	**Frontoniidæ** Kahl, [p. 163.
2	(1). Oral aperture lies at the end or the bottom of a peristome	3.
3	(12). Ciliation on all sides or limited to the oral side	4.
4	(5). Peristome runs as sickle-shaped ciliated cleft, perpendicular to the surface of the body, into the depressed oral aperture. An hour-glass-shaped body lies in front of the anterior end of the peristomial cleft .	[p. 180. **Ophryoglenidæ** Kent,
5	(4). Peristome extends along the surface of the body from the anterior pole to the oral aperture	6.
6	(9). Peristome bears an undulating membrane along one border	7.
7	(8). Peristome runs from the truncated anterior end of the body to the small cytostome situated in the anterior third of the body. Peristome bears an undulating membrane along its left border.....	**Sagittariidæ*** Grandori.
8	(7). Peristomial plate bears along the right border an undulating membrane which surrounds the hinder margin of the oral aperture like a pocket. Left peristomial border bears a ciliary row or membrane	[p. 182. **Pleuronematidæ** Kent,
9	(6). Peristome differently provided	10.

10 (11). Right peristomial border with two undulating membranes. Ectoplasmic pocket surrounding the cytostome absent ..... **Cohnilembidæ** * Kahl.

11 (10). Peristomial groove provided along the right border either with a dense ciliary field, besides the undulating membrane, or only a thick undulating membrane. To the right of the cytostome, or surrounding it behind, is a pocket sunk below the ectoplasm with a small membrane ..... **Philasteridæ** * Kahl.

12 (3). Ciliation reduced to two broad ciliary girdles ..... [Lachm., p. 189. **Urocentridæ** Clap. &

1. Family FRONTONIIDÆ Kahl, 1926 (=CHILIFERA Bütschli).

Body ovoidal, uniformly ciliated, without a peristome. Cytostome situated in the anterior half of the body, at the end of an open groove or of a hooded funnel. Oral groove provided with one or more membranes and free cilia, arranged in a variety of ways. Contractile vacuole single, usually central. Macronucleus single or double, central.

Key to Indian Genera.

1 (16). Posterior end without a caudal bristle. 2.

2. Cytostome not followed by a funnel-shaped cytopharynx, or cytopharynx, if present, without undulating membrane or cilia ..... 3.

3 (6 or 8). Oral aperture anteriorly pointed, posteriorly transversely truncated... 4.

4 (5). Cytostome along the right border, near the end of the body; membrane in the right oral margin ..... TRICHODA, p. 168.

5 (4). Cytostome on the ventral surface; large undulating membrane in the left oral margin. A postoral seam running to the posterior pole; no striated band on the dorsal surface posteriorly. Body not narrowed behind in a uniformly triangular manner ..... FRONTONIA, p. 164.

6 (3). Oral aperture not transversely truncated behind, but obliquely pointed or rounded ..... 7.

7. Cytostome a small sigmoid cleft, removed from the anterior pole, with two membranes ..... SIGMOSTOMUM, p. 167.

8 (3). Oral aperture anteriorly rounded or truncate ..... 9.

9 (14). Cytostome obliquely placed, from right anterior to left posterior direction, the right margin with a projecting ectoplasmic lip. Inside the cytostome are three ciliary structures, an outer membrane on the left, beneath that an inner, and to the right at the bottom a three-rowed ciliary band .. 10.

10 (11). Cytostome near the middle of the ventral surface ; dorsal series of cilia not strikingly bent to the right anteriorly ..... Glaucoma, p. 170.

11 (10). Cytostome lying in the right border of the body ..... 12.

12 (13). Dorsal series of cilia bend anteriorly more or less obliquely to the right .. Colpidium, p. 173.

13 (12). Only one strong membrane extends from the left margin into the upper, concave, ectoplasmic lip. Small, contractile ; in damp moss, or marine. [p. 176. Pseudoglaucoma,

14 (9). Oral aperture without the ectoplasmic lip on the right ; cytostome with only one membrane..... 15.

15. Membrane inserted in the left and anterior margin and encloses the mouth in a cap-like manner ..... Stegochilum, p. 178.

16 (1). Posterior end with a caudal bristle. Ciliation uniform ; anterior pole with unciliated frontal plate. From the anterior end an indistinct furrow runs to the mouth, bearing somewhat strong cilia along its right border.... Uronema, p. 178.

Genus **FRONTONIA** Ehrenberg, 1838, emend. Claparède & Lachmann.

Oursaria, part, Ehrenberg, 1838, p. 325.
Ophryoglena, part (*acuminata* and *atra*), Ehrenberg, 1838, p. 360.
Frontonia subgenus, Ehrenberg, 1838, p. 329.
Panophrys, Dujardin, 1841, p. 491.
Cyrtostomum, Stein, 1859 *a*, p. 59 ; 1859 *d*, pp. 63, 82, 87 ; 1867, pp. 67, 69, 92, 123.
Frontonia, Claparède & Lachmann, 1858–61, pp. 259–60; Fromentel, 1874, p. 190.
Cyrtostomum, Kent, 1880–2, pp. 496–7.
Frontonia, Bütschli, 1887–9, p. 1703 ; Schewiakoff, 1896, p. 309 ; Roux, 1901, p. 59 ; Hickson, 1903, p. 402 ; Minchin, 1912, p. 439 ; Calkins, 1926, p. 406 ; Lepsi, 1926 *a*, p. 50 ; Schoenichen, 1927, p. 205 ; Reichenow, 1929, p. 1179 ; Kahl, 1930–5, p. 316.

Body elongated, cylindrical, more or less flattened, rounded at both ends, the posterior end being somewhat narrower. Dorsal surface convex, ventral flat. Right border straight or slightly concave, left border convex. Cilia long, fine, arranged along longitudinal lines. Oral fossa lies in the anterior third of the ventral surface, to the right of the median line ; oval in form, the long axis antero-posterior, sharply

pointed in front and broadly truncated behind. The left border of the oral fossa is more strongly curved and provided with a large undulating membrane, composed of three lamellæ and four rows of cilia: the right border with cilia; inner shorter cilia membranoid and united, and the outer three rows of free cilia extending beyond the cytostome to the postoral groove, which extends towards the posterior end of the body. Contractile vacuole single, central, with or without radiating canals. Macronucleus ellipsoidal, central, obliquely placed, with numerous micronuclei attached to it. Body often filled with algæ and diatoms. Locomotion quick, the animal rotating on its long axis and often changing its direction.

88. **Frontonia leucas** (Ehrenberg). (Fig. 72, A & B.)

Bursaria leucas, Ehrenberg, 1838, p. 329, pl. xxxiv, fig. 8.
Frontonia vernalis, Ehrenberg, 1838, p. 329, pl. xxxiv, fig. 7.
Panophrys (*Bursaria*) *leucas*, Dujardin, 1841, p. 494.
Panophrys (*Bursaria*) *vernalis*, Dujardin, 1841, p. 492, pl. xiv, fig. 7.
Panophrys chrysalis, Dujardin, 1841, p. 492, pl. xiv, fig. 7.
†*Bursaria leucas*, Carter, 1856 *b*, pp. 115–32, 248, pl. vii, fig. 85.
Frontonia leucas, Claparède & Lachmann, 1858–61, pp. 259–60.
Cyrtostomum leucas, Stein, 1859 *a*, p. 59; 1859 *d*, pp. 63, 82, 87; 1867, pp. 67, 69, 92, 123.
Panophrys (*Bursaria*) *leucas*, Stein, 1867, p. 44.
Panophrys (*Bursaria*) *vernalis*, Stein, 1867, p. 44.
Frontonia leucas, Fromentel, 1874, p. 190.
Cyrtostomum leucas, Kent, 1880–2, p. 497, pl. xxvi, fig. 37; Fabre-Domergue, 1888, pp. 13–18, pl. ii, figs. 16–21; Balbiani, 1888, pp. 23–55, pl. i, figs. 1–12; Maupas, 1889, p. 786.
Frontonia leucas, Bütschli, 1887–9, p. 1703, pl. lxii, fig. 3, *a–c*; Schewiakoff, 1889, pp. 38–41, pl. v, figs. 57–64; 1893, p. 45; 1896, pp. 312–13, pl. v, fig. 113; pl. vi, fig. 164; pl. vii, figs. 173, 177, 191 & 201; Roux, 1901, pp. 59–60, pl. iii, fig. 13; Penard, 1922, pp. 131–9, figs. 132–6; Lepsi, 1926 *a*, p. 57, fig. 179; Calkins, 1926, p. 158, fig. 83; Schoenichen, 1927, p. 205, pl. xii, fig. 29; Reichenow, 1929, p. 1179, fig. 1165.
†*Frontonia leucas*, Bhatia & Mullick, 1930, pp. 396–8, fig. 3.
Frontonia leucas, Kahl, 1930–5, p. 317, fig. 55, *1*.

Body elongated, rounded at both extremities, wider anteriorly and narrower posteriorly. Posterior end slightly pointed, with few longer cilia. Right border straight or slightly concave, left border convex. Cilia long, fine, and arranged along longitudinal lines, the lines of the right side meeting those of the left in front of the mouth. Oral fossa oval, lying in the anterior third of the ventral surface, the postoral groove extending to the posterior part of the body. Contractile vacuole single, situated about the middle near the right border, with long radiating canals. Macronucleus ellipsoid, granular, and with several micronuclei. Colourless or brownish, or often green on account of contained zoochlorellæ.

Dimensions.—Size very variable, from 150–600 μ.

Remarks.—The length of the specimens found at Srinagar varied from 200 to 324 μ. The living specimens were quite opaque and nothing could be made out except the contractile vacuole with its radiating canals and the large number of algal filaments on which the organisms had fed In specimens properly fixed and stained with iron hæmatoxylin the detailed structure of the oral fossa could be made out (Penard, 1922 ; Bhatia & Mullick, 1930).

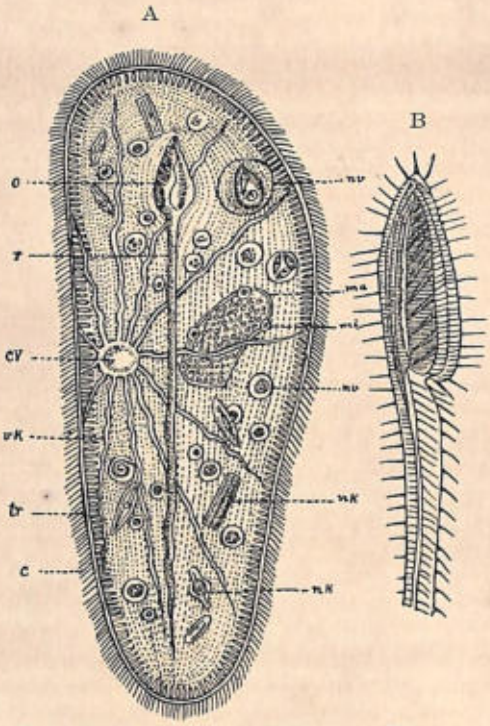


Fig. 72.—A. *Frontonia leucas* (Ehrbg.). *c*, cilia ; *cv*, contractile vacuole ; *ma*, macronucleus ; *mi*, micronucleus ; *nk*, food-particles ; *nv*, food-vacuoles ; *o*, cytostome ; *r*, pharyngeal groove ; *tr*, trichocysts ; *vk*, radiating canal. (From Reichenow, after Tönniges.) B. Oral field of *Frontonia leucas* (Ehrbg.). (After Bhatia and Mullick.)

The oral fossa (fig. 72, B) is oval, being pointed at its anterior end and elongated in the direction of the animal. From the base of this oral fossa on the right side a longitudinal furrow or seam extends almost to the posterior end of the body. The fossa is ornamented by cilia, which are enlarged at their

points of attachment and are free at their distal extremity ; in addition a broad, striated lamella is attached to the left, and a long and narrow undulating membrane to the right border of the framework. On the right side of the fossa are three parallel striated bands, separated by lines of small and close-set basal granules from which the cilia arise. The innermost band also bears longer cilia along its left border, and, in addition, gives attachment to the long, narrow, undulating membrane, referred to above ; this extends along the whole length of the oral fossa, but stops at the commencement of the postoral or pharyngeal groove, which runs along the ventral side of the animal almost to the posterior end of the body.

Along the left margin of the oral fossa are two striated bands. At the anterior end of the fossa there seem to be three such bands, making an acute angle with those of the right side, but only two of the bands extend along the left border. At the base of the oral fossa the outer one stops, while the inner is curved and continued to form the wall of the pharyngeal groove. The inner band bears along its right border a number of thick lashes, as shown in the figure. To this border is also attached a broad, transversely striated membrane, which extends across and covers the oral fossa. This membrane is free at its right border, and thus leaves uncovered a narrow groove, which is continued behind as the pharyngeal groove.

Trichocysts are abundantly distributed all over the body in the cortical region. Penard has described a large variety of trichocysts in this species, but Bhatia and Mullick recognized only three kinds, viz., (1) a spherical form of trichocysts lying close to the border of the oral fossa, (2) fusiform, and (3) somewhat curved, rod-like trichocysts, distributed all over the surface.

The large macronucleus is ellipsoidal and situated in the middle of the body. It is granular in structure. There are numerous micronuclei lying over the macronucleus. Each of these is an elongated oval body, with a strong nuclear membrane, and a single dense body inside.

Habitat.—Clear standing water : KASHMIR, Srinagar ; fresh water : BOMBAY, Bombay.

Genus **SIGMOSTOMUM** Gulati, 1925.

Sigmostomum, Gulati, 1925, p. 751 ; Kahl, 1930–5, p. 322 ; Calkins, 1933, p. 505.

Form, position of the contractile vacuole and the cytostome as in *Frontonia*. Cytostome is a sigmoid cleft with a membrane along each margin. Ectoplasm with trichocysts arranged in a honeycomb-like manner. Macronucleus oval, with a single micronucleus. Feeds on algal filaments.

89. **Sigmostomum indicum** Gulati. (Fig. 73.)

†*Sigmostomum indicum*, Gulati, 1925, p. 751, pl. ii, fig. 20.
Sigmostomum indicum, Kahl, 1930–5, p. 322.

Body oval, about three times as long as broad, anterior end a little broader than the posterior end. Cilia evenly distributed all over the body. Trichocysts well developed. Cytostome ventral, in the anterior half of the body, an S-shaped slit lined by undulating membranes on both lips. No peristomial field leading to the cytostome. Cytopharynx absent. Contractile vacuole single, spherical, central. Macronucleus oval, in the posterior half of the body, and granular in structure. Micronucleus small, oval, lying by the side of the macronucleus. Locomotion swift, restlessly rotating on its own axis. Feeds on large filamentous algæ.



Fig. 73.—*Sigmostomum indicum* Gulati. *c.v*, contractile vacuole. (After Gulati.)

Dimensions.—Length 145μ, width 42μ.

Remarks.—Kahl thinks that Gulati's examples were, in all probability, specimens of *Frontonia leucas*, but I do not agree with him, as there were no indications of either a postoral seam, the special structures in the oral fossa, or the radiating canals connected with the contractile vacuole, which Gulati could not have missed.

Habitat.—Pond water : PUNJAB, Lahore.

Genus **TRICHODA** O. F. Müller, 1773.

Trichoda, O. F. Müller, 1773, p. 71 ; Ehrenberg, 1838, p. 306 Kent, 1880–2, p. 535.
Glaucoma, part, Bütschli, 1887–9, p. 1702.
Trichoda, Schoenichen, 1927, p. 204.

Animalcules free-swimming, very small, elastic, but more or less persistent in shape ; ovate or pyriform. Cytostome

situated near the pointed and obliquely truncated anterior extremity, approached by an ovate oral fossa the right margin of which gives attachment to a single, vibratile, flap-like membrane. Cuticular surface finely ciliate throughout; a circlet of larger cilia surrounding the entrance to the oral fossa. Especially abundant in putrid infusions.

90. **Trichoda pura** Ehrenberg. (Fig. 74.)

Trichoda pura, Ehrenberg, 1838, p. 307, pl. xxxi, fig. xi; Kent, 1880–2, p. 535, pl. xxvii, fig. 47.
Glaucoma pura, Bütschli, 1887–9, p. 1702.
†*Trichoda pura*, Bhatia, 1916, p. 182.
Trichoda pura, Schoenichen, 1927, p. 204.
Glaucoma sp., Sandon, 1927, p. 181.

Body pyriform, rounded posteriorly, tapering gradually towards the anterior extremity. Cytostome at the anterior

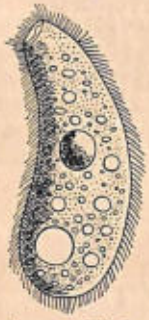


Fig. 74.—*Trichoda pura* Ehrbg. (After Kent.)

extremity. Oral fringe of cilia conspicuous; those of the general cuticular surface very fine. Contractile vacuole located posteriorly. Macronucleus single or double, spherical, subcentral. In pond water and vegetable infusions.

Dimensions.—Length up to 40 μ.

Remarks.—The animalcules were found in large numbers in an infusion of hay. Two specimens measured 32 μ by 16 μ and 38 μ by 22 μ respectively. The cytostome was near the anterior end but not terminal; the oral fossa was more or less oval, with a single quivering membrane on the right side attached to the posterior outer angle of the fossa and sometimes springing out of it.

Habitat.—Hay infusions: PUNJAB, Lahore.

Genus **GLAUCOMA** Ehrenberg, 1830.

Glaucoma, Ehrenberg, 1830, p. 42; 1838, p. 334; Dujardin, 1841, p. 475; Stein, 1854, p. 250; 1859*d*, p. 74; 1867, pp. 92, 123; Claparède & Lachmann, 1858–61, p. 277; Fromentel, 1874, p. 188; Kent, 1880–2, p. 795; Bütschli, 1887–9, p. 1702; Roux, 1901, p. 54; Hickson, 1903, p. 402; Minchin, 1912, p. 439; Calkins, 1926, p. 406; Lepsi, 1926 *a*, p. 53; Wenyon, 1926, pp. 1183–6; Schoenichen, 1927, p. 203; Sandon, 1927, p. 181; Reichenow, 1929, p. 1180; Kahl, 1930–5, p. 328.

Animalcules free-swimming, small to medium-sized, persistent in shape, generally ellipsoid or egg-shaped, posteriorly rounded, anteriorly somewhat less wide or even pointed. Usually somewhat flattened dorso-ventrally. Dorsal rows of cilia not strikingly bent to the right side anteriorly. Sometimes with a thick covering of trichocysts. Cytostome in the anterior half near the middle of the ventral surface, usually obliquely placed in a right anterior to left posterior direction, the right margin with a projecting ectoplasmic lip; inside are three ciliary structures—an outer membrane on the left, an inner beneath that, and a three-rowed ciliary band at the bottom on the right. Cytopharynx more or less elongated, provided with an undulating membrane. Contractile vacuole dorsal, median or subterminal. Anal aperture subterminal. Macronucleus central, round, with a micronucleus lying close to it. Locomotion constant, moderately quick, often gliding on the ventral surface. In soil, pond water or infusions. Feeds on bacteria and fine detritus. Can tolerate high concentration of carbon dioxide.

Key to Indian Species.

1. Body narrowed anteriorly. Cytostome in the anterior fourth of the body, not obliquely placed. Length 38–75 μ ..... [p. 170. *G. pyriformis* (Ehrbg.).
2. Body broadly oval. Cytostome in the anterior third of the body, usually obliquely placed. Length 60–85 μ ..... [p. 172. *G. scintillans* Ehrbg.

91. **Glaucoma pyriformis** (Ehrenberg) Schewiakoff. (Fig. 75.)

Leucophrys pyriformis, Ehrenberg, 1838, pp. 312–13, pl. xxxii, fig. 4.
Trichoda pyrum, Dujardin, 1841, pp. 397–8.
Glaucoma pyriformis, Schewiakoff, 1889, pp. 35–6, pl. iv, figs. 54, 55, 1893, p. 42; 1896, pp. 298–9, pl. iv, fig. 104; Roux, 1901, p. 55, pl. iii, fig. 6; Fauré-Fremiet, 1911, p. 207; Bullington, 1925, p. 272; Lepsi, 1926 *a*, p. 63, figs. 173, 174; Wenyon, 1926, pp. 1184–6, fig. 502; Sandon, 1927, p. 181; Schoenichen, 1927, p. 203, fig. 727; Knowles, 1928, fig. 132.
†*Glaucoma pyriformis*, Bhatia & Mullick, 1930, p. 398.
Glaucoma pyriformis, Kahl, 1930–5, p. 330, fig. 58, *13*.

Animalcules free-swimming, small to medium sized. Body pear-shaped, narrowed but rounded anteriorly. Cytostome in

the anterior fourth of the body, oval, elongated in the direction of the long axis of the body and not obliquely placed ; surrounded along the left, anteriorly and on the right by a cap-like membrane. Cytopharynx short, provided with a finger-shaped, protrusible undulating membrane. Contractile vacuole single, near the posterior end. Macronucleus rounded and central, with a small micronucleus.

Dimensions.—Length 32–75μ, width 24–47μ.

Remarks.—The specimens met with at Srinagar were somewhat smaller than the size usually given for the species, measuring only about 32μ. The cytostome in these specimens

Fig. 75.

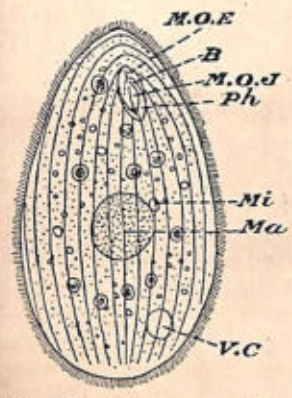


Fig. 76.

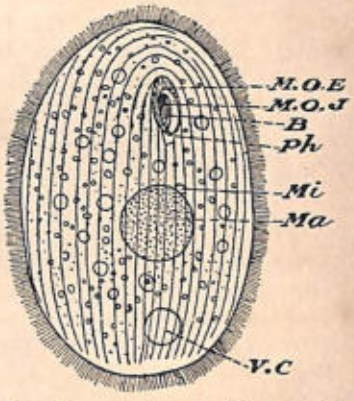


Fig. 75.—*Glaucoma pyriformis* (Ehrbg.). *B*, cytostome ; *Ma*, macronucleus ; *Mi*, micronucleus ; *M.O.E*, external undulating membrane ; *M.O.J*, internal undulating membrane ; *Ph*, cytopharynx ; *V.C*, contractile vacuole. (After Roux.)

Fig. 76.—*Glaucoma scintillans* Ehrbg. Lettering as in the preceding figure. (After Roux.)

was oval and was provided with an undulating membrane attached along the left margin and extending along the anterior margin to its right border ; the membrane along the right border was broader than that along the left. Body cilia were fine and arranged in longitudinal rows. The organism is narrower in front than *G. scintillans*, and the undulating membrane is better developed on the right side of the cytostome.

Habitat.—Pond water : KASHMIR, Srinagar.

92. **Glaucoma scintillans** Ehrenberg. (Fig. 76.)

Glaucoma scintillans, Ehrenberg, 1830, pp. 53, 63, 70, 78, pl. iv, fig. 1; 1838, p. 335, pl. xxxvi, fig. 5.
Acomia ovulum, Dujardin, 1841, p. 383, pl. vii, fig. 7.
Acomia ovata, Dujardin, 1841, p. 383, pl. vi, fig. 12.
Glaucoma scintillans, Dujardin, 1841, pp. 476–7, pl. vi, fig. 13; pl. vii, fig. 8; pl. xiv, fig. 4; Stein, 1854, pp. 250–1, pl. vi, figs. 45–53; 1859 *d*, pp. 74, 188; 1867, pp. 92, 123; Schmarda, 1854, pp. 7, 24; Samuelson, 1857, pp. 18–19.
Paramæcium ovale, Claparède & Lachmann, 1858–61, p. 269, pl. xiv, fig. 1.
Glaucoma scintillans, Claparède & Lachmann, 1858–61, p. 277; Pritchard, 1861, p. 624, pl. xxviii, figs. 4–7; Balbiani, 1861, p. 519, pl. ix, figs. 21, 22; Diesing, 1866, pp. 76–7; Fromentel, 1874, pp. 188, 306, pl. xvi, fig. 2; pl. xxi, fig. 24; Kent, 1880–2, pp. 795–6, pl. xlv, figs. 39, 40; Maupas, 1883, pp. 465–7, pl. xix, figs. 23, 24; 1888, pp. 236–7; 1889, pp. 261–3, pl. xv, figs. 66–72; Bütschli, 1887–9, pp. 1345, 1377, 1395, 1417, 1702, pl. lxii, fig. 5, *a–b*; Schewiakoff, 1889, pp. 32–5, pl. iv, figs. 47–53; 1893, p. 42; 1896, pp. 297–8, pl. iv, fig. 103; Roux, 1901, p. 54, pl. iii, fig. 5; Minchin, 1912, p. 445; Prowazek, 1913, p. 68.
†*Glaucoma scintillans*, Gulati, 1925, p. 748, fig. 12.
Glaucoma scintillans, Bullington, 1925, p. 272; Calkins, 1926, p. 383, fig. 168; Lepsi, 1926 *a*, p. 63, figs. 171, 172; Kahl, 1926, pp. 348–51, fig. M_2; 1930–5, p. 329, fig. 58, *3*; Schoenichen, 1927, p. 203, pl. xii, fig. 28; Sandon, 1927, p. 181, pl. vi, fig. 8; Reichenow, 1929, p. 1180.

Animalcules free-swimming, small to medium-sized. Body broadly oval, anteriorly only slightly narrowed. Slightly flattened dorso-ventrally; ventral surface flattened, dorsal convex. Ciliary striations close, cilia short, fine and close-set. Cytostome in the anterior third of the body, rather large, and somewhat obliquely placed. Undulating membrane attached to the left, anterior, and right borders of the aperture; continuously moving. Cytopharynx short, shallow and sac-like, with a large undulating membrane. Contractile vacuole single, posterior. Macronucleus spherical, with an adjacent micronucleus. Very common in stagnant water. Feeds on bacteria.

Dimensions.—Length 60–80 μ, width 36–56 μ.

Remarks.—Unlike other authors, Gulati shows the macronucleus as oval and granular in structure. According to him the colour of the organism is greenish-white and a large number of food-vacuoles are scattered irregularly in the body.

Habitat.—Ditch water: PUNJAB, Lahore.

Genus **COLPIDIUM** Stein, 1860.

Colpidium, Stein, 1860, p. 47; Kent, 1880–2, p. 537; Bütschli, 1887–9, p. 1704; Schewiakoff, 1896, p. 303; Roux, 1901, p. 56; Hickson, 1903, p. 402; Penard, 1922, p. 128; Lepsi, 1926*a*, p. 53; Calkins, 1926, p. 406; Wenyon, 1926, p. 1175; Schoenichen, 1927, p. 207; Sandon, 1927, p. 181; Reichenow, 1929, p. 1180; Kahl, 1930–5, p. 333.

Animalcules free-swimming, small to medium-sized. Body oval to kidney-shaped, somewhat compressed; anterior end narrower and curved from left to right, posterior end rounded and broader. The dorsal rows of cilia more or less sharply bent over to the right anteriorly. Cytostome lateral, triangular, at some distance from the anterior end, situated in the right margin on the ventral surface, and leading into a moderately long, tubular cytopharynx; provided, as in *Glaucoma*, with a narrow undulating membrane along both margins, the right membrane continued into the cytopharynx and apparently attached to the dorsal wall. Contractile vacuole in the middle of the dorsal border or terminal. Anal aperture subterminal, ventral. Macronucleus single or double, rounded or ellipsoid, central, with a micronucleus close by. Fresh water and marine, very common in infusions and soils. A facultative anærobe, developing abundantly where oxygen is deficient.

Key to Indian Species.

1 (2). Contractile vacuole in the middle of the dorsal side. A diagonal (adoral) depression on the anterior fourth of the body dorsally. Length 30–150 μ ..... [Stein, p. 174. *C. colpoda* (Ehrb.)

2 (1). Contractile vacuole near the right border, in the posterior third or quarter of the body ..... 3.

3 (4). Ellipsoidal, rounded at both ends. Length 50–120 μ..... [Bresslau, p. 173. *C. campylum*(Stokes)

4 (3). Egg-shaped, more pointed anteriorly. Length 35–50 μ ..... [p. 175. *C. striatum* Stokes.

93. **Colpidium campylum** (Stokes) Bresslau. (Fig. 77.)

Tillina campylum, Stokes, 1886*a*, pp. 103–4, pl. i, fig. 12; 1888, pp. 44–5, pl. iii, figs. 42, 43.
Glaucoma colpidium, Schewiakoff, 1893, p. 48; 1896, pp. 300–1, pl. iv, fig. 107.
Colpidium campylum, Bresslau, 1922, pp. 21–8.
†*Colpidium compyla*, Gulati, 1925, p. 748, fig. 14.
Colpodium campylum, Lepsi, 1926*a*, p. 62, fig. 190; Kahl, 1930–5, p. 334, fig. 58, *17–19*.

Form very variable according to locality and state of nutrition, long finger-shaped to short ovoid, rounded at the two ends. Ciliary rows wider apart than in *C. colpoda*.

Dorsal surface shows a more or less distinct bend but never an adoral depression. Cytostome and cytopharynx as described for the genus. Contractile vacuole near the right margin, in the posterior third or fourth of the body. Macronucleus spherical, central. Micronucleus close to the macronucleus or some distance behind. Very common in stagnant water, infusions and soil.

Dimensions.—Length 50–120 μ.

Fig. 78. Fig. 77.

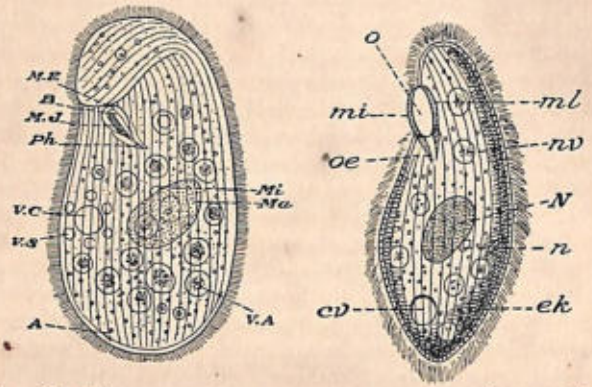


Fig. 77.—*Colpidium campylum* (Stokes). *cv*, contractile vacuole; *ek*, ectoplasm; *mi*, right undulating membrane; *ml*, left undulating membrane; *N*, macronucleus; *n*, micronucleus; *nv*, food-vacuole; *o*, cytostome; *oe*, cytopharynx. (After Schewiakoff.)

Fig. 78.—*Colpidium colpoda* (Ehrbg.). *A*, anus; *B*, cytostome; *Ma*, macronucleus; *M.E*, external undulating membrane; *Mi*, micronucleus; *M.J*, internal undulating membrane; *Ph*, cytopharynx; *V.C*, contractile vacuole; *V.S*, subsidiary vacuoles. (After Roux.)

Remarks.—This species is usually described as more elongated than the other members of the genus. The specimens examined at Lahore by Gulati were four times as long as broad and measured 70 μ by 17 μ. Contractile vacuole is shown by him as postero-terminal, and the micronucleus a little in front of it.

Habitat.—Hay infusion : PUNJAB, Lahore.

94. **Colpidium colpoda** (Ehrenberg) Stein. (Fig. 78.)

Paramecium colpoda, Ehrenberg, 1831, p. 114; 1833, pp. 174, 324, pl. iii, fig. 3; 1837, p. 164; 1838, p. 352, pl. xxxix, fig. 9.
Kolpoda cucullus, Dujardin, 1841, pp. 479–81, pl. iv, fig. 29.
Paramæcium colpoda, Claparède & Lachmann, 1858–61, p. 267.
Colpidium colpoda, Stein, 1860, p. 47; 1867, pp. 69, 118, 158, 160.
Colpidium ren, Stein, 1867, p. 41.

Colpidium cucullus, Kent, 1880–2, pp. 537–8, pl. xxvii, fig. 49.
Colpidium colpoda, Maupas, 1883, pp. 459–60, pl. xix, figs. 30, 31 ; 1888 *a*, pp. 235–6 ; 1889, pp. 238–49, pls. xiv–xv, figs. 1–38.
Glaucoma pyriformis, Gourret & Roeser, 1886, pp. 513–14, pl. xxxiv, fig. 6.
Colpidium colpoda, Bütschli, 1876, pp. 313–15, pl. ix, figs. 7–11 ; pl. x, figs. 26–8 ; 1887–9, p. 1704, pl. lxii, fig. 6 ; Schewiakoff, 1889, pp. 42–4, pl. v, figs. 65–8 ; 1893, p. 46 ; 1896, pp. 305–6, pl. iv, fig. 110, pl. vii, fig. 200 ; Roux, 1901, p. 57, pl. iii, fig. 10.
†*Colpidium colpoda*, Bhatia, 1920, p. 261.
Colpidium colpoda, Penard, 1922, p. 128, fig. 130.
†*Colpidium colpoda*, Gulati, 1925, p. 749, pl. ii, fig. 15.
Colpidium colpoda, Lepsi, 1926 *a*, pp. 61–2, figs. 188, 189 ; Schoenichen, 1927, p. 207, pl. xii, fig. 31 ; Sandon, 1927, p. 182, pl. vi, fig. 4 ; Kahl, 1930–5, p. 334, fig. 58, *21*, *22*.

Body ovoid, anteriorly bent towards the right side. Dorsal surface convex, covered with closely situated, longitudinal ciliary lines bent over to the right anteriorly ; ventral surface presenting a depression or concavity in its anterior part. Torsion mentioned by many authors is merely an appearance, due to the dorsal rows of cilia on the anterior part being prolonged on to the ventral surface, whereby the preoral seam is strongly curved to the left. Posterior extremity bears some longer cilia in addition to the normal ones. Cytostome and undulating membranes as described for the genus. Contractile vacuole single, situated in the middle of the dorsal surface. Macronucleus round or ellipsoid, with a single micronucleus. Very common in infusions and soils.

Dimensions.—Length 100–150 μ. (Sandon gives 30–45 μ ; Roux, length 90–120 μ, width 50–80 μ.)

Remarks.—In the forms met with at Lahore the cytostome was situated at the bottom of a triangular depression and was not followed by a cytopharynx ; both margins of the oral fossa bore simple, flap-like undulating membranes. Contractile vacuole was postero-terminal. Macronucleus was large, rounded, subcentral.

Habitat.—Infusion of leaves : PUNJAB, Lahore.

95. **Colpidium striatum** Stokes. (Fig. 79.)

Colpidium striatum, Stokes, 1886 *a*, pp. 103–4, pl. i, fig. 12 ; 1888, p. 177, pl. iv, fig. 28.
†*Colpidium striatum*, Gulati, 1925, p. 748, fig. 13.
Colpidium striatum, Sandon, 1927, p. 182.
†*Colpidium striatum*, Madhava Rao, 1928, p. 114, pl. iii, fig. 5.
Colpidium striatum, Kahl, 1930–5, p. 334, fig. 60, *10*.

Body egg-shaped, anterior end narrower than the posterior. Cytostome and cytopharynx as described for the genus. Contractile vacuole single, near the posterior end. Macronucleus spherical, central ; micronucleus small, situated a little in front of the macronucleus.

Dimensions.—Length 35–50 μ.

Remarks.—This species is scarcely distinct from *C. campylum*. The specimens found by Gulati at Lahore measured 35 μ by 17 μ. According to him the cytostome has two undulating membranes, only one of which is continued down the cytopharynx; the macronucleus shows a big central chromatin



Fig. 79.—*Colpidium striatum* Stokes. *c.v*, contractile vacuole. (After Gulati.)

mass, and the micronucleus is situated some distance in front of the macronucleus.

Habitat.—Infusion of dry leaves and hay : PUNJAB, Lahore. Soil : Mysore.

96. **Colpidium** sp.

†*Colpidium* sp., Chaudhuri, 1929, p. 54.

Habitat.—Soils from N.W.F. PROVINCE, Peshawar ; PUNJAB, Ghora Gali ; KASHMIR, Srinagar ; UNITED PROVINCES, Dehra Dun, Agra ; BIHAR, Patna ; BENGAL, Chittagong, Dacca ; CEYLON, Colombo.

Genus **PSEUDOGLAUCOMA** Kahl, 1931.

Pseudoglaucoma, Kahl, 1930–5, p. 335.

Very small to small organisms. Cytostome lies in the right margin of the body and shows a projecting ectoplasmic lip-like structure ; the oral groove is provided with a membranoid series of cilia arising from its left border.

97. **Pseudoglaucoma digitata,** sp. nov. (Fig. 80.)

†*Glaucoma pyriformis*, Bhatia, 1920, p. 261.

Organisms small. Body pear-shaped. Cytostome in the right margin of the body, with a projecting lip-like structure, and a membrane stretching completely across the oral groove.

Contractile vacuole single, situated near the middle. Macronucleus ovoidal, situated about the middle, with a micronucleus close behind it.

Dimensions.—Length 60μ.

Remarks.—This form, met with in a pond at Lahore in August, 1918, and which I referred with some hesitation to *Glaucoma pyriformis*, probably belongs to the genus *Pseudoglaucoma* recently described by Kahl. This genus differs from *Glaucoma* in possessing a single strong membrane arising from the left border and projecting into a concave ectoplasmic lip-like structure. The cytostome is situated in the right border, as in *Colpidium*, and not about the middle of the ventral surface, as in *Glaucoma*.

Fig. 80.

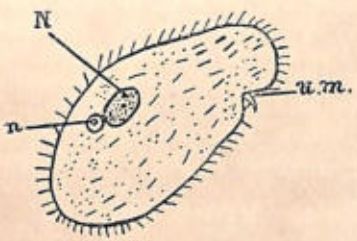


Fig. 81.

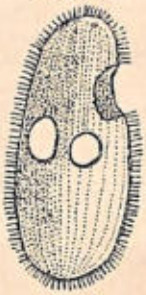


Fig. 80.—*Pseudoglaucoma digitata*, sp. nov. *N*, macronucleus; *n*, micronucleus; *u.m*, undulating membrane.
Fig. 81.—*Stegochilum ovale* Ghosh. (After Ghosh.)

The animals measure 60μ in length and 30μ in width. The form of the body is somewhat pyriform and the ciliation uniform, though very fine. Cilia along the margin are equally fine and rather widely separate from one another. The cytostome is situated along the right border, at 9μ from the anterior end, and the triangular oral fossa is provided with a single membrane stretching across it and with a finger-shaped projection protruding from its middle.

It differs from the other species of *Pseudoglaucoma* recently described by Kahl in its larger size, the position of the contractile vacuole, and form of the macronucleus.

Habitat.—Pond water: PUNJAB, Lahore.

Genus **STEGOCHILUM** Schewiakoff, 1893.

Stegochilum, Schewiakoff, 1893, p. 48 ; 1896, p. 282 ; Kahl, 1930–5, p. 337.

Distinguishable from *Glaucoma* by the absence of the oral funnel and the inner membrane. The outer membrane is inserted continuously along the left, anterior and right margins, and covers the cytostome anteriorly in a cap-like manner.

98. **Stegochilum ovale** Ghosh. (Fig. 81.)

†*Stegochilum ovale*, Ghosh, 1921 *a*, p. 9, fig. 7.
Stegochilum ovale, Kahl, 1930–5, p. 337.

Body elongately oval, wider posteriorly, and rounded at both ends. Cytostome in the anterior half of the body. Undulating membrane attached to the left, anterior and right margin of the cytostome. No cytopharynx. Longitudinal ciliary striæ meridional. Contractile vacuole single, central. Macronucleus oval, central. Micronucleus at the side of the macronucleus. Size not stated.

Remarks.—The species differs from the other two in the genus in its shape and the position of the macronucleus and the contractile vacuole.

Habitat.—Vegetable infusions : Bengal, Calcutta.

Genus **URONEMA** Dujardin, 1841.

Uronema, Dujardin, 1841, p. 392 ; Kent, 1880–2, p. 546.
Cryptochilum, Maupas, 1883, p. 443 ; Schewiakoff, 1896, p. 284.
Uronema, Bütschli, 1887–9, p. 1705 ; Schewiakoff, 1896, p. 280 ; Roux, 1901, p. 52 ; Hickson, 1903, p. 402 ; Penard, 1922, pp. 111–117 ; Calkins, 1926, p. 405 ; Wenyon, 1926, pp. 1180–3 ; Lepsi, 1926 *a*, p. 51 ; Schoenichen, 1927, p. 208 ; Knowles, 1928, p. 522 ; Kahl, 1930–5, p. 355.

Body egg-shaped or elongated, not strongly flattened. Ventral surface with a depression in the neighbourhood of the cytostome. Body covered with fine cilia, longitudinal striations strongly marked. Anteriorly an unciliated frontal pole. From the anterior end a faint groove runs back to the cytostome, the right margin of the groove being provided with stronger cilia. Posterior end of the body provided with a long caudal seta. Oral aperture oval in the direction of the long axis of the animal, with an undulating membrane along its left margin and a row of special cilia along the right. Cytopharynx absent. Contractile vacuole single, posterior. Macronucleus spherical, central, with a micronucleus adjacent to it. Locomotion swift, with rotation on its long axis. Feeds on bacteria, algæ and detritus.

99. **Uronema accuminatum** Madhava Rao. (Fig. 82.)

†*Uronema accuminata*, Madhava Rao, 1928, p. 115, pl. iii, fig. 1.

Allied to *U. marinum*.

Dimensions.—Length 50 μ.

Remarks.—Madhava Rao has recorded this species without mentioning the name of the author of the species. He gives

Fig. 82.



Fig. 83.

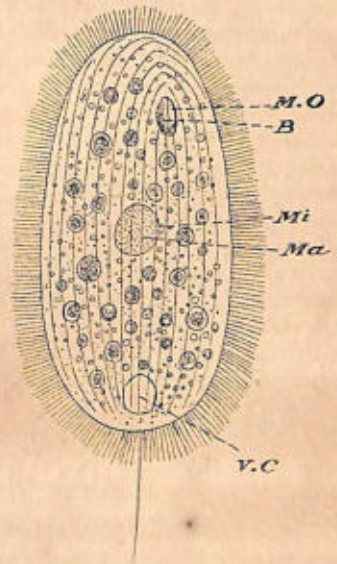


Fig. 82.—*Uronema accuminatum* Madhava Rao. (After Madhava Rao.)
Fig. 83.—*Uronema marinum* Duj. *B*, cytostome; *Ma*, macronucleus; *Mi*, micronucleus; *M.O*, undulating membrane; *V.C*, contractile vacuole. (After Roux.)

no description, and from the figure given it is impossible to ascertain if the organism belongs to *Uronema* at all.

Habitat.—Soil: Mysore.

100. **Uronema marinum** Dujardin. (Fig. 83.)

Uronema marinum, Dujardin, 1841, p. 392, pl. vii, fig. 13.
Uronema marina, Cohn, 1866, pp. 275–6, pl. xv, fig. 53.
Uronema marinum, Kent, 1880–2, p. 546, pl. xxvii, figs. 60 & 61.
Cryptochilum nigricans, Maupas, 1883.
Uronema marina, Maupas, 1883, p. 618; Bütschli, 1887–9, pp. 1704–5, pl. lxiv, fig. 1; Schewiakoff, 1889, pp. 44–5, pl. v figs. 69–71; 1893, p. 47; 1896, pp. 281–2, pl. iv, fig. 92; Roux 1901, p. 52, pl. iii, fig. 2; Lepsi, 1926 *a*, p. 59, figs. 195, 196;

Wenyon, 1926, p. 1182, fig. 500 B ; Schoenichen, 1927, p. 209, pl. xii, fig. 34.
Loxocephalus putrinus, Kahl, 1926.
†*Uronema marina*, Madhava Rao, 1928, p. 114, pl. iii, fig. 2.
Uronema marinum, Kahl, 1930–5, p. 356, fig. 60, *21*, *22*, *24*.

Very small to small. Body elongated, ellipsoidal in shape, with slight lateral compression. Cilia arranged uniformly in longitudinal rows ; a single long bristle at the posterior end. Cytostome a longitudinal oval opening on the ventral surface in the anterior part of the body, with a row of closely-set cilia on the right border and an undulating membrane on the left. No cytopharynx. Contractile vacuole single, posterior. Macronucleus spherical, central ; micronucleus adjacent. Movements rapid, rotating on the long axis.

Dimensions.—Length 30–60 μ.

Remarks.—Madhava Rao records *U. marina* without naming the author of the species. From his brief description it is inferred that *U. marinum* Duj. is intended. He mentions that the ventral side is almost straight from the mouth to the front and drawn out, the dorsal side being curved. Cilia are described as short and thick, though fine and close-set cilia are characteristic of the species, and his figure shows fairly long cilia.

Habitat.—Soil : Mysore.

2. Family OPHRYOGLENIDÆ Kent, 1882, emend. Kahl, 1931.

Body ciliated on all sides, with a peristome. The peristome runs as a sickle-shaped ciliated cleft, perpendicular to the surface of the body, into the depressed oral aperture. An hourglass-shaped body lies in front of the anterior end of the peristomial cleft.

The family includes the single genus *Ophryoglena*.

Genus **OPHRYOGLENA** Ehrenberg, 1831.

Ophryoglena, Ehrenberg, 1831, p. 117 ; 1838, p. 360.
Otostoma, Carter, 1856 *a*, pl. ix, figs. 6–8 ; 1856 *b*, p. 119.
Ophryoglena, Claparède & Lachmann, 1858–61, p. 256.
Panophrys, Stein, 1860 *a*, p. 61.
Otostoma, Kent, 1880–2, p. 500.
Ophryoglena, Bütschli, 1887–9, p. 1703 ; Schewiakoff, 1896, p. 317 ; Roux, 1901, p. 60 ; Hickson, 1903, p. 402 ; Penard, 1922, pp. 145–152 ; Calkins, 1926, p. 406 ; Schoenichen, 1927, p. 205 ; Reichenow, 1929, p. 1180 ; Kahl, 1930–5, p. 360.

Body oval, often dorso-ventrally flattened. Cilia fine, close and uniform, in longitudinal rows meeting in front of

the cytostome. Sometimes exhibiting a buccal area with special cilia. Cytostome on the anterior part of the ventral surface; an elongated oval slit, semilunar, with concavity towards the left; its right border provided with special cilia, which follow a spiral direction. Cytopharynx with narrow undulating membrane. To the left of the cytostome is an organ of unknown function, of a semilunar form, called the "hour-glass organ." A pigment spot sometimes present in the anterior part of the body. Contractile vacuoles varying in number and position. Macronucleus of variable form. Locomotion swift, uninterrupted by rotation on the long axis. Feeds on detritus or fat-globules.

101. **Ophryoglena flava** (Ehrenberg). (Fig. 84.)

Bursaria flava, Ehrenberg, 1833, p. 233; 1838, p. 330, pl. xxxv, fig. 2.
Panophrys flava, Dujardin, 1841, p. 494.
†*Otostoma* sp., Carter, 1856 *a*, pl. ix, figs. 6–8; 1856 *b*, p. 119.
Panophrys flava, Stein, 1860 *a*, p. 61.
Ophryoglena flava, Claparède & Lachmann, 1858–61, pp. 257–8.
Bursaria flava, Stein, 1867, pp. 44, 67, 92.
†*Otostoma carteri*, Kent, 1880–2, p. 500, pl. xxvi, figs. 55–8.
Panophrys flava, Kent, 1880–2, p. 534.
Ophryoglena flava, Bütschli, 1887–9, pp. 1703–4, pl. lxi, fig. 11, pl. lxii, fig. 2; Schewiakoff, 1893, p. 46; Roux, 1901, p. 61, pl. iii, fig. 16; Penard, 1922, pp. 145–8, fig. 143; Calkins, 1926, p. 383, fig. 168; Lepsi, 1926 *a*, p. 56, fig. 184; Schoenichen, 1927, p. 206; Reichenow, 1929, pp. 166, 1180, fig. 200; Kahl, 1930–5, p. 361, fig. 61, *39*.

Very large. Body elongated oval, rounded at both extremities. Cytostome well developed, situated in a depression on the ventral surface at about one-third of the length of the body from the anterior end. Cytopharynx ear-shaped, longitudinally plicate, recurved and narrower at its posterior extremity. Anal aperture postero-terminal. Cilia of cuticular surface short, even, and disposed in fine, parallel, longitudinal lines. Contractile vacuoles two, one in the anterior and the other in the posterior part of the body, with long, narrow radiating canals. Macronucleus elongated, elliptical or fusiform, placed obliquely about the middle.

Dimensions.—Length 250–400 μ. Penard gives 500 μ, Roux 560 μ.

Remarks.—Carter gave a brief description of this form from Bombay, and Kent subsequently named it *Otostoma carteri*. Later authorities have considered it to be identical with *Ophryoglena flava* (Ehrbg.). *O. flava* is usually described as narrower and pointed posteriorly, but Carter's form is described and figured as narrower anteriorly. Carter made the interesting observation that the organism encysts within the internodes

of semi-decayed *Nitella*, and segments into two, four, or eight individuals, which are subsequently liberated from the cyst.

Habitat.—Fresh water, among *Nitella* : BOMBAY, Bombay.

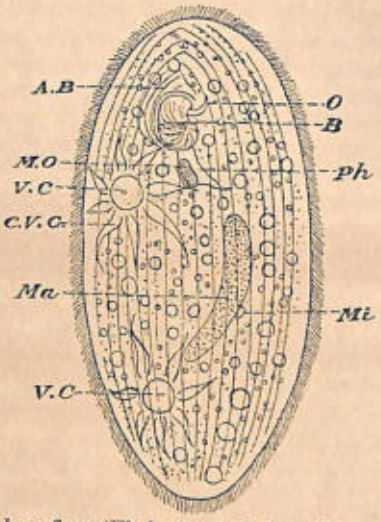


Fig. 84.—*Ophryoglena flava* (Ehrbg.). *A.B*, buccal area ; *B*, cytostome ; *C.V.C*, radiating canal ; *Ma*, macronucleus ; *Mi*, micronucleus ; *M.O*, undulating membrane ; *O*, hour-glass organ ; *Ph*, cytopharynx ; *V.C*, contractile vacuoles. (After Roux.)

3. Family PLEURONEMATIDÆ Kent, 1882.

Body with long cilia, longer or more powerful in the anterior region. Peristome extends along the surface of the body from the anterior pole to the oral aperture. Peristomial plate bears along the right border an undulating membrane, which surrounds the hinder margin of the oral aperture like a pocket. Left peristomial border bears a ciliary row or membrane.

Key to Indian Genera.

1 (2).	Peristomial groove small, at the anterior end	[p. 186. BALANTIOPHORUS,
2 (1).	Peristomial groove reaching at least up to the middle of the body	3.
3 (4).	Large size, 70–188 μ, peristome beginning near the anterior end and with a semicircular excavation on the left near the cytostome	PLEURONEMA, p. 184.
4 (3).	Small size, rarely a little more than 50 μ, without a semicircular excavation of the peristome near the cytostome	CYCLIDIUM, p. 183.

Genus **CYCLIDIUM** Hill, O. F. Müller, 1773.

Cyclidium, Hill, 1752 ; O. F. Müller, 1773, pp. xxvii & 49.
Cyclidium, part, Ehrenberg, 1838, p. 245.
Cyclidium, Claparède & Lachmann, 1858–61, p. 271 ; Stein, 1867, p. 159 ; Fromentel, 1874, p. 189 ; Kent, 1880–2, p. 544 ; Bütschli, 1887–9, p. 1713 ; Schewiakoff, 1896, p. 357 ; Roux, 1901, p. 73 ; Hickson, 1903, pp. 401, 403 ; Calkins, 1926, pp. 385, 407, fig. 169 ; Lepsi, 1926 *a*, p. 48 ; Wenyon, 1926, p. 1183 ; Schoenichen, 1927, p. 216 ; Reichenow, 1929, p. 1180 ; Kahl, 1930–5, p. 375.

Small to very small, ovoid, with one or more long caudal setæ at the posterior extremity. An unciliated, distinctly truncated frontal plate is always present anteriorly. Peristomial groove generally extending to two-thirds of the length of the body, wider posteriorly. Right peristomial margin with membrane which encloses the small oral groove like a pocket, the entrance to which is provided with preoral cilia. The left margin of the peristome bears either free cilia or a membrane, which becomes continuous behind with the membrane arising from the right side. Contractile vacuole single, posterior. Macronucleus spherical with an adjacent micronucleus.

102. **Cyclidium glaucoma** O. F. Müller. (Fig. 85.)

Cyclidium glaucoma, O. F. Müller, 1786, p. 80, pl. xi, figs. 6–8 ; Ehrenberg, 1829, pp. 10, 11, 15, 19, 20 ; 1838, pp. 245–6, pl. xxii, fig. 1.
Alyscum saltans, Dujardin, 1841, p. 391, pl. vi, fig. 3.
Enchelys nodulosa, Dujardin, 1841, p. 389, pl. vi, fig. 2, pl. vii, fig. 9.
Acomia cyclidium, Dujardin, 1841, p. 382, pl. vii, fig. 5.
Cyclidium glaucoma, Claparède & Lachmann, 1858–61, pp. 272–3.
Pleuronema cyclidium, Claparède & Lachmann, 1858–61, p. 276, pl. xiv, fig. 6.
Cyclidium glaucoma, Stein, 1860 *a*, p. 59 ; 1867, p. 159.
Cyclidium nigricans, Fromentel, 1874, p. 307, pl. iii, fig. 10.
Cyclidium glaucoma, Kent, 1880–2, pp. 544–5, pl. xxvii, figs. 57, 58 ; Gourret & Roesser, 1886, pp. 479–80, pl. xxix, figs. 11, 12, pl. xxx, fig. 1 ; Bütschli, 1887–9, pp. 1713–14, pl. lxiv, fig. 8 ; Stokes, 1888, p. 183 ; Maupas, 1889, pp. 271–2, pl. xvi, fig. 14 ; Schewiakoff, 1889, pp. 60–2, pl. vii, figs. 94–6 ; 1893, p. 54 ; 1896, pp. 359–61, pl. v, fig. 133 ; Roux, 1901, p. 74, pl. iv, fig. 11.
†*Cyclidium glaucoma*, Bhatia, 1922, p. 30.
Cyclidium glaucoma, Penard, 1922, pp. 180–1, fig. 180.
†*Cyclidium glaucoma*, Gulati, 1925, p. 750, fig. 19.
Cyclidium glaucoma, Lepsi, 1926 *a*, p. 54, fig. 241 ; Wenyon, 1926, p. 1182, fig. 500 A ; Schoenichen, 1927, p. 216, pl. xii, fig. 46 ; Sandon, 1927, p. 186 ; Thomson & Robertson, 1929, p. 278, fig. 187, *2*.
†*Cyclidium glaucoma*, Chaudhuri, 1929, p. 54.
Cyclidium glaucoma, Kahl, 1930–5, p. 376, fig. 64, *26*.

Very small. Body ovate, compressed, a little over twice as long as broad ; cuticular surface longitudinally striate.

Cilia of the general surface of the body long and fine, with a single very long and conspicuous caudal seta. Contractile vacuole postero-terminal. Macronucleus spheroidal, central, with an adjacent micronucleus. Locomotion jerky. In pond water and infusions.

Dimensions.—Length 18–24 μ, width 10–12 μ.

Remarks.—Specimens found at Lahore measured on an average 18 μ in length. The peristome did not extend much behind the middle of the body and the undulating membrane was large, hood-like and extensile.

Habitat.—Pond water: PUNJAB, Lahore; soil: BENGAL, Sibpore.

Fig. 85.

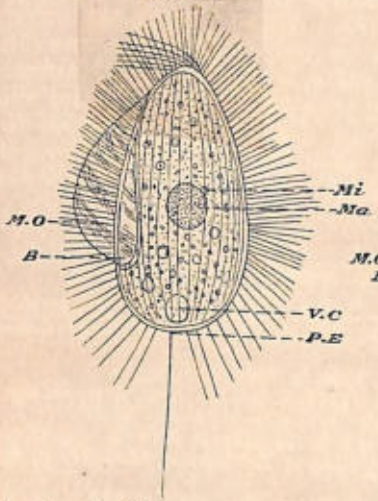


Fig. 86.

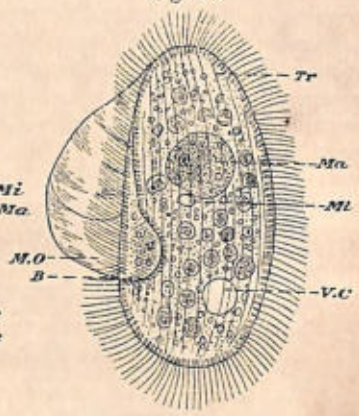


Fig. 85.—*Cyclidium glaucoma* O. F. Müll. *B*, cytostome; *Ma*, macronucleus; *Mi*, micronucleus; *M.O*, undulating membrane; *P.E*, excretory pore; *V.C*, contractile vacuole. (After Roux.)

Fig. 86.—*Pleuronema chrysalis* (O. F. Müll.). *Tr*, trichocysts; other lettering as in fig. 85. (After Roux.)

Genus **PLEURONEMA** Dujardin, 1841.

Pleuronema, Dujardin, 1841, p. 474; Claparède & Lachmann, 1858–61, p. 274; Stein, 1867, p. 159; Fromentel, 1874, p. 186; Kent, 1880–2, p. 542; Bütschli, 1887–9, p. 1713; Schewiakoff, 1896, p. 354; Roux, 1901, p. 71; Hickson, 1903, pp. 401, 403; Minchin, 1912, pp. 439, 442; Lepsi, 1926 *a*, p. 48; Wenyon, 1926, p. 1183; Schoenichen, 1927, p. 214; Sandon, 1927, p. 186; Reichenow, 1929, p. 1180; Kahl, 1930–5, p. 387.

Body persistently egg-shaped, only slightly flattened laterally; anterior end somewhat narrower than the posterior.

Body covered uniformly with long, fine bristle-like cilia, arranged in longitudinal lines which converge below the peristome. Peristome occupying nearly the whole of the ventral surface, beginning near the anterior extremity and widening behind, extending along three-fourths of the entire length of the body, and posteriorly strongly excavated along the left side. Cytostome small, at the posterior extremity of the peristome near the left border. Cytopharynx absent. From the left border of the peristome arises a large and broad undulating membrane which, passing along the posterior side of the fossa, extends along the right side of the peristome. Contractile vacuole single, posterior, dorsal. Macronucleus large, spherical, situated in the anterior part of the body, with a single micronucleus. Movements irregular, during the course of which the membrane can be drawn into the peristome; rotation on its long axis, suddenly stopping for longer or shorter intervals, in the course of which the membrane is extended. Feeding on organic debris and bacteria. In pond water. Not common in soils.

Pleuronema is recognizable from the other genera of the family chiefly by its larger size and by the possession of a semicircular excavation of the peristome in the neighbourhood of the cytostome.

103. **Pleuronema chrysalis** (O. F. Müller). (Fig. 86.)

Paramæcium chrysalis, O. F. Müller, 1786, p. 90, pl. xii, figs. 15–20.
Paramecium chrysalis, Ehrenberg, 1829, pp. 7, 10, 17, 20; 1830, pp. 25, 43, 54, 56, 65, 78, pl. iv, fig. 2; 1831, p. 114; 1835, p. 164; 1838, p. 352, pl. xxxix, fig. 8.
Pleuronema crassa, Dujardin, 1841, pp. 474–5, pl. vi, fig. 1, pl. xiv, fig. 2.
Pleuronema marina, Dujardin, 1841, p. 475, pl. xiv, fig. 3.
Pleuronema chrysalis, Perty, 1852, p. 146; Claparède & Lachmann, 1858–61, pp. 274–6, pl. xiv, fig. 8; Stein, 1859 *d*, pp. 61, 62, 73, 77; 1860 *a*, p. 58; 1867, p. 159; Fromentel, 1874, p. 401, pl. xxi, fig. 10, pl. xxii, fig. 16; Kent, 1880–2, p. 543, pl. xxvii, fig. 55.
Pleuronema coronata, Kent, 1880–2, p. 544, pl. xxvii, fig. 56.
Pleuronema chrysalis, Bütschli, 1887–9, p. 1713, pl. lxiv, fig. 6; Schewiakoff, 1889, pp. 58–60, pl. vii, figs. 92, 93; 1893, pp. 53–4; 1896, pp. 356–7, pl. v, fig. 132; Roux, 1901, p. 71, pl. iv, fig. 9; Hickson, 1903, fig. 52; Minchin, 1912, p. 56, fig. 27.
†*Pleuronema chrysalis*, Ghosh, 1921 *a*, p. 10.
Pleuronema chrysalis, Lepsi, 1926 *a*, p. 54, fig. 236; Calkins, 1926, p. 385, fig. 169; Sandon, 1927, p. 186; Schoenichen, 1927, p. 215, pl. xii, fig. 44; Reichenow, 1929, pp. 178, 1180, fig. 207; Kahl, 1930–5, pp. 387–8, fig. 65, *23*.

Small to medium-sized. Body irregularly egg-shaped, more or less flattened laterally, right margin straight, left convex, anteriorly narrowed, rounded at both extremities. Long and fine cilia in even longitudinal rows over the whole cuticular surface, cilia at the posterior end not specially

elongated. Left border of the peristome deeply excavated posteriorly. Undulating membrane narrow anteriorly and rapidly widening posteriorly, equal in width to the body when fully extended. Contractile vacuole single, postero-dorsal. Macronucleus large, spherical, anterior to the middle, with an adjacent micronucleus. Mostly remains quiet; when disturbed shows swift, straight locomotion.

Dimensions.—Length 70–120 μ.

Remarks.—Kent considers this species identical with *Paramecium chrysalis* Ehrenberg. Kahl remarks that *Paramecium chrysalis* O. F. Müller is undoubtedly a true *Paramecium*, and so is Ehrenberg's form of that name described in 1831. Ehrenberg later removed it to *Pleuronema*. If *Paramecium chrysalis* of O. F. Müller and Ehrenburg are not to be placed in the genus *Pleuronema* the correct name of the above species would be *Pleuronema crassa* Dujardin.

The contractile vacuole is stated by Kent to be situated anteriorly. He also states that the oral fossa is followed by a tubular pharyngeal passage. In both these characters descriptions given by other authors differ from Kent. Sandon, in his description of the genus, says "undulating membrane sometimes withdrawn into pharynx while animal is not feeding; mouth at posterior end of peristome without pharynx." He probably means that the membrane is withdrawn into the peristome, as there is no pharynx.

Habitat.—Hay infusions: BENGAL, Calcutta.

104. **Pleuronema** sp.

†*Pleuronema* sp., Sandon, 1927, p. 186.

Habitat.—Doubtfully recorded from culture from a soil from BURMA, Hmawbi.

105. **Pleuronema** sp.

†*Pleuronema* sp., Chaudhuri, 1929, p. 54.

Habitat.—In soil. The locality is not indicated in Table III of Chaudhuri's paper.

Genus **BALANTIOPHORUS** Schewiakoff, 1889.

Balantiophorus, Schewiakoff, 1889, p. 64; 1893, p. 56; 1896, p. 365; Roux, 1901, p. 75; Lepsi, 1926 *a*, p. 52; Schoenichen, 1927, p. 214; Sandon, 1927, p. 187.
Glaucoma, part, Kahl, 1930–5, p. 332.
Espejoia, part, Kahl, 1930–5, p. 337.
Cyrtolophosis, Kahl, 1930–5, p. 353.

Body transparent, elongated egg-shaped, rounded at both ends; dorsal side more convex than the ventral. Cilia

fine, often longer at the anterior end. Peristome short, confined to the anterior portion of the ventral surface. Left, posterior and right margins of the peristome with a bag-like undulating membrane, which can be withdrawn into the peristome. Contractile vacuole posterior. Macronucleus ovoid, central. Locomotion very lively, with rotation. Feeds on bacteria.

Remarks.—Kahl thinks that the genus *Balantiophorus* was wrongly established by Schewiakoff for certain species which had already been described and placed in the genus *Cyrtolophosis* Stokes, 1888. As Stokes' work is not available to me and the generic name *Cyrtolophosis* is not noted in the 'Zoological Record,' I am retaining *Balantiophorus* as a generic name.

Key to Indian Species.

1. Body elongate and rather narrow. Cilia sparsely scattered ..... *B. elongatus* Schew., [p. 187.
2. Body shorter and broader. Cilia arranged in longitudinal rows ..... *B. minutus* Schew., [p. 187.

106. **Balantiophorus elongatus** Schewiakoff. (Fig. 87.)

Balantiophorus elongatus, Schewiakoff, 1893, pp. 56–7, pl. iv, fig. 50; 1896, p. 368, pl. vi, fig. 139; Lepsi, 1926 *a*, p. 61, fig. 256.
†*Balantiophorus elongatus*, Sandon, 1927, p. 187, pl. vi, fig. 7; Chaudhuri, 1929, p. 60, pl. ii, figs. 32–3.
Cyrtolophosis elongata, Kahl, 1930–5, p. 354, fig. 61, *5*.

Very small. Shape elongate and rather narrow. Cilia long, sparsely scattered and not arranged in longitudinal rows. Peristome short, occupying only the anterior part of the ventral surface. Contractile vacuole single, posterior. Macronucleus oval, central, with a small micronucleus. A common soil Ciliate.

Dimensions.—Length 28–30 μ, width 10 μ.

Habitat.—Soils from KASHMIR, Srinagar; N.W.F. PROVINCE, Peshawar; PUNJAB, Gurdaspur, Jullundhur, Lahore, Ghora Gali; UNITED PROVINCES, Agra, Benares; BOMBAY, Dharwar; CENTRAL INDIA, Indore; MADRAS, Kanara; BENGAL, Cuttack, Sibpore, Calcutta, Chittagong; BIHAR, Patna; ASSAM, Cinnamara (near Jorhat); CEYLON, Colombo.

107. **Balantiophorus minutus** Schewiakoff. (Fig. 88.)

Balantiophorus minutus, Schewiakoff, 1889, pp. 64–5, pl. vii, figs. 99–101; 1893, p. 56; 1896, pp. 367–8, pl. vi, fig. 138; Roux, 1901, p. 75, pl. iv, fig. 14; Lepsi, 1926 *a*, p. 61, fig. 255; Schoenichen, 1927, p. 214, fig. 737.
†*Balantiophorus minutus*, Sandon, 1927, p. 188; Chaudhuri, 1929, p. 60, pl. ii, figs. 17–19.
Cyrtolophosis mucicola, Kahl, 1930–5, p. 354, fig. 61, *2*.

Very small. Body ovoid, very narrow in front, broadly

rounded posteriorly. Cilia short, uniform, arranged in distinct longitudinal rows. Contractile vacuole posterolateral. Macronucleus spherical, central, with a small micronucleus.

Dimensions.—Length 24–28 μ, width 9–12 μ.

Remarks.—*B. minutus* is shorter and broader than *B. elongatus*, and is further distinguished by the cilia being more numerous and arranged in distinct longitudinal rows.

Fig. 87.

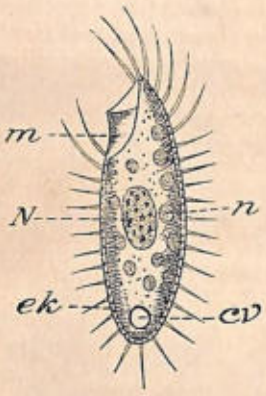


Fig. 88.

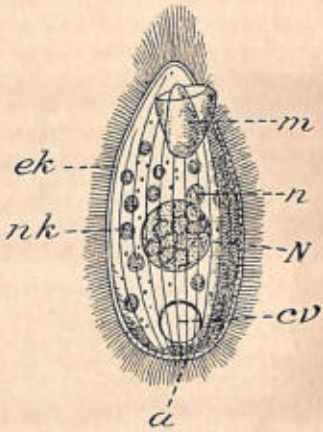


Fig. 87.—*Balantiophorus elongatus* Schew. *cv*, contractile vacuole; *ek*, ectoplasm; *m*, cytostome; *N*, macronucleus; *n*, micronucleus. (After Schewiakoff.)

Fig. 88.—*Balantiophorus minutus* Schew. *a*, anus; *cv*, contractile vacuole; *ek*, ectoplasm; *m*, cytostome; *N*, macronucleus; *n*, micronucleus; *nk*, food-vacuole. (After Schewiakoff.)

Habitat.—Soils from N.W.F. Province, Peshawar; Punjab, Lahore, Jullundhur; United Provinces, Dehra Dun; Bombay, Dharwar; Madras, Coimbatore; Bihar, Patna; Bengal, Sibpore, Calcutta, Chittagong.

108. **Balantiophorus** sp.

†*Balantiophorus* sp., Chaudhuri, 1929, p. 54.

Habitat.—Soils from Punjab, Lahore; Ceylon, Colombo.

4. Family UROCENTRIDÆ Claparède & Lachmann, 1858.

Body cylindrical or barrel-shaped, with cilia confined to two or three ciliary girdles, with or without a tuft of caudal cilia. Cytostome obliquely placed about the middle. Cytopharynx with undulating membranes and free cilia. Contractile vacuole single, terminal. Macronucleus horseshoe-shaped.

Key to Indian Genera.

1. With three ciliary girdles and a caudal tuft. UROCENTRUM, p. 189.
2. With two ciliary girdles, and without a caudal tuft ..... TELOTRICHIDIUM, [p. 191.

Genus **UROCENTRUM** Nitzsch, 1817.

Urocentrum, Nitzsch, 1817, p. 4; 1827, p. 68; Ehrenberg, 1838, p. 268; Dujardin, 1841, p. 531; Claparède & Lachmann, 1858–61, p. 134; Stein, 1867, p. 161; Kent, 1880–2, p. 641; Bütschli, 1887–9, p. 1711; Schewiakoff, 1896, p. 344; Roux, 1901, p. 69; Hickson, 1903, p. 403; Calkins, 1926, p. 405; Lepsi, 1926 *a*, p. 49; Schoenichen, 1927, p. 212; Reichenow, 1929, p. 105; Kahl, 1930–5, p. 354.

Flexible. Body almost cylindrical, barrel-shaped, rounded anteriorly and posteriorly. With three ciliary girdles, the anterior and posterior broad, and a narrow one of shorter cilia in the middle; posteriorly a ciliary tuft, and a ciliary row along the right margin. Peristomial furrow narrow, narrowing from the posterior end to the middle of the body, where the cytostome is situated. Cytostome obliquely placed. Cytopharynx with a row of longer cilia along its dorsal wall. Contractile vacuole terminal, with four or eight elongated canals. Macronucleus horseshoe-shaped. Anus posterior. Locomotion swift, with rotation on its long axis and frequent changes of direction.

109. **Urocentrum turbo** (O. F. Müller). (Fig. 89.)

Cercaria turbo, O. F. Müller, 1786, pp. 123–4, pl. xviii, figs. 13–16.
Urocentrum turbo, Nitzsch, 1817, p. 4; 1827, p. 68; Ehrenberg, 1830, p. 66; 1838, p. 268, pl. xxiv, fig. 7; Dujardin, 1841, pp. 531–2; Claparède & Lachmann, 1858–61, pp. 134–5; Stein, 1859 *d*, p. 73; 1867, pp. 69, 118, 148; Pritchard, 1861, p. 584, pl. x, figs. 231, 232.
†*Urocentrum turbo*, Carter, 1865, pp. 399–402.

Urocentrum turbo, Fromentel, 1874, pp. 259–60, pl. xxiv, figs. 5, 5 *a* ; Kent, 1880–2, pp. 641–3, pl. xxxiii, figs. 7–10 ; Entz, 1882, pp. 179–89, pl. viii, figs. 12–14 ; Bütschli, 1887–9, pp. 1711–12, pl. lxiv, fig. 15 ; Schewiakoff, 1889, pp. 49–54, pl. vi, figs. 76–86 ; 1893, p. 53 ; 1896, pp. 347–8, pl. v, fig. 130, pl. vi, fig. 165, pl. vii, figs. 166–8, 186, 190, 205 ; Roux, 1901, p. 70, pl. iv, fig. 7.

†*Urocentrum turbo*, Gulati, 1925, p. 749, pl. ii, fig. 17.

Urocentrum turbo, Bullington, 1925, pp. 224, 269 ; Lepsi, 1926 *a*, p. 56, fig. 234 ; Calkins, 1926, p. 383, fig. 168 D ; Schoenichen, 1927, p. 213, pl. xii, fig. 42.

†*Urocentrum turbo*, Bhatia & Mullick, 1930, pp. 398–9.

Urocentrum turbo, Kahl, 1930–5, pp. 354–5, fig. 61, *26* & *26 a*.

Body flexible and unevenly cylindrical, rounded at both ends. Three ciliary girdles, the anterior very wide, the

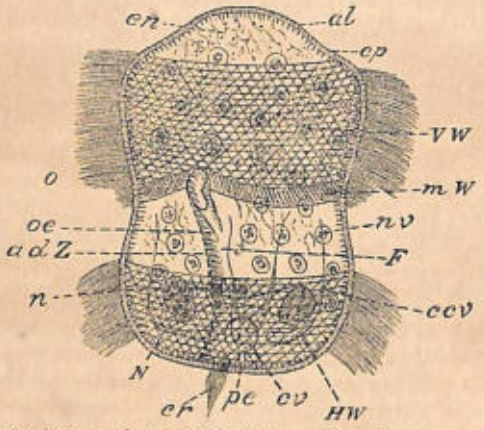


Fig. 89.—*Urocentrum turbo* (O. F. Müll.). *adZ*, adoral zone ; *al*, alveolar layer ; *ccv*, radial canal ; *ep*, pellicle ; *cr*, caudal ciliary tuft ; *cv*, contractile vacuole ; *en*, endoplasm ; *F*, furrow ; *HW*, posterior ciliary girdle ; *mW*, middle ciliary girdle ; *N*, macronucleus ; *n*, micronucleus ; *nv*, food-vacuole ; *o*, cytostome ; *oe*, cytopharynx ; *pe*, excretory pore ; *VW*, anterior ciliary girdle. (After Schewiakoff.)

posterior less so, and the one round the middle narrow and consisting of very short cilia. Cytostome obliquely placed just behind the middle ciliary girdle ; a narrow furrow extends backwards from it to the hinder end of the body. Contractile vacuole single, posterior. Macronucleus horseshoe-shaped, with two spherical extremities, placed horizontally across the posterior region of the body, with a single micronucleus lying about its middle.

Dimensions.—Usually 50–80 μ, rarely 80–110 μ, in length.

Remarks.—The organisms were found at Srinagar in pond water overgrown with *Lemna*. They became very abundant

in a jar containing pond water richly covered with *Lemna* during the course of two or three days, but a little later they became very scarce again. Specimens were unusually small, varying from 33μ to 60μ. The body appeared to be divided into two regions by a constriction in the middle. The posterior region was narrower and provided with a long, flattened and flexible caudal appendage, formed of a bundle of cilia; in some specimens this appendage was either not present or was seen to be curved up over the body. The anterior part of the body was vacuolated. Trichocysts were very abundant and distributed all over the body.

Kahl describes in the cytopharynx a stiff ectoplasmic membrane which divides the funnel into an anterior portion (with two undulating membranes) and a posterior portion (with basal ciliary field). The contractile vacuole is usually described as possessing four radiating canals, but according to Kahl there are eight, reaching the middle of the body.

Habitat.—Pond water: KASHMIR, Srinagar; PUNJAB, Lahore. Fresh water: Bombay.

Genus **TELOTRICHIDIUM** Kent, 1880–2.

Telotrichidium Kent, 1880–2, p. 643; Bütschli, 1887–9, p. 1764; Lepsi, 1926 *a*, p. 18; Kahl, 1930–5, p. 663.

Free-swimming, ovate or campanulate, possessing no caudal appendage. Ciliary girdles two in number. Oral aperture ventral, immediately behind the anterior wreath of cilia. Anal aperture postero-terminal. Contractile vacuole and macronucleus conspicuously developed. Multiplying by longitudinal fission.

110. **Telotrichidium matthaii** Gulati. (Fig. 90.)

*Telotrichidium natthaii**, Gulati, 1925, p. 749, pl. ii, fig. 18.
Telotrichidium nathaei, Kahl, 1930–5, p. 663.

Animalcules entirely free-swimming, ovate, campanulate or subquadrate, with a convex anterior margin and a retractile, knob-like projection protruded asymmetrically on one side of the posterior margin. Cilia restricted to two girdles, each consisting of a single row; posterior girdle hidden from view on retraction. Cytostome in the middle of the body on the ventral side, followed by a ciliated cytopharynx. Anus situated close to the posterior projection. Contractile vacuoles one or two, lying in the neighbourhood of the mouth. Macronucleus horseshoe-shaped. Micronucleus oval or rounded,

* *natthaii* is an obvious misprint for *matthaii*.

near one of the angles of the macronucleus. Fission always longitudinal.

Dimensions.—Length 145μ, width 108μ.

Remarks.—Gulati has recorded longitudinal fission and also encystment in this species. He has also described conjugation between individuals of unequal size. As pointed out by him, the individuals show some resemblance to Vorticellæ detached from their stalks.

This species differs from the only other previously known species of the genus, *Telotrichidium crateriforme*, in that (1) the posterior girdle of cilia runs obliquely almost along the

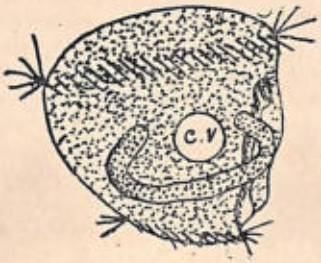


Fig. 90.—*Telotrichidium matthaii* Gulati. *c.v*, contractile vacuole. (After Gulati.)

posterior border, (2) there is no thick anterior annular border, and (3) the posterior end is retractile.

Gulati's observations seem to show that *Telotrichidium* is a valid genus, whose position is close to *Urocentrum*. The true Vorticellæ may be supposed to have been derived from such Hototrichan forms as *Urocentrum* and *Telotrichidium*, and these forms were actually placed in the order PERITRICHA by Kent, but later workers have shown that their correct position is among the HYMENOSTOMATA. Kahl is, however, of the opinion that the so-called species of *Telotrichidium* are Vorticellæ detached from their stalks.

Habitat.—Ditch water in which dry leaves were rotting: PUNJAB, Lahore.

4. Suborder *THIGMOTRICHA* Chatton & Lwoff.

HOLOTRICHA in which the anterior body cilia form a group for attaching the organism to the substratum (thigmotactic apparatus). They include forms at very different levels of organization, including on the one hand forms which possess a highly organized cytostomial apparatus, and on the other forms in which a cytostome is almost or quite absent, and which consequently absorb their food by means of a sucking tentacle. With the exception of a few species, they all live in the mantle-cavities of various marine or freshwater molluscs, where they may be attached by the thigmotactic field of cilia, or may show free locomotion.

Identification Table of Families.

1 (4). Ciliation uniform, in closely situated meridional rows; body laterally flattened; peristome not beginning close to the anterior end of the body. 2.

2 (3). Thigmotactic field extending over the whole of one surface; peristome and cytostome well developed: commensals or parasites of molluscs or sea-urchins ..... [p. 194.
Conchophthiridæ Kahl.

3 (2). Thigmotactic field reduced to a small part of the left surface; oral funnel without distinct peristome; contractile vacuole opening into the cytostome ..... [Chatton & Lwoff.
Thigmophryidæ *

4 (1). Ciliation not uniform ..... 5.

5 (10). Ciliary rows distributed irregularly on both surfaces or in a spiral course, or largely or even completely rudimentary; cytostome with well-developed peristome, or cytostome rudimentary or absent..... **Ancistrumidæ** * Issel.

6 (9). Chiefly entozoic in mussels, less often in snails and holothurians ..... 7.

7 (8). Laterally flattened; ciliary rows meridional; adoral zone begins near the anterior end and, winding to the left, extends to the cytostomial groove situated near the posterior end ..... [MINÆ * Kahl.

8 (7). Ciliary rows meridional or markedly spiral; adoral zone spiral, beginning Subfam. ANCISTRU-

	from the anterior end and extending to the posterior end	[Pickard †. Subfam. BOVERIINÆ*
9 (6).	Epizoic on echinoderms. Ciliation complete. Cytostome rudimentary or absent	[RINÆ* König. Subfam. HEMISPEI-
10 (5).	Ciliation greatly reduced; with a short sucking tentacle for attachment; cytostome functionless or completely absent; multiplication by ciliated buds	11.
11 (12).	Adult forms showing two rows of basal granules in furrows, but the cilia themselves only rarely visible. Multiplication by buds which carry both the basal groups which develop into cilia. Nutrition by osmosis. Completely fixed to the branchial lamellæ of mussels	[Chatton & Lwoff. **Sphenophryidæ***.
12 (11).	Cilia reduced to a thigmotactic field at the anterior end; adoral cilia present in addition to an attaching tentacle, or adoral cilia absent and only an attaching and food-absorbing tentacle present. Fixed to the gills of mussels, or to the stalk of Vorticellids or Suctoria	**Hypocomidæ*** Bütschli.

Family CONCHOPHTHIRIDÆ Kahl, 1931.

Body laterally flattened, uniformly ciliated, creeping on the somewhat concave left surface. The right surface shows a peristomial groove extending from the ventral border to the middle of the body; at the bottom of this lies the oral funnel. Cytopharynx ciliated. Contractile vacuole single, central. Macronucleus simple or multipartite. Commensals or parasites of molluscs and sea-urchins.

Genus **CONCHOPHTHIRIUS** Stein, 1861.

Conchophthirius, Stein, 1861, p. 87; 1867, pp. 64, 336; Engelmann, 1862, p. 379.
Conchophthirus, Kent, 1880–2, p. 490; Bütschli, 1887–9, p. 1720; Calkins, 1926, p. 407; Strand, 1928, p. 31; Reichenow, 1929, p. 1177; Kahl, 1930–5, pp. 285–6.

Body laterally flattened, ventral border extended, somewhat concave in the neighbourhood of the cytostome; dorsal border curved. Left side flat or somewhat dish-shaped, right surface broad, slightly convex. A depression on the ventral side as in *Colpoda*. Cytostome at the bottom of the

† Pickard (1927) has separated the genus *Boveria* from the family Ancistrumidæ and placed it in a new family Boveridæ under HETEROTRICHA, but this view is not accepted by Reichenow (1929), Cheissen (1931), Calkins (1933), and Kahl (1934 *a*).

depression, followed by a funnel bent dorsally and provided with cilia. Cilia on the body fine, thickly set, usually presenting a tufted or matted aspect. Contractile vacuole single, usually near the middle of the body. Macronucleus simple or multipartite. Commensals on various Lamellibranchiate and Gastropod Mollusca.

Remarks.—Raabe (1932) has used Klein's method to demonstrate the silver-line system in four species of this genus. The silver-line system provides a well-defined characteristic of the genus and indicates clear differences between the species. Kidder (1934) describes a well-integrated neuromotor system. It consists of an external fibrillar system, demonstrated by Klein's silver-nitrate method, and an internal set of fibres, demonstrated after hæmatoxylin destained with 10 per cent. hydrogen peroxide.

Key to Indian Species.

1 (3).	Peristomial groove opens ventralwards between the middle and posterior end of the ventral border	2.
2.	Body 1½ times as long as broad. No cytopharynx. Contractile vacuole subcentral. Macronucleus posterior, oval .	[p. 197. *C. lamellidens* Ghosh,
3 (1).	Peristomial groove opens ventralwards at or in front of the middle of the ventral border.....	4.
4.	Left side without depression	5.
5 (6).	Form very broad. Ciliated cytopharynx very long, extending across almost close to the dorsal border. Contractile vacuole near the macronucleus. Macronucleus oval, subcentral	[p. 195. *C. curtus* Engelmann,
6 (5).	Form narrow, elongated, with parallel sides, 2½ times as long as broad. Contractile vacuole single, about ⅓ length of the body from the posterior end. Macronucleus oval, posterior	[p. 196. *C. elongatus* Ghosh,

111. **Conchophthirius curtus** Engelmann. (Fig. 92.)

Conchophthirius curtus, Engelmann, 1862, pp. 379–81, pl. xxxi, fig. 2; Kent, 1880–2, p. 491.
†*Conchophthirus curtes*, Ghosh, 1918, p. 133, fig. 2.
Conchophthirus curtus, Kahl, 1930–5, p. 287, fig. 47, *31*.

Body shortly oval, nearly as broad as long, equally rounded at both extremities, dorsal border strongly convex, ventral flattened. Peristomial depression somewhat in front of the middle of the ventral border. Cytopharynx long, tubular, and recurved. Cuticular surface delicately striate longitudinally, clothed throughout with long, fine, matted cilia, with a tuft of strong cilia at the posterior end of the right side.

Contractile vacuole somewhat behind the middle, with subsidiary vacuoles surrounding it. Macronucleus oval, subcentral, with one or two micronuclei.

Dimensions.—Length about 120μ.

Remarks.—Ghosh mentions that his specimens differed from the description of the species as given by Engelmann in the following points :—The oval macronucleus is mostly placed with its long axis in a line with the length of the body, the contractile vacuole is without accessory vesicles, and the cytopharynx is not only directed dorsalwards, but also curves posteriorly at a little distance behind the macronucleus.

Fig. 91. Fig. 92. Fig. 93.

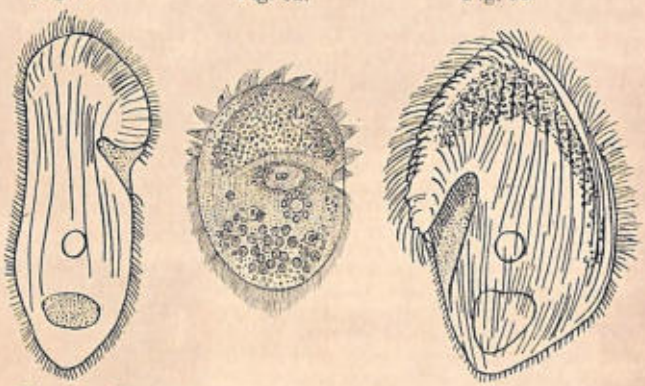


Fig. 91.—*Conchophthirius elongatus* Ghosh. (After Ghosh.)
Fig. 92.—*Conchophthirius curtus* Engelm. (After Engelmann.)
Fig. 93.—*Conchophthirius lamellidens* Ghosh. (After Ghosh.)

There is obviously an error in his labelling fig. 2 as *C. elongatus* and fig. 4 as *C. curtus*. Those consulting his original paper should note that what is given as fig. 2 is really a figure of *C. curtus*, and fig. 4 of *C. elongatus*.

Habitat.—In the mantle-chamber of *Lamellidens marginalis* : Bengal, Calcutta.

112. **Conchophthirius elongatus** Ghosh. (Fig. 91.)

†*Conchophthirus elongatus*, Ghosh, 1918, p. 132, fig. 4.
Conchophthirus elongatus, Kahl, 1930–5, p. 288, fig. 47, *33*.

Body elongated, about 2½ times as long as broad, wide anteriorly ; anterior end rounded, posterior end narrow and bluntly pointed. Dorsal border nearly straight, slightly convex in front and behind and faintly concave in the middle ; ventral border with a shallow notch just behind the anterior third of the length of the body. Peristome small, conical, directed

forwards and dorsalwards. No cytopharynx. Longitudinal ciliary striæ very marked at the anterior end, less so over the rest of the body. Contractile vacuole single, at the junction of the middle and posterior third of the body-length, sometimes slightly displaced. Macronucleus oval, posterior and subterminal.

Dimensions.—Length 50 μ.

Habitat.—In the mantle-chamber of *Lamellidens marginalis* : Bengal, Calcutta.

113. **Conchophthirius lamellidens** Ghosh. (Fig. 93.)

†*Conchophthirus lamellidens*, Ghosh, 1918, p. 132, fig. 3.
Conchopthirus lamellidens, Kahl, 1930–5, p. 286, fig. 47, *35*.
†*Conchopthirus lamellidens*, Ray & Chakravarty, 1934 *a*, p. 1 ; 1934 *b*, pp. 663–4.

Body ovate, about $1\frac{1}{2}$ times as long as broad, bluntly pointed at both ends ; dorsal border strongly convex, ventral convex and minutely dentate in the anterior and slightly notched in the posterior half. Peristome in the anterior portion of the notch, short and tubular, being directed forwards and dorsalwards. Generally a dark granular zone in the endoplasm in the anterior third of the body. Longitudinal striæ very distinct. Contractile vacuole single, subcentral. Macronucleus oval or triangular, posterior and subterminal.

Dimensions.—Length 90 μ.

Remarks.—Ray and Chakravarty (1934 *a*) have studied the morphology of this Ciliate in detail, but their observations have not yet been published. They (1934 *b*) also claim to have discovered a lunar periodicity in conjugations in this Ciliate.

Habitat.—In the mantle-chamber of *Lamellidens marginalis* : Bengal, Calcutta.

5. Suborder *APOSTOMEA* Chatton & Lwoff.

Endoparasitic HOLOTRICHA in which the cytostome is reduced to a small rosette or quite absent. In the family Fœttingeriidæ, which includes a number of genera and species, the organisms show a complicated life-history accompanied by change of hosts. At encystment the helicoidal ciliation of the vegetative individuals or "trophonts" disappears, the cilia being detached from the body and remaining in the mucous wall of the cyst. Later in the encysted stage the ciliary bands show a meridional instead of a helicoidal course. The encysted individual known as the "tomont" undergoes a transverse fission which is described as linear palintomic multiplication, resulting in the formation of a number of free-swimming parts called "tomites." The tomites acquire a ciliation differing from the trophont, and later metamorphose into trophonts within a phoretic cyst. They are parasites of Crustacea and Cœlenterata. In the family Opalinopsidæ are included endoparasites of the kidneys and liver of Heteropoda and Cephalopoda.

Identification Table of Families.

1 (2). Asymmetrical forms with the cytostome reduced to a small rosette. With few meridional rows of cilia and reduced adoral row. Macronucleus often branching or like a network. Micronucleus and contractile vacuole near the cytostome. Complicated life-history	[Chatton. **Fœttingeriidæ***
a. Tomite and trophont with cytostomial rosette; tomont in the cyst with meridional rows, with short postoral rows in two groups	[Lwoff. [GERIINÆ* Chatton & Subfam. FŒTTIN-
b. Tomite and trophont without cytostomial rosette; tomont freely motile, with incompletely distorted ciliary rows	[Chatton & Lwoff. Subfam. POLYSPIRINÆ*
c. Only known as trophont in the gastrovascular cavity of a ctenophore....	Subfam. PERICARYO- [NINÆ* Chatton & [Lwoff.
2 (1). Oval or elongated forms, with cilia in the form of helicoid bands; cytostome present or absent. Macronucleus breaks up into chromidia. Multiplication by buds which remain united to form chains. Parasites in the kidney or liver of Cephalopoda and Heteropoda	**Opalinopsidæ*** Hartog.

6. Suborder *ASTOMATA* Schewiakoff, emend. Cépède.

The ASTOMATA are parasites of various Invertebrate hosts and are chiefly found in the Annelids. They generally live in the alimentary canal, though some forms are found in the body-cavity and in the tissues of various organs.

Cépède (1910, 1923) recognized as many as eleven families, only two of which, viz. Anoplophryidæ and Haptophryidæ, comprise a large number of forms, the others being based on a single species in each case. The family Anoplophryidæ was further subdivided into six subfamilies. Rossolimo (1926) described a new genus *Radiophrya* and placed it in a seventh subfamily of Anoplophryidæ. Cheissen (1930) gave a new classification, and divided ASTOMATA into six families, viz., Anoplophryidæ, Intoshellinidæ, Maupasellidæ, Hoplitophryidæ, Haptophryidæ, and Chromidinidæ. The family Anoplophryidæ was divided into eight and Hoplitophryidæ into three subfamilies. As in Cépede's classification, the family Anoplophryidæ was treated as a lumber-room, and several of the subfamilies, based on a single species, were referred to it. More recently Heidenreich (1935 *a*) has further revised this classification and divided the group into only three families, viz., Anoplophryidæ, Hoplitophryidæ, and Intoshellinidæ. He revised the synonymy of many species, and excluded from this scheme a large number of insufficiently characterized species.

Identification Table of Families.

1 (2). Skeletal elements completely absent. Body elongated. Cilia in long and close rows. Macronucleus elongated .. **Anoplophryidæ** Cépède. [p. 200.

2 (1). Skeletal elements present..... 3.

3 (4). With an organ of fixation, in the form of a girdle with spikes or a disc with teeth, at the anterior end of the body. Cilia long, arranged spirally or in longitudinal rows ..... **Intoshellinidæ*** Cépède.

4 (3). With an organ of fixation, consisting of a pointed spike, or with a supporting skeleton, lying in the ectoplasm, or partly in the ectoplasm and partly in the endoplasm..... **Hoplitophryidæ** Cheis- [sin. p. 205.

1. Family ANOPLOPHRYIDÆ Cépède, 1910, emend. Cheissen, 1930; further emend. Heidenreich, 1935.

Body elongated. Skeleton completely absent. Cilia arranged in long and close rows. Contractile vacuoles variable in number and position. Macronucleus elongated. The family is divided into two subfamilies, as follows :—

1. Without an anterior unciliated cone; rounded at both ends, anterior end often broader than the posterior ..... [Cépède, p. 200. ANOPLOPHRYINÆ
2. With an anterior unciliated cone; peculiar arrangement of ciliary rows ..... [Cépède. BÜTSCHLIELLINÆ*

Subfamily ANOPLOPHRYINÆ Cépède, 1910.

Body elongate, cylindrical or slightly flattened, rounded at both ends, anterior end often broader than the posterior. It is uniformly ciliated, there being no anterior unciliated cone. Reproduction by transverse division, which may lead to the separation of chains of buds from the posterior end of the body. Includes a single genus.

Genus **ANOPLOPHRYA** Stein, 1860.

Anoplophrya Stein, 1860 *a*, p. 57; Kent, 1880–2, p. 563; Bütschli, 1887–9, p. 1716; Schewiakoff, 1896, p. 379; Cépède, 1910; p. 411; Rossolimo, 1926 *a*, pp. 471–3; Wenyon, 1926, p. 1167; Reichenow, 1929, p. 1183; Cheissen, 1930, pp. 545–7, 608–9; Kudo, 1931, p. 341; Kahl, 1934 *a*, p. 175; Heidenreich, 1935 *a*, pp. 319–26, 362–3, 387–8.

Endoparasites. Free-swimming, mouthless, body cylindrical or flattened, rounded at both extremities, thickly and uniformly ciliate; possessing no supplementary organs of prehension. Contractile vacuole or vacuoles well developed. Macronucleus mostly band-like and axial. Occurring as parasites within the intestinal viscera of various Invertebrata.

Key to Indian Species.

1 (4). Contractile vacuole single ..... 2.
2 (3). Posterior end with a notch. Macronucleus club-shaped, pointed anteriorly. [p. 204. *A. variabilis* Ghosh.
3 (2). Posterior end pointed. Macronucleus band-shaped, straight or curved..... [son, p. 201. *A. ælosomatis* Ander-
4 (1). Contractile vacuoles multiple ..... 5.

5 (8). Contractile vacuoles scattered irregularly. 6.
6 (7). Contractile vacuoles three. Body oval, subtruncate posteriorly. Macronucleus ribbon-shaped ..... [p. 202. *A. lloydi* Ghosh,
7 (6). Contractile vacuoles four. Body cylindrical, wider anteriorly. Macronucleus ribbon-shaped ..... [p. 202. *A. cylindrica* Ghosh,
8 (5). Numerous vacuoles arranged in two rows, mostly non-contractile..... 9.
9. Body elongate, band-like, anterior end dilated, posterior tapering. Macronucleus band-like ..... [p. 203. *A. elongata* Ghosh,

114. **Anoplophrya ælosomatis** Anderson. (Fig. 94.)

†*Anoplophrya ælosomatis* Anderson, 1889, pp. 381–3, pl. i, figs. 1–5.
Anoplophrya maupasi, Cépède, 1910, pp. 411–18, pl. xiii, figs. 47–65, text-fig. 3.
Radiophrya (?) *ælosomatis*, Heidenreich, 1935 *a*, pp. 366–7.

Body oval, tapering at both ends, tapering portion considerably produced posteriorly, twice as long as broad. Surface

Fig. 94.

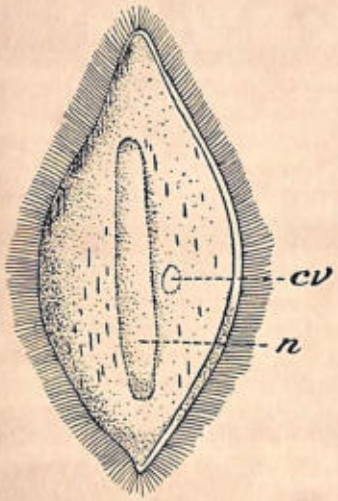


Fig. 95.

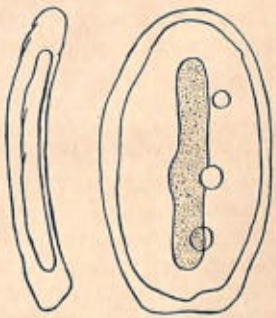


Fig. 94.—*Anoplophrya ælosomatis* Anderson. *cv*, contractile vacuole; *n*, macronucleus. (After Anderson.)
Fig. 95.—*Anoplophrya lloydi* Ghosh. Cilia not shown in the figure. (After Ghosh.)

densely ciliated and finely striated in a longitudinal direction. Contractile vacuole single, central, close to the macronucleus. Macronucleus axial, band-shaped, extending nearly the

whole length of the body, generally straight, sometimes curved or S-shaped, coarsely granular.

Multiplication by transverse fission; in numerous cases a second constriction and appearance of fission anterior to the first, the segments remaining attached for some time and the posterior segment breaking off first. These compound forms are considerably larger, measuring up to 227 μ in length.

Dimensions.—Length 62–83 μ.

Remarks.—Heidenreich (1935) regards *A. maupasi* Cépède as a synonym of this species, and considers it as doubtfully belonging to the genus *Radiophrya* Rossolimo. But as the latter genus is characterized by the possession of radial striations arranged in a fan-like manner and a pointed organ of fixation, and there is no hint of either of these in the original descriptions or figures by Anderson or Cépède, I am letting the species stand in the genus *Anoplophrya*.

Habitat.—In the alimentary canal of the Oligochæte *Ælosoma chlorosticum* Wood-Mason: Bengal, Calcutta.

115. **Anoplophrya lloydi** Ghosh. (Fig. 95.)

†*Anoplophrya lloydii*, Ghosh, 1918, p. 129, fig. 1; 1921, p. 6.
Anoplophrya lumbrici, Heidenreich, 1935 *a*, pp. 319–323.

Elongately oval, with subtruncate posterior end, curved longitudinally, the dorsal side convex and ventral concave. Ciliary striæ close. Contractile vacuoles three, on the right side. Macronucleus irregularly ribbon-shaped, extending nearly the whole length of the body; micronucleus small, spherical, placed by the side of the macronucleus. Size not stated.

Remarks.—The species is stated by Ghosh to be nearest to *A. striata* Duj. in many respects. Heidenreich (1935 *a*), however, considers *A. lloydi* as a synonym of *A. lumbrici* (Schrank). He has revived that name, and refers quite a number of species of different authors to it. I am, however, letting Ghosh's species stand till the organisms have been studied again by someone.

Habitat.—In seminal vesicles of the earthworm, *Pheretima posthuma* (L. Vaill.): Bengal, Calcutta.

Doubtful Species.

116. **Anoplophrya cylindrica** Ghosh. (Fig. 96.)

†*Anoplophrya cylindrica*, Ghosh, 1922 *c*, p. 284, fig. 1.

Body elongated and cylindrical, about six times as long as its transverse diameter; anterior one-third of the body is stouter than the rest. Both extremities rounded, the anterior

a little wider than the posterior. Ectoplasm thin, endoplasm finely granular. Contractile vacuoles four and irregularly arranged. Macronucleus elongated, extending through almost the entire length of the body.

Dimensions.—Length about 230 μ.

Remarks.—This form resembles *A. paranoides* Pierantoni, and differs from other species of the genus in having an elongated and cylindrical body. It differs from *A. paranoides*

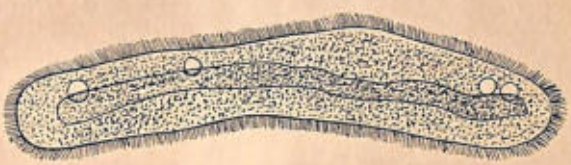


Fig. 96.—*Anoplophrya cylindrica* Ghosh. (After Ghosh.)

in having a rounded posterior end, short cilia, a macronucleus without a club-shaped anterior end, in the number of contractile vacuoles, and in its occurrence in a host belonging to an entirely different phylum.

Habitat.—In the intestinal canal of *Vivipara bengalensis* (the common banded pond-snail) : Bengal, Calcutta.

117. **Anoplophrya elongata** Ghosh. (Fig. 97.)

†*Anoplophrya elongata*, Ghosh, 1921 *a*, p. 6, fig. 1.

Body elongated and band-like, sometimes twisted in the posterior region. Anterior end slightly dilated and rounded. Lateral margins nearly parallel to each other. Posterior end tapering bluntly to a point. Cilia small and uniformly arranged in faint longitudinal rows. Numerous small vacuoles arranged in two longitudinal rows, mostly non-contractile. Macronucleus flattened and band-like, extending through almost the entire length of the body.

Dimensions.—Length 150 μ, width 30 μ.

Remarks.—Heidenreich (1935 *a*) considers both *A. elongata* and *A. variabilis* as lying outside the family Anoplophryidæ as they are not sufficiently characterized, and I think the same remark can apply to *A. cylindrica*. I am, however, including the description of these species, as these were published in journals not easily obtainable, and the forms are well worth fresh study.

Habitat.—In the rectum of small freshwater Gastropods : Bengal, Calcutta.

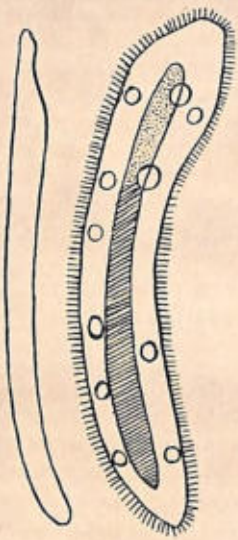


Fig. 97.—*Anoplophrya elongata* Ghosh. (After Ghosh.)

118. **Anoplophrya variabilis** Ghosh. (Fig. 98.)

†*Anoplophrya variabilis*, Ghosh, 1921 *a*, pp. 6–7, fig. 2.

Body band-like, about three to four times as long as broad, with parallel sides. Anterior end rounded, posterior end with



Fig. 98.—*Anoplophrya variabilis* Ghosh. (After Ghosh.)

a minute notch. Body uniformly covered with small cilia arranged in faint longitudinal rows. Two curved hook-like cirri sometimes supplemented by long cilia at the notched

posterior end. Contractile vacuole single, posterior. Macronucleus club-shaped, with the pointed end anterior.

Dimensions.—Length 84–174 μ.

Habitat.—In the intestinal tract of small freshwater Gastropods : BENGAL, Calcutta.

2. Family HOPLITOPHRYIDÆ Chiessen, 1930, emend. Heidenreich, 1935.

Forms possessing a skeleton, which forms an organ of fixation, consisting of a pointed spike (sometimes denticulated) or a supporting skeleton lying in the ectoplasm, or partly in the ectoplasm and partly in the endoplasm.

Heidenreich (1935 *a*) has combined the families Hoplitophryidæ Cheissen and Maupasellidæ (Cépede) Cheissin into one, and divides it into five subfamilies, viz., Eumonodontophryinæ *, Hoplitophryinæ *, Radiophryinæ *, Mesnilellinæ *, and Maupasellinæ, of which the last one only is known from India so far.

Subfamily MAUPASELLINÆ Cépède, 1910.

Body elongated. Skeleton at the anterior end, consisting of a free, mobile spike, with an ectoplasmic basis and endoplasmic skeletal rods connected with it.

Genus **MAUPASELLA** Cépède, 1910.

Maupasella, Cépède, 1910, p. 408 ; Calkins, 1926, p. 402 ; Wenyon, 1926, p. 1168 ; Reichenow, 1929, p. 1183 ; Kudo, 1931, p. 341.

Endoparasites, with an anterior fixation apparatus in the form of a conical process derived from thickened ectoplasm. Body with dense ciliation. Contractile vacuoles irregularly disposed. Macronucleus elongated and ribbon-shaped. Micronucleus spindle-shaped, with its axis parallel to that of the body.

119. **Maupasella nova** Cépède. (Fig. 99.)

Maupasella nova, Cépède, 1910, pp. 408–10, figs. 29–33 and text-fig. 2; Keilin, 1920, pp. 92–4, pl. vi, figs. 1–18; Wenyon, 1926, p. 1168, fig. 493, *2*, *2 a*.
†*Maupasella nova*, Bhatia & Gulati, 1927, pp. 100–2.
Maupasella nova, Reichenow, 1929, p. 1183; Kudo, 1931, p. 341, fig. 146 *f*; Heidenreich, 1935, pp. 345–8, figs. 7, 8.

Possesses the characters of the genus.

Dimensions.—Varies much in size and form, long specimens measuring 80–130 μ by 18–25 μ, and short ones only 50–77 μ by 25–47 μ.

Remarks.—The general form of the parasite, as stated by Cépède, is variable, but two very distinct types can be distinguished, viz., ovoidal and elongated. The measurements of an ovoidal form are: length of the body 77 μ, width of

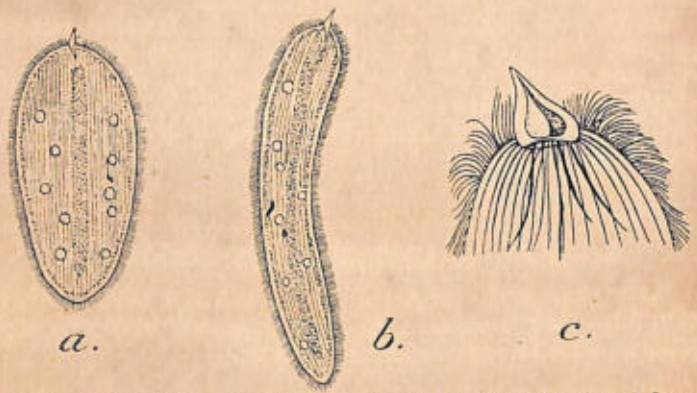


Fig. 99.—*Maupasella nova* Cépède. *a*, oval form; *b*, elongated form; *c*, an enlarged view of the fixation apparatus. (*a* & *b*, after Cépède; *c*, after Heidenreich.)

the body anteriorly 25 μ, posteriorly 22 μ, length of the nucleus 65 μ. Such individuals are the outcome of transverse division of the elongated form. They are dorso-ventrally flattened; broader anteriorly and gradually taper towards the narrower posterior end, which is bluntly rounded like the anterior end. The anteriorly placed fixation apparatus is mobile. The whole body is very flexible, and the individuals are sometimes seen to bend themselves into a semicircle.

The measurements of an elongated individual are: length of the body 130 μ, width of the body 18 μ, length of the nucleus 90 μ. These are forms that are about to divide transversely. The individuals often show a constriction about the middle, indicating that fission will shortly take place. Others, which

do not show such a constriction, are highly flexible and are often curved into a coil. The individuals are of nearly uniform width throughout and look like a piece of flat ribbon rounded at both ends. The cilia are fine and close-set, and form a dense covering over the body ; they are disposed in longitudinal rows. The fixation apparatus is triradiate in form. The radius projecting out of the body anteriorly is shorter than the other two ; but all are sharply pointed and slightly curved. There are many contractile vacuoles, disposed irregularly in some individuals and arranged in two rows in others. The macronucleus is granular in structure and stretches almost along the entire length of the body. The micronucleus is fusiform and lies near the posterior end of the macronucleus or sometimes near its middle.

Keilin (1920) found in many specimens obtained from the alimentary canal of *Allolobophora caliginosa* Sav., collected near Paris, a ribbon-like supplementary chromatic body, but no such body was found by Bhatia and Gulati in parasites from the alimentary canal of *Pheretima posthuma* (L. Vaill.) and *P. hawayana* (Rosa) examined at Lahore.

Heidenreich (1935) has described the structure of the fixation apparatus, and shown it as consisting of an ectoplasmic spike with which are connected a number of skeletal rods lying in the endoplasm.

Habitat.—In the alimentary canal of *Pheretima posthuma* (L. Vaill.) and *P. hawayana* (Rosa) : PUNJAB, Lahore.

INCERTÆ SEDIS.

Genus **CAUDALINA** Madhava Rao, 1928.

Caudalina, Madhava Rao, 1928, p. 115.

Remarks.—Madhava Rao described the two following species as new and belonging to a new genus which he named *Caudalina*. He has referred this genus to the family Discophryidæ in the suborder ASTOMATA. Cépede (1923) changed the name of this family to Haptophryidæ. This family includes intestinal parasites of Turbellaria or Batrachia with an oval nucleus, a laterally situated, elongated, and contractile excretory vessel, and an anterior sucker (except in *Lachmanella*). The two species described by Madhava Rao possess none of these characters. His forms are not intestinal parasites, the macronucleus is not described as oval, the single contractile vacuole is not elongated and canal-like, and there is no anterior sucker. The forms are so imperfectly described that they will have to be re-examined before their correct systematic position can be determined.

120. **Caudalina armata** Madhava Rao. (Fig. 100.)

†*Caudalina armata*, Madhava Rao, 1928, p. 115, pl. iii, figs. 6 & 8.

Body elongated, tapering at either end, broadest at about one-third of the length of the body from the posterior end, and from this part two arm-like processes arise. These processes are bent and help in locomotion. Cilia throughout

Fig. 100.



Fig. 101.

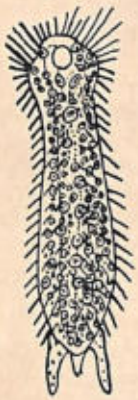


Fig. 100.—*Caudalina armata* Madhava Rao. (After Madhava Rao.)
Fig. 101.—*Caudalina bangalorensis* Madhava Rao. (After Madhava Rao.)

the margin of the body, and on the outer margin of the food-groove (?). No well-defined cytopharynx (?). Contractile vacuole single. Nuclei two (?).

Dimensions.—Length 80μ, maximum width 20μ.

Habitat.—Soil : MYSORE, Bangalore.

121. **Caudalina bangalorensis** Madhava Rao. (Fig. 101.)

†*Caudalina bangalorensis*, Madhava Rao, 1928, p. 115, pl. iii, fig. 7.

Body elongated, with the anterior end widened into a pentagonal disc, with a slight neck-like constriction behind it ; widest in the posterior part and tapering posteriorly. There are two tapering arm-like processes at the posterior end which help in locomotion. Between these two there are two more very small processes similar in appearance. Cilia in longitudinal rows, elongated and closer round the anterior end. Contractile vacuole near the anterior end. Macronucleus nearly central, with an adjacent micronucleus.

Dimensions.—Length 90μ.

Habitat.—Soil : MYSORE, Bangalore.

II. Order SPIROTRICHA Bütschli, emend. Kahl

This order includes all those Ciliates which possess a row of differentiated aggregates of cilia, known as the adoral zone of membranelles, extending from the anterior end of the body to the cytostome. The individual membranelles are transversely placed and are like little plates formed by the fusion of two to four rows of cilia. In this order the adoral zone is usually described as wound to the left. This is true if the oral end of the zone is regarded as the beginning. But as the zone does not grow out from the cytostome but rather leads to it and plays the physiological rôle of carrying the food to the cytostome in a whirlpool, it would be more reasonable, according to Reichenow, to regard its aboral end as its commencement. So regarded, the adoral zone may be said to be wound to the right, that is, in a clockwise direction.

The order is divided by Reichenow into five suborders, as follows :—

I. Heterotricha Stein.
II. Oligotricha Bütschli.
III. Entodiniomorpha Reichenow.
IV. Ctenostomida Lauterborn.
V. Hypotricha Stein.

Identification Table of Suborders.

1 (8).	Mostly possessing free cilia. Only exceptionally small groups of cirri are present, but even then in addition to free cilia..	2.
2 (3).	Body uniformly covered by fine cilia, which may be variously reduced. Peristome moderate in extent	**Heterotricha**, p. 210.
3 (2).	Body cilia very much reduced or completely absent	4.
4 (5).	Small, laterally flattened, with long cilia confined to a few rows or groups, especially at the posterior end. Pellicle covered with armour-plates. Cytostome with a comb-like structure. Adoral zone limited to 8 membranelles which are situated in a groove opening ventralwards	**Ctenostomida**, p. 360.

5 (4). Body cilia strongly reduced, in some completely absent, so that the adoral zone only is present. Ciliary structures often modified into bristles or cirri .... 6.

6 (7). Body round in cross-section, with cilia greatly reduced or none at all. Adoral zone forms a nearly complete or quite complete ring around the margin of the peristome, which is usually at right angles to the long axis of the body. Fresh water or marine ..... **Oligotricha,** p. 267.

7 (6). Body oval, often dorso-ventrally flattened, usually with posterior spines or postero-lateral appendages. Adoral zone forms a nearly complete or complete ring around the margin of the peristome, and there may be an additional incomplete or complete ring of dorsal membranelles posterior to the adoral zone ..... [p. 273. **Entodiniomorpha,**

8 (1). Body usually flattened dorso-ventrally, bearing motile organs only on the ventral surface, where there may be rows of cilia, or cilia and cirri, or the cirri may be grouped as frontals, ventrals, anals, caudals, etc. One or more undulating membranes may be present in the peristome in addition to the adoral zone. Short, stiff, tactile bristles may be present on the dorsal surface ..... **Hypotricha,** p. 361.

1. Suborder *HETEROTRICHA* Stein.

Body is uniformly covered with fine cilia, which, however, may be reduced. An adoral zone of membranelles extends from the anterior end of the body to the cytostome, and beginning with the aboral end is wound, as in other suborders of SPIROTRICHA, to the right. Various forms are assumed by the body, according as the peristomial field is at right angles to the long axis of the body or parallel with it.

The HETEROTRICHA are here arranged in accordance with the classification adopted by Reichenow and Kahl. Out of the ten families, representatives of seven, viz., Spirostomidæ, Plagiotomidæ, Condylostomidæ, Stentoridæ, Folliculinidæ, Bursaridæ, and Balantidiidæ have been found in India; no representatives of Metopidæ, Reichenowellidæ, and Licnophoridæ have so far been recorded. Kahl has included the family Peritromidæ also under this order, but, in accordance with general usage, it will be treated under HYPOTRICHA in this work.

Identification Table of Families.

1 (15). Peristomial surface unciliated ..... 2.

2 (9 or 14). Peristome elongate and groove-shaped, with the adoral zone running from the anterior end to the cytostome near the centre of the body... 3.

3 (6). Peristome with adoral zone runs straight backwards on the ventral side, and bends round to the right shortly in front of the oral funnel .. 4.

4 (5). Oral funnel completely absent. Cytostome cleft-like, near the adoral zone, but usually firmly closed and not recognizable; no undulating membrane ..... [Kahl.
Reichenowellidæ *.

5 (4). Oral funnel generally distinct; in the typical genera an undulating membrane or a bi-seriate ciliary row extends forwards from the cytostome to the right margin of the peristomial groove..... [p. 212.
Spirostomidæ Kent,

6 (3). Peristome does not run straight backwards ..... 7.

7 (8). Zone of membranelles runs diagonally from left to right over the ventral surface to the posteriorly situated oral funnel, right peristomial margin provided with an undulating membrane and row of cilia, body spirally twisted ..... **Metopidæ** * Kahl.

8 (7). Endoparastic, form oval to bean-shaped, cilia along right peristomial margin absent ..... [p. 218.
Plagiotomidæ Poche,

9 (2). Peristome somewhat triangular, the broader field anterior ..... 10.

10 (11). Peristome only slightly sunken, zone of membranelles surrounds in a strong curve an unciliated peristomial field, the right margin provided with an undulating membrane ..... [p. 231.
Condylostomidæ Kahl,

11 (10). Peristome usually deeply sunk..... 12.

12 (13). Peristome forming a sac-like depression of the anterior end, which is provided with a ventral slit. Zone of membranelles runs in this depression and is continued into the bent oral funnel. [p. 240.
Bursaridæ Perty,

13 (12). Peristome forms a cleft, broader anteriorly and extending from the anterior pole of the body, more or less backwards, towards the ventral surface. Dorsal wall of the peristome provided with an adoral row of long cilia. Cytostome at the bottom of the peristome, may be followed by a distinct cytopharynx. Endoparasitic ..... [now, p. 244.
Balantidiidæ Reiche-

14 (2). Body divisible into three parts, an anterior adhesive disc enclosed by four ciliary wreaths, a slender neck

carrying an undulating membrane but no cilia, and a peristomial disc. Peristome unciliated, but surrounded by spirally wound zone of membranelles. Ectoparasitic on various marine animals	**Licnophoridæ*** Stevens.
15 (1). Peristomial surface ciliated, no undulating membrane	16.
16 (17). Peristome drawn out into two wings, the zone of membranelles continued along the margin of both ; living in pseudochitinous test, marine	[p. 238. **Folliculinidæ** Dons.
17 (16). Peristomial surface at right angles to the long axis of the body, or at a marked angle with such axis ; free or in gelatinous tests	[p. 233. **Stentoridæ** Claus.

1. Family SPIROSTOMIDÆ Kent, 1881.

Peristome elongate and groove-shaped. The adoral zone runs straight from the anterior end of the body towards the cytostome near the centre of the body, and bends round to the right shortly in front of the oral funnel. Oral funnel generally distinct. An undulating membrane or a bi-seriate ciliary row extends forwards from the cytostome to the right margin of the peristomial groove.

Key to Indian Genera.

1. Right peristomial margin provided with an undulating membrane in front of the cytostome ; body pointed anteriorly	BLEPHARISMA, p. 212.
2. No undulating membrane in front of the cytostome, worm-like, contracting in a screw-like manner	SPIROSTOMUM, p. 213.

Genus **BLEPHARISMA** Perty, 1849.

Bursaria, part, Ehrenberg, 1838, p. 325 ; Dujardin, 1841, p. 508.
Blepharisma, Perty, 1849, p. 170 ; 1852, p. 137 ; Stein, 1867, p. 177 ; Kent ; 1880–2, p. 585 ; Bütschli, 1887–9, p. 1721 ; Roux, 1901, p. 77 ; Hickson, 1903, p. 405 ; Lepsi, 1926*a*, p. 65 ; Calkins, 1926, p. 408 ; Schoenichen, 1927, p. 217 ; Reichenow, 1929, p. 1185 ; Kahl, 1930–5, p. 442.

Bodily form persistent, almost lanceolate, strongly flattened laterally, anterior end pointed, sickle-shaped, and curved towards the ventral side. Dorsal side more bulging than the ventral side. Body cilia long, fine, situated in longitudinal rows. Peristome narrow, extending up to the middle of the

body and widening posteriorly ; left margin with well-developed adoral zone ; right margin with posteriorly a short undulating membrane, which is rolled upon itself, and consequently appears like a bristle. Cytostome at the posterior end of the peristome. Cytopharynx generally short. Contractile vacuole single, posterior. Anus terminal. Macronucleus rounded, oval, bipartite, or moniliform. Locomotion moderately quick, with rotation on its long axis. Feeding on bacteria, fungi, etc. Colourless or red.

122. **Blepharisma** sp. (Fig. 102.)

Blepharisma sp., Chaudhuri, 1929, p. 60, pl. iii, figs. 1 & 2.



Fig. 102.—*Blepharisma* sp. (After Chaudhuri.)

Habitat.—Lumpy soil : CENTRAL INDIA, Indore.

Genus **SPIROSTOMUM** Ehrenberg, 1833.

Spirostomum Ehrenberg, 1833, p. 252 ; 1835, p. 165 ; 1838, p. 332 ; Dujardin, 1841, p. 514 ; Claparède & Lachmann, 1858–61, p. 231 ; Stein, 1867, p. 187 ; Fromentel, 1874, p. 175 ; Kent, 1880–2, p. 586 ; Bütschli, 1887–9, p. 1723 ; Roux, 1901, p. 79 ; Hickson, 1903, p. 405 ; Minchin, 1912, pp. 438, 439, 445 ; Calkins, 1926, p. 408 ; Lepsi, 1926 *a*, p. 64 ; Wenyon, 1926, p. 1197 ; Schoenichen, 1927, p. 219 ; Reichenow, 1929, p. 1185 ; Kahl, 1930–5, p. 437.

Animalcules free-swimming, very large, highly elastic, contractile and flexible ; very elongated, cylindical or somewhat flattened ; anteriorly rounded, posteriorly truncated. Peristome long, extending down the left side of the ventral surface as far as or beyond the middle of the body, widest at this point and continued inward as a short funicular cytopharynx ; adoral cilia bordering the outer or left-hand side only of the peristomial area ; no undulating membrane. Contractile vacuole taking up the whole of the posterior end of the body

and continued forwards as a straight canal extending along the whole length of the body. Macronucleus ovate or moniliform. Micronuclei numerous. Locomotion very active, followed by contractions and often by a spiral twisting on its long axis. Inhabiting fresh water. Feeding on algæ, detritus, etc.

Remarks.—According to Ann Bishop (1927) there is no undulating membrane. According to Kahl (1932) there is an undulating membrane, composed of two rows of short cilia, along the right wall of the peristome posteriorly and extending to the bottom of the short oral funnel.

Key to Indian Species.

1. Body cylindrical, length more than 500 μ, up to 4500 μ. Peristome extending at least up to the middle of the body. Macronucleus rosary-shaped ..... [p. 214. *S. ambiguum* Ehrbg.,
2. Body elongated, spindle-shaped, length up to 450 μ. Peristome only 1/3 the body-length. Macronucleus oval to spindle-shaped ..... [p. 217. *S. teres* Cl. & Lachm.,

123. **Spirostomum ambiguum** Ehrenberg. (Fig. 103.)

Trachelius ambiguus, Ehrenberg, 1830, p. 62; 1831, p. 107.
Holophrya ambigua, Ehrenberg, 1831, p. 102.
Bursaria ambigua, Ehrenberg, 1831, p. 132.
Spirostomum ambiguum, Ehrenberg, 1835, p. 165; 1838, p. 332, pl. xxxvi, fig. 11; Dujardin, 1841, p. 514; Claparède & Lachmann, 1858–61, p. 231; Stein, 1859 *d*, pp. 55, 60, 64, 72, 78, 80, 86, 88, 90, 95; 1867, pp. 197–208, pl. ii, figs. 10–11; pl. iii, figs. 2–9; pl. iv, fig. 1; Balbiani, 1860 *b*, pp. 77, 87, pl. iv, figs. 19–24; 1861, p. 107, pl. ix, figs. 7–9; Pritchard, 1861, p. 623, pl. xxix, figs. 297, 298; Fromentel, 1874, pp. 284–5, pl. xv, figs. 1–1 *f*; Kent, 1880–2, pp. 586–7, pl. xxix, figs. 13 & 14; Roux, 1901, pp. 80–81, pl. v, fig. 1; Hickson, 1903, p. 406, fig. 57; Minchin, 1912, p. 431, fig. 180.
†*Spirostomum ambiguum*, Bhatia, 1916, p. 183; Ghosh, 1921, p. 10.
Spirostomum ambiguum, Bishop, 1923, pp. 391–434, pls. xxii–xxiii; 1927, pp. 147–172, pls. xvii–xviii, and 3 text-figs; Lepsi, 1926 *a*, p. 69, figs. 305, 306; Wenyon, 1926, p. 1197, fig. 509; Kahl, 1926, pp. 420–1, fig. Y 3 *a–b*; Schoenichen, 1927, p. 219, fig. 740 and pl. xii, fig. 50; Reichenow, 1929, p. 1186, fig. 1167 A & C.
†*Spirostomum ambiguum*, Bhatia & Mullick, 1930, p. 399.
Spirostomum (*Trichoda*) *ambiguum*, Kahl, 1930–5, p. 437, fig. 72, *1*.
Spirostomum minus, Kahl, 1930–5, p. 440, fig. 72, *2*.

Body elongate, thread-like, from ten to twenty times or more as long as broad, nearly or entirely cylindrical, the anterior and posterior extremities often equally rounded, or the posterior one occasionally truncated. Peristome

extending quite to the centre of the body, or even beyond this point. Contractile vacuole single, taking up the whole of the posterior end of the body, and extending forward as a straight canal. Macronucleus elongated, moniliform. Micronuclei numerous. In pond water among aquatic plants.

Fig. 103.



Fig. 104.

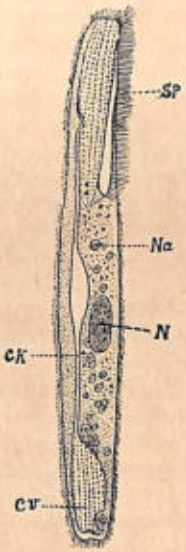


Fig. 103.—*Spirostomum ambiguum* Ehrbg. *ck*, canal extending forward from the vacuole; *cv*, contractile vacuole; *N*, macronucleus; *Na*, food-vacuole; *Sp*, adoral zone. (After Stein.)

Fig. 104.—*Spirostomum teres* Cl. & L. Lettering as in the preceding figure. (After Stein.)

Dimensions.—Length of the extended body 500–800 μ (var. *minor*), 3–4·5 mm. (var. *major*).

Remarks.—Fairly commonly found in pond water in which aquatic plants are growing. The animalcules, being of such a large size, are easily visible to the naked eye and appear to

be thread-like bodies moving about actively. The specimens sometimes show a spiral twisting of the body upon their long axis, as figured by Kent (plate xxix, fig. 14). According to Roux a smaller form of *S. ambiguum*, from 500–600 μ in length, is recognized as var. *minor*. The peristome is shorter than in the typical form, and does not extend beyond the middle of the body. Specimens found at Lahore have often measured more than 600 μ, but never exceeded 800 μ, and have therefore been referred to var. *minor*. Kahl (1930–5) considers this a distinct species and describes it as *S. minus* Roux.

The macronucleus is usually moniliform and runs through the greater part of the body. The beads are rounded, oval, or elongated-oval and tapering at either end; they are usually connected together by elongate and narrow commissures. Each lobe or bead of the nucleus is seen, in preparations stained with iron-hæmatoxylin, to contain a number of larger granules (macrosomes) which are vacuolated, and a number of smaller granules (microsomes); these latter are more deeply stained in borax-carmine preparations. The micronuclei are numerous, but usually less in number than the lobes of the macronucleus. Each micronucleus consists of a deeply staining granular mass surrounded by a clear non-staining halo. The micronuclei are not in contact with the lobes of the macronucleus, but are situated at some distance from them.

The form and structure of the macronucleus vary a good deal in different specimens. In some specimens it is vermiform, resembling a band, which is twisted in its course. In some the band is very much shortened, and in still others there is an approach to the oval nucleus resembling that of *S. teres*. In the larger specimens the macronucleus is always moniliform, and the shape and size of the beads vary a good deal: occasionally there are no visible commissures, and the lobes of the macronucleus appear to be discrete. These variations in form of the macronucleus are to be regarded as stages in growth. There is no correspondence between the number of micronuclei and the lobes of the macronucleus. Bhatia and Mullick (1930) have made an interesting observation regarding a correspondence between the form of the macronucleus and the length of the peristome: in specimens showing a band-shaped or vermiform nucleus the peristome usually extends to about one-third of the length of the body, whereas in specimens with a moniliform nucleus the peristome reaches the middle of the body or even extends beyond it. Thus *S. teres*, and the *minor* and *major* varieties of *S. ambiguum*, form a series, the structural peculiarities of which are closely paralleled by the stages of growth of the individual specimens of *S. ambiguum*.

Specimens of *S ambiguum* are longer and thicker than those of *S. teres*, and can be readily recognized from the latter by the length of the peristome and the form of the macronucleus.

Habitat.—Pond water : KASHMIR, Srinagar ; PUNJAB, Lahore ; BENGAL, Calcutta.

124. **Spirostomum teres** Claparède & Lachmann. (Fig. 104.)

Uroleptus filum (?), Ehrenberg, 1833, p. 133 ; 1838, p. 359, pl. xl, fig. v.

Spirostomum filum (?), Dujardin, 1841, p. 515 ; Claparède & Lachmann, p. 233.

Spirostomum teres, Claparède & Lachmann, 1858–61, p. 233, pl. xi, figs. 1, 2 ; Balbiani, 1861, p. 126, pl. ix, figs. 1–5 ; Kent, 1880–2, p. 586 ; Roux, 1901, p. 81, pl. v, fig. 2 ; Lepsi, 1926 *a*, p. 69, figs. 302–4 ; Kahl, 1926, p. 421, fig. Y 3 *e* ; 1930–5, p. 440, fig. 72, 7 ; Schoenichen, 1927, p. 219 ; Reichenow, 1929, p. 1186, fig. 1167 B.

†*Spirostomum teres*, Bhatia & Mullick, 1930, p. 399.

Body elongated, spindle-shaped, flattened. Peristome generally extending up to one-third the length of the body only ; anterior end narrower, posterior end truncated. Contractile vacuole single, occupying the whole of the posterior end of the body and extending forwards as a long canal. Macronucleus oval to spindle-shaped, central.

Dimensions.—Length 150–450 μ.

Remarks.—Specimens were found in pond water, overgrown with *Lemna* and other aquatic plants, at Srinagar. The peristomial groove extends only up to about one-third of the length of the body. The macronucleus is oval. Sometimes there are two oval macronuclei lying in the centre, closely approximated to each other : each of these contains a large number of rounded microsomes.

Habitat.—Pond water : KASHMIR, Srinagar.

125. **Spirostomum** sp.

†*Spirostomum* sp., Chaudhuri, 1929, p. 54, pl. ii, fig. 25.

Habitat.—Soil : CENTRAL INDIA, Indore ; Madras ; Hyderabad ; UNITED PROVINCES, Agra.

2. Family PLAGIOTOMIDÆ Poche, 1913, emend. Kahl.

Form of the body oval or bean-shaped. Peristome does not run straight backwards. Cilia along the right peristomial margin absent. Endoparasitic.

Genus **NYCTOTHERUS** Leidy, 1849.

Nyctotherus, Leidy, 1849, p. 233; 1850, p. 158; 1853, p. 241; Stein, 1867, p. 335; Kent, 1880–2, p. 579; Bütschli, 1887–9, p. 1721; Hickson, 1903, p. 405; Minchin, 1912, pp. 439, 440, 447; Hegner & Taliaferro, 1924, pp. 433–5; Calkins, 1926, p. 408; Lepsi, 1926*a*, p. 66; Wenyon, 1926, p. 1198; Bhatia & Gulati, 1927, p. 112; Grassé, 1928, p. 55; Knowles, 1928, p. 523; Reichenow, 1929, p. 1186; Thomson & Robertson, 1929, pp. 274–5.

Body flattened, oval or kidney-shaped, a notch or concavity occurring near the middle of the right side; the dorsal side is strongly convex, the ventral bent inwards in the middle; peristome commencing a little behind the anterior extremity and continued in a cleft-like manner on the ventral side to the centre of the body. The body is covered with cilia, and in front of the notch there is an adoral zone of cilia on the peristome that leads to the cytostome, an opening situated in the notch. The cytostome is continued into a long curved cytopharynx, on the anterior wall of which is a row of parallel plates of fused cilia. This row of plates extends in the adoral region nearly as far as the anterior end of the body. At the hinder end of the body is the anus, continuous with a short unciliated anal tube. Contractile vacuole single, opening into the upper end of the anal tube. An oval macronucleus, with a micronucleus lying close to it, is situated in front of the cytopharynx. In some species the macronucleus is provided with a caryophore, or nuclear stalk. Occurring as parasites within the intestine of Amphibia and of various groups of Invertebrata.

Remarks.—Grassé (1928) has split the genus according to the presence or absence of the caryophore or nuclear stalk (Aufhangeapparates) into the subgenera *Nyctotherus* s. str. and *Nyctotheroides*; to the latter would belong the species occurring in Amphibia and *N. tipula*. This splitting of the genus is not followed in this work.

Key to Indian Species.*

1	(7). Cytopharynx transversely or obliquely directed and reaching the middle....	2.
2	(5). Body ovoid	3.
3	(4). Body broadly egg-shaped. Macronucleus egg-shaped. Length very variable, 70–360 μ	*N. ovalis* Leidy, p. 226.
4	(3). Body ovoid. Cytopharynx slightly curved. Macronucleus ovoid or slightly horseshoe-shaped. Length 60–70μ.	[p. 229. *N. termitis* Dobell.
5	(2). Body reniform	6.
6.	Cytopharynx curved in a semicircle, with a diverticulum at its junction with the cytostome. Macronucleus reniform or horseshoe-shaped. Length 120–170 μ.....	[p. 228. *N. papillatus* Dobell,
7	(1). Cytopharynx reaching beyond the middle of the body.....	8.
8	(11). Cytopharynx shorter than the transverse diameter of the body	9.
9	(10). Cytopharynx slightly curved, with the concavity directed forwards. Body elongated. Macronucleus elongately oval. Length 170 μ	*N. kempi* Ghosh, p. 221.
10	(9). Cytopharynx broadly curved posteriorly. Body kidney - shaped. Length 160–180 μ (Bezz.) or 71–111 μ (Stein). Breadth $\frac{2}{3}$–$\frac{3}{4}$ of the body-length. Macronucleus kidney-shaped.	[p. 220. *N. cordiformis* (Ehrbg.),
11	(8). Cytopharynx nearly equal to or longer than the transverse diameter of the body	12.
12	(15). Cytopharynx nearly equal to the transverse diameter of the body	13.
13	(14). Cytopharynx with a bow directed ventralward, and with its tip directed forward.	
	a. Body kidney-shaped, 660 μ by 460 μ. Macronucleus flattened lengthwise	[p. 224. *N. magnus* Bezz.,
	b. Body ovoid, 130–230 μ by 80–145 μ. Cytopharynx forming a sharp angle with the peristome. Macronucleus a triangular mass.	[p. 225. [*barica* De Mello, *N. magnus* v. *mala*-
14	(13). Cytopharynx extending obliquely backward, reaching about $\frac{1}{3}$ of the length of the body from the posterior end. Body kidney-shaped. Macronucleus large and ovoid. Length 92 μ	[Gulati, p. 229. *N. reniformis* Bhatia &
15	(12). Cytopharynx longer than the transverse diameter of the body.....	16.
16.	Cytopharynx spirally rolled. Macronucleus irregular-shaped. Body egg-shaped, 350 μ by 220 μ	[Bezz., p. 222. *N. macropharyngeus*

* A key to all the species of the genus known up to 1926 and the list of hosts are given by Bhatia & Gulati (1927).

126. **Nyctotherus cordiformis** (Ehrenberg) Stein. (Fig. 105.)

Bursaria cordiformis, Ehrenberg, 1838, p. 328, pl. xxxv, fig. vi, 1–4; Stein, 1854, pp. 42, 183; 1856, p. 36.
Plagiotoma cordiformis, Claparède & Lachmann, 1858–61, p. 236, pl. xi, figs. 8, 9; Stein, 1859 *d*, pp. 78, 81, 84, 85, 90.
Nyctotherus cordiformis, Stein, 1867, pp. 338–44, pl. xv, figs. 1–10; Kent, 1880–2, p. 580, pl. xxix, fig. 4; Bezzenberger, 1904, p. 149; Minchin, 1912, pp. 10, 444, figs. 9, 186 F.
†*Nyctotherus cordiformis*, Ghosh, 1921 *a*, p. 10.
Nyctotherus cordiformis, Hegner & Taliaferro, 1924, p. 434; fig. 169; Wenyon, 1926, p. 1199, fig. 511.
†*Nyctotherus cordiformis*, Bhatia & Gulati, 1927, p. 115.
Nyctotheroides cordiformis, Grassé, 1928, pp. 55–68; Knowles, 1928, p. 523, figs. 36, 132; Reichenow, 1929, p. 1187; Thomson & Robertson, 1929, fig. 182.
†*Nyctotherus cordiformis*, De Mello, 1932, pp. 100–1, 111, 113–14, 116, 124, pls. xii, fig. 1, xiv, fig. 1.

Body bean- or kidney-shaped, somewhat pointed anteriorly, much compressed, the breadth equal to two-thirds or three-quarters of the total length. Cytopharynx reaching beyond the middle of the body, shorter than the transverse diameter of the body, broadly curved, with opening behind. Contractile vacuole single, postero-terminal, with anal aperture close to it. Macronucleus kidney-shaped, with a minute centrally attached micronucleus.

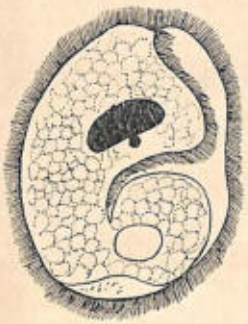


Fig. 105.—*Nyctotherus cordiformis* (Ehrbg.). (After de Mello.)

Dimensions.—Length usually between 80–220 μ. Cyst ovoid, 80–90 μ in length, containing a single individual.

Remarks.—Bezzenberger (1904) in his identification table gives 160–180 μ as the length for this species and the width as two-thirds to three-quarters of the length. The specimens found at Lahore were considerably smaller, and measured 95 μ by 75 μ: these dimensions, however, fall within the limits of those given by Stein (1867). De Mello gives the length as minimum 88 μ, maximum 325 μ, and usually between 100–220 μ, in specimens from *Bufo melanostictus*; and minimum 45 μ, maximum 150 μ, usually between 80–125 μ, in

specimens from *Rana malabarica*. The cytopharynx was nearly straight, shorter than the transverse diameter of the body, and bending only slightly at its inner end. Grassé (1928) referred this species to the subgenus *Nyctotheroides*, and observed anisogamous conjugation in this species.

Habitat.—Intestine and cloaca of *Bufo melanostictus* Schneid.: Punjab, Lahore; Bengal, Calcutta; Nova Goa. Intestine of *Rana tigrina* Daud., *R. malabarica* Tsch., *R. limnocharis* Wiegm.: Nova Goa.

127. **Nyctotherus kempi** Ghosh. (Fig. 106.)

†*Nyctotherus kempi*, Ghosh, 1921 *a*, pp. 10–11, fig. 11.
Nyctotherus kempi, Bhatia & Gulati, 1927, p. 177; Reichenow, 1929, p. 1187.

Body elongate, about thrice as long as broad, much flattened dorso-ventrally, specially in the anterior half, highly flexible.



Fig. 106.—*Nyctotherus kempi* Ghosh. (After Ghosh.)

Anterior end tapering to a point, posterior end rounded. Left side convex. Right side more or less straight, sometimes with a shallow notch in the posterior region. Peristome linear, along the right side and extending beyond the middle of the body. Cytopharynx about half the diameter of the body. Longitudinal ciliary lines distinct and close to one other, all converging in front to the anterior beak. Endoplasm clear in the anterior third of the body and on the left side, coarsely granular in remaining portion. Contractile vacuole single, small, at the posterior end of the body. Macronucleus elongately oval, in front of the middle. Micronucleus adjacent.

Dimensions.—Length 170 μ, width 84 μ.

Remarks.—The body is so highly flexible that the anterior half is sometimes doubled over the posterior portion.

Dr. H. N. Ray, who has re-examined the form, has informed me in a personal communication that Ghosh's description of the species needs correction in certain respects. According to him the anterior end of the body is rounded and only slightly narrower than the posterior end; the peristome extends into the posterior third of the body; the cytopharynx is more than half the diameter of the body and is directed backwards; the macronucleus is broadly elliptical, and placed obliquely about the middle of the body; and the micronucleus is placed at the posterior end of the macronucleus.

Habitat.—Rectum of *Pila* (*Ampullaria*) *globosa* (Swainson): Bengal, Calcutta.

128. **Nyctotherus macropharyngeus** Bezzenberger. (Fig. 107.)

†*Nyctotherus macropharyngeus*. Bezzenberger, 1904, pp. 141–4, figs. 1–3; Dobell, 1910, p. 75; Ghosh, 1921 *a*, p. 10.
Nyctotherus macropharyngeus, Hegner & Taliaferro, 1924, p. 435; Wenyon, 1926, pp. 1199–1200.
†*Nyctotherus macropharyngeus*, Bhatia & Gulati, 1927, pp. 114–15.
Nyctotheroides macropharyngeus, Grassé, 1928, pp. 55–68.
†*Nyctotherus macropharyngeus*, De Mello, 1932, pp. 109–11, 116–17, 118, 124, pl. xiii, fig. 9; Gulati, 1933, pp. 367–9, 2 text-figs.

Body egg-shaped, pointed anteriorly; length of the body about one and a half times the width. Cytopharynx reaching beyond the middle of the body, substantially longer than the transverse diameter of the body, spirally coiled. Contractile vacuole single or 2 to 3, posterior. Macronucleus irregularly shaped, with micronucleus above it or close to it.

Dimensions.—Length, minimum 140μ, maximum 360μ; macronucleus 60–100μ in length by 38–50μ in width in specimens from *R. tigrina*; length, minimum 90μ, maximum 380μ, usually between 80–335μ, in specimens from *R. limnocharis*.

Remarks.—The body is sometimes oval, highly convex along one margin. The posterior part of the body is distinctly thicker than the anterior part, and at the anterior end a thinner portion appears to project like a frill. The dorsal surface of the body is convex, and the ventral flattened or somewhat concave. An individual appears to be composed of two oval flaps placed over one another, with one of them projecting at the anterior end. The peristome commences a little behind the anterior end and is continued on the ventral side to the centre of the body and there is bent inwards to meet the well-developed cytopharynx. Only the left border of the peristome is provided with specially strong membranelles, which are continuous with the cilia in the cytopharynx. The cytopharynx is a large funnel-shaped tube, the posterior

portion of which is coiled upon itself in 2 or $2\frac{1}{2}$ spiral turns. The anterior wall of the cytopharynx is throughout provided with specially strong cilia.

The cytoplasm is clearly marked off into cortical and medullary portions. The ectoplasm is narrow, and the basal granules of the cilia are large and very compactly arranged. The whole surface of the body is covered with short fine cilia arranged in oblique lines, which are very close to each other. The contractile vacuole is very slow in its pulsations and empties itself through the anal opening. The anal tube does not appear to be always present.

The endoplasm is coarsely granular. The macronucleus and the micronucleus are situated in the anterior half of the

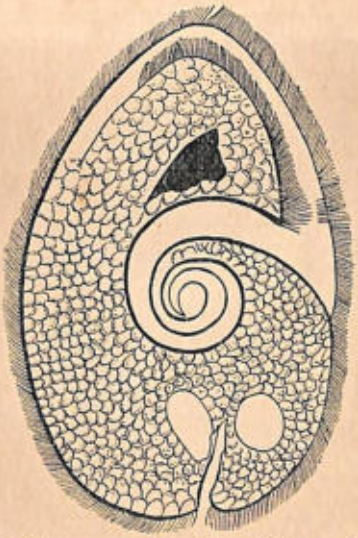


Fig. 107.—*Nyctotherus macropharyngeus* Bezz. (After de Mello.)

body. The form of the macronucleus varies a good deal, being pentagonal, like a trapezium, oval, or cone-shaped, with the apex of the cone directed to one side. It shows a finely granular structure with one or more karyosomes. The micronucleus is usually placed over the macronucleus, but less frequently lies close beside it. Mitochondria are seen as small spherical particles scattered about in the cytoplasm. The specimens found at Lahore were smaller in size than those described by Bezzenberger : an average specimen measured 207 μ in length and 142 μ in width, the macronucleus being 40 μ in length by 39 μ in width.

Gulati (1933) has described transverse binary fission and isomorphic conjugation in this species.

Habitat.—Cloaca of *Rana tigrina* Daud. : BENGAL, Calcutta ; BOMBAY ; CEYLON, Colombo. Cloaca of *R. tigrina* Daud., *R. cyanophlyctis* Schneid., and *R. hexadactyla* Lesson : PUNJAB, Lahore. Intestine of *R. tigrina* Daud., *R. limnocharis* Wiegm., and *R. cyanophlyctis* Schneid. : NOVA GOA.

129. **Nyctotherus magnus** Bezzenberger. (Fig. 108.)

†*Nyctotherus magnus*, Bezzenberger, 1904, pp. 145–8, figs. 5–8.
Nyctotherus magnus, Hegner & Taliaferro, 1924, p. 435 ; Wenyon, 1926, p. 1199.

Body flattened, kidney-shaped, with the posterior end only slightly thicker than the anterior, possessing a semi-lunar

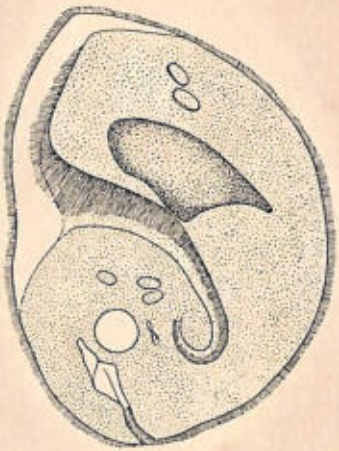


Fig. 108.—*Nyctotherus magnus* Bezz. (After Bezzenberger.)

frill-like extension at the anterior end. Cilia short and fine, arranged in rows and arising from large basal granules. Cytopharynx funnel-shaped, approximately as long as the transverse diameter of the animal, describing a bow with the opening directed ventralwards, and the end inflected forward. The entire left margin of the peristome and the cytopharynx bear membranelles. The right peristomial border bears cilia which are longer than the body cilia. Contractile vacuole single, situated in the posterior part of the body and emptying itself into a slit-like anal tube. Macronucleus strongly flattened in its long direction, and lying in front

of the cytopharynx. Micronucleus lies against the concave surface of the macronucleus.

Dimensions.—Length 660 μ, width 460 μ.

Habitat.—Cloaca of *Rana hexadactyla* Lesson : Asia (exact locality not cited by Bezzenberger).

130. **Nyctotherus magnus** var. **malabarica** de Mello. (Fig. 109.)

†*Nyctotherus magnus* var. *malabarica*, de Mello, 1932, pp. 111, 112, 124, pl. xiii, figs. 10, 11.

Body ovoid, with the anterior pole slightly narrower and more pointed than the posterior pole, which is wider and regularly rounded. Peristome wide, commencing a little to one side of the anterior pole, regularly rounded anteriorly, and with its internal margin parallel to the external border of the body, making with the cytopharynx a sharp angle. Cytopharynx

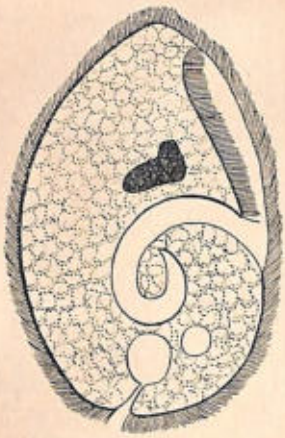


Fig. 109.—*Nyctotherus magnus* v. *malabarica* de Mello. (After de Mello.)

extending beyond the middle of the body, as long as the transverse diameter of the body, fissure-like, describing a regular curve with its opening directed ventralwards. Cuticle marked by transverse sinuous striations. Contractile vacuole single, connected with the anal groove. Macronucleus irregularly ovoid, generally presenting the form of a triangular mass, with its wide base directed towards the anterior border of the cytopharynx. Micronucleus an oval mass lodged in the parenchyma of the macronucleus.

Dimensions.—Length, minimum 130 μ, maximum 230 μ, average 150–155 μ ; width, minimum 80 μ, maximum 145 μ, average 110 μ ; macronucleus 45 by 30 μ.

Habitat.—Intestine of *Rana tigrina* Daud. : Nova Goa.

131. **Nyctotherus ovalis** Leidy. (Fig. 110, A & B, 111.)

Nyctotherus ovalis, Leidy, 1849, p. 233 ; 1850 *a*, p. 100.
Plagiotoma blattarum, Claparède & Lachmann, 1858–61, p. 240.
Bursaria blattarum, Stein, 1854, p. 42.
Plagiotoma blattarum, Stein, 1859 *d*, pp. 78, 81, 84, 85, 90.
Nyctotherus ovalis, Stein, 1867, pp. 344–7, pl. xv, figs. 11–16 ; Kent, 1880–2, p. 580 ; Bütschli, 1887–9, pl. lxvi, fig. 6 ; Bezzenberger, 1904, p. 149.
†*Nyctotherus ovalis*, Ghosh, 1921 *a*, p. 10.
Nyctotherus ovalis, Wenyon, 1926, p. 1200 ; Lepsi, 1926 *a*, p. 67, fig. 272 ; Calkins, 1926, p. 145, fig. 74, *D*.
†*Nyctotherus ovalis*, Bhatia & Gulati, 1927, p. 116 ; de Mello, Carvalho & Gaitondó, 1934, pp. 249–57, figs. 1–5.

Body broadly egg-shaped, often scarcely longer than broad, the anterior extremity rounded. Body divided into two parts

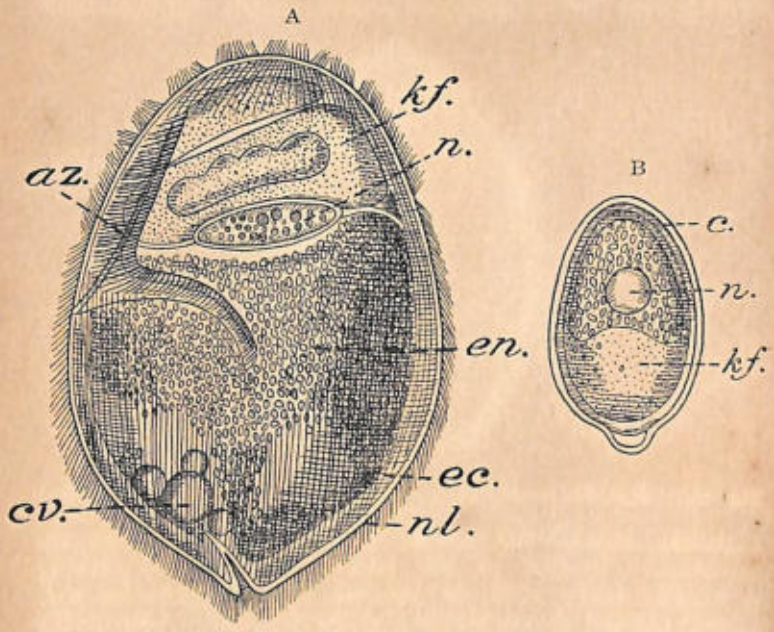


Fig. 110.—A. *Nyctotherus ovalis* Leidy. *az.*, adoral zone ; *cv.*, contractile vacuole ; *ec.*, ectoplasm ; *en.*, endoplasm ; *kf.*, granular field ; *n.*, macronucleus ; *nl.*, pellicle. B. *Nyctotherus ovalis* Leidy ; cyst ; *c.*, cyst-wall ; *n.*, macronucleus ; *kf.*, granular field. (From Bütschli, after Stein.)

by a caryophore diaphragm, one anterior, smaller, transparent and of finely alveolar structure, the other posterior, infranuclear, occupying more or less two-thirds of the length of the body, formed of large alveoli, and containing numerous

inclusions and foreign bodies. Cytopharynx not reaching beyond the middle of the body, transverse in direction, extending slightly beyond the posterior opening of the bow and reaching up to the middle. Contractile vacuole single, subterminal. Macronucleus egg-shaped, curved.

Dimensions.—Length very variable, from 70 to 360 μ.

Remarks.—Grassé (1928) recognized in this species a caryophore or suspensor of the macronucleus, composed of separate fibrils connecting the macronucleus with the body-wall, and restricted the name *Nyctotherus* to a subgenus that includes those species in which this structure is found. More recently Froilano de Mello and others (1934) have described in detail

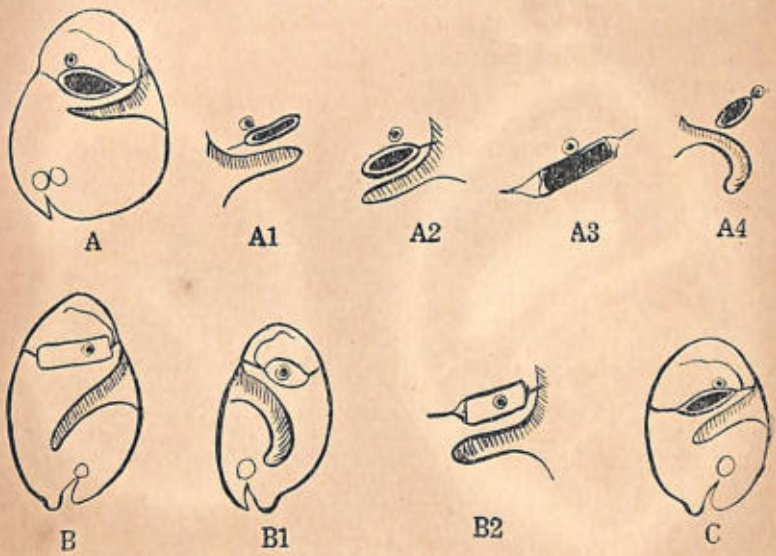


Fig. 111.—Morphological types of *Nyctotherus ovalis* Leidy. (After de Mello, Carvalho and Gaitondó.)

the structure of this caryophore diaphragm with its frontal lamina, as well as of the neuromotor apparatus attached as an appendix to the cytopharynx, and the fibrillæ in the lumen of the cytopharynx. They recognize three morphological types among the different specimens of this species (fig. 111): (A) those with micronucleus separate from macronucleus, and anal groove simple; (B) those with micronucleus embedded in the mass of the macronucleus, anal groove with one border protruded into a nipple-like point; and (C) a transitional type with nuclear apparatus as in (A) and anal groove as in (B).

Habitat.—Mid-gut and hind-gut of *Periplaneta americana*: Punjab, Lahore; Nova Goa; Bengal, Calcutta.

132. **Nyctotherus papillatus** Dobell. (Fig. 112.)

†*Nyctotherus papillatus*, Dobell, 1910, p. 76.
Nyctotherus papillatus, Wenyon, 1926, p. 1200 ; Bhatia & Gulati, 1927, p. 117.
†*Nyctotherus papillatus*, de Mello, 1930, pp. 951–2 ; 1931 *a*, p. 1184 ; 1931 *b*, pp. 1440–1 ; 1932, pl. xii, fig. 2.

Body reniform. Cytopharynx extends to the median line, is sharply curved into an almost perfect semicircle, and has a well-marked spiral twist. Anus opens just dorsally to a well-marked papilla at the extreme posterior end of the animal. Contractile vacuole single, close to the anus. Macronucleus anterior, reniform or horseshoe-shaped, with the ends

Fig. 112. Fig. 113.

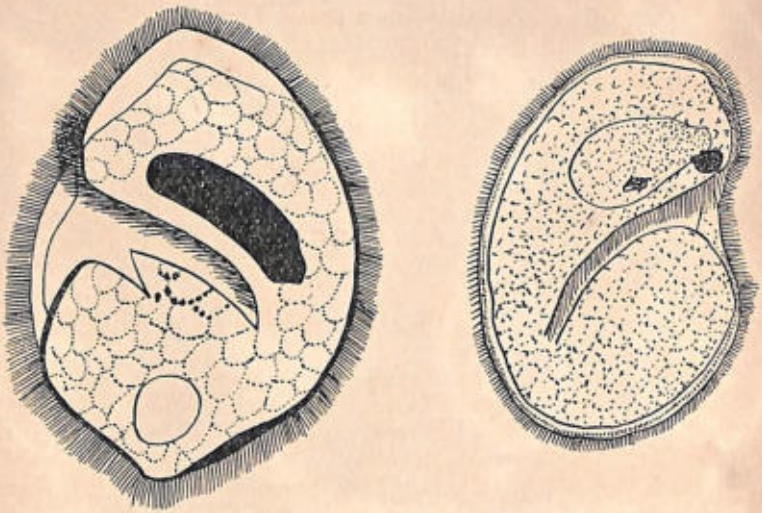


Fig. 112.—*Nyctotherus papillatus* Dobell. (After de Mello.)
Fig. 113.—*Nyctotherus reniformis* Bh. & G. (After Bhatia & Gulati.)

directed ventrally, so that it appears ovoid when seen from the side. Micronucleus not always seen, but sometimes visible lying on the macronucleus.

Dimensions.—Length 120–300 μ.

Remarks.—A curious little diverticulum of the cytopharynx, situated at the point of its junction with the mouth, is nearly always present ; it passes dorso-posteriorly for a very short distance. De Mello has always found it in his specimens from Nova Goa. The measurements of the form vary a good deal. Dobell found that specimens from *Bufo melanostictus* measured *ca.* 120 μ in length, whilst those from *Rhacophorus*

maculatus were distinctly larger, attaining a length of 170 μ. De Mello has found that his specimens from Nova Goa have much larger dimensions than those given for specimens from Ceylon, the smallest measuring 140 μ by 90 μ and the largest 300 μ by 150 μ, mostly 160–200 μ in length and 90–150 μ in width. The dimensions of the macronucleus in his specimens were: maximum 100 μ by 20–25 μ, minimum 50 μ by 20–30 μ.

Habitat.—Rectum of *Bufo melanostictus* Schneid., *Rhacophorus maculatus* (Günther): CEYLON, Peradeniya. Intestine of *Rhacophorus maculatus* (Günther): NOVA GOA.

133. **Nyctotherus reniformis** Bhatia & Gulati. (Fig. 113.)

†*Nyctotherus reniformis*, Bhatia & Gulati, 1927, pp. 115–16, fig. 12.

Body reniform; length about 1½ times the width. Cytopharynx extending obliquely backwards, reaching to about one-fifth of the length of the body from the posterior end. Contractile vacuole single, posterior. Macronucleus large and ovoidal, with a prominent micronucleus close to its pointed end.

Dimensions.—Length 92 μ.

Remarks.—The cytoplasm is clearly marked into cortical and medullary regions. The cortical region forms a narrow zone round the medullary region, which is alveolar. The cilia are fine and close-set. On the surface of the body the cilia are arranged in oblique rows, running somewhat parallel to the cytopharynx. The macronucleus is a large oval mass situated in the anterior half of the body, with its narrow pointed end directed towards one side. The micronucleus is a fairly big rounded structure lying close to the pointed end of the macronucleus. The dimensions of an average specimen are 92 μ by 60 μ; macronucleus, 35 μ by 17 μ.

Habitat.—Rectum of *Bufo macrotis* Bouleng.: PUNJAB, Sialkot.

134. **Nyctotherus termitis** Dobell. (Fig. 114.)

†*Nyctotherus termitis*, Dobell, 1910, p. 81, fig. 21.
Nyctotherus termitis, Wenyon, 1926, p. 1200; Bhatia & Gulati, 1927, p. 117; de Mello, Carvalho & Gaitondó, 1934, p. 250.

Body roughly ovoid, with a more or less strongly marked constriction at the level of the macronucleus, and another similar constriction half-way between this and the extreme anterior end. Cytopharynx situated near the middle, running in obliquely, with a very slight curvature, not extending more than half-way across the animal. Anus posterior, well

marked though narrow. Contractile vacuole single, near the anus on the ventral side. Macronucleus ovoid or slightly horseshoe-shaped. Micronucleus seen sometimes, in close contact with the macronucleus. Caryophore diaphragm present.

Dimensions.—Length 60–70 μ, maximum width rather more than 40 μ.

Remarks.—This species in general structure closely resembles *N. ovalis* of the common cockroach. As remarked by Dobell,



Fig. 114.—*Nyctotherus termitis* Dobell. (After Dobell.)

it is a striking fact that the white ants should harbour a *Nyctotherus* so closely resembling that of the cockroach, when it is remembered that the Trichonymphids are also confined to these two hosts.

As remarked by Froilano de Mello and others (1934), the caryophore diaphragm is shown in Dobell's figure of this species.

Habitat.—In the alimentary canal of *Calotermes militaris*: CEYLON.

3. Family CONDYLOSTOMIDÆ Kahl, 1927.

Peristome somewhat triangular, broader anteriorly, only slightly sunken. Adoral zone runs in a strong curve surrounding an unciliated peristomial field. The right margin of the peristome is provided with an undulating membrane.

Genus **KONDYLIOSTOMA** Bory, 1824.

Kondyliostoma, part, Bory, 1824, p. 139.
Condylostoma, Ehrenberg, 1838, pp. 308, 311, 314.
Kondylostoma, Dujardin, 1841, p. 516.
Condylostoma, Agassiz, 1846, p. 96.
Kondylostoma, Claparède & Lachmann, 1858–61, p. 243.
Condylostoma, Stein, 1867, p. 171; Kent, 1880–2, p. 584; Bütschli, 1887–9, p. 1725; Roux, 1901, p. 81; Hickson, 1903, pp. 405, 406; Calkins, 1926, p. 408; Lepsi, 1926 *a*, p. 66; Schoenichen, 1927, p. 220; Sandon, 1927, p. 190; Reichenow, 1929, p. 1188; Kahl, 1930–5, p. 452.

Body ovate or elongate and almost cylindrical, changeable in form, slightly flattened, obliquely truncate anteriorly. Peristome restricted to the anterior extremity of the body, harp-shaped, containing within an adoral ciliary spiral and a large flap-like undulating membrane. Cilia on the ventral side somewhat larger and more sparse than on the dorsal side. Contractile vacuole single or multiple, sometimes associated with elongate canal-like extensions. Anal aperture posteroterminal. Macronucleus elongate, moniliform.

Salt and fresh water. Feeding on unicellular algæ, detritus, etc.

135. **Kondyliostoma patens** (Müller) Dujardin. (Fig. 115.)

Trichoda patens, Müller, 1786, p. 181, pl. xxvi, figs. 1–2.
Uroleptus (?) *patens*, Ehrenberg, 1833, p. 278.
Kondylostoma patens, Dujardin, 1841, p. 516, pl. xii, fig. 2; Claparède & Lachmann, 1858–61, p. 244, pl. xii, fig. 3.
Kondylostoma patulum, Claparède & Lachmann, 1858–61, p. 246, pl. xii, fig. 4.
Condylostoma patens, Stein, 1859 *d*, pp. 72, 73, 78, 95; 1867, pp. 173–7, pl. i, figs. 1–4; Kent, 1880–2, p. 584, pl. xxix, fig. 12; Bütschli, 1887–9, pl. lxvii, fig. 4; Lepsi, 1926 *a*, p. 70, fig. 315; Sandon, 1927, p. 190.
†*Condylostoma patens*, Madhava Rao, 1928, p. 115.
Condylostoma (*Trichoda*) *patens*, Kahl, 1930–5, p. 453, fig. 75, *1*.

Body highly elastic, elongate elliptical, nearly cylindrical, length when extended equal to seven or eight times the greatest breadth, widest posteriorly, somewhat flattened anteriorly. Cuticular striæ fine, distributed equally and in parallel longi-

tudinal lines throughout the surface of the body. Peristomial field an irregularly triangular or harp-shaped excavation occupying an almost median position at the anterior extremity of the ventral surface, its length equal to about one-fifth to one-sixth of the body, unciliated; undulating membrane conspicuous, extending along the entire length of the right peristomial border, its width equal to one-half of that of the peristomial field. Cytopharynx narrow, tubular, equal to one-half the length of the peristome. Contractile vacuole canal-like, often breaking up into vesicular spaces, extending along the left border. Macronucleus elongate, moniliform, located towards the right side.

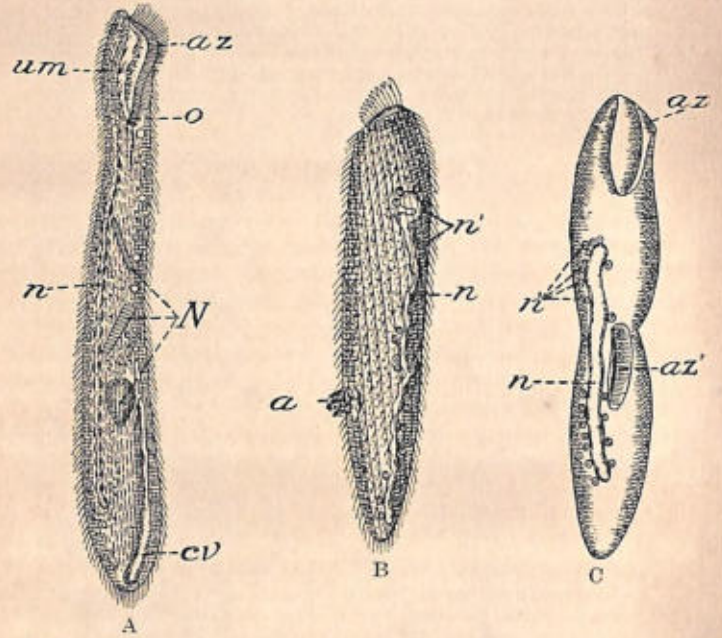


Fig. 115.—*Kondyliostoma patens* (Müller). A, ventral view; B, dorsal view; C, dividing stage. *a*, anus; *az*, adoral zone; *az'*, new adoral zone; *cv*, contractile vacuole; *N*, food-particles; *n*, macronucleus; *n'*, micronuclei; *o*, cytostome; *um*, undulating membrane. (After Bütschli.)

Dimensions.—Length of extended body up to 500 μ.

Remarks.—This species is usually referred to as marine, though it has been doubtfully recorded by Koch from garden soil (Sandon). Madhava Rao has given a very inadequate description, and mentions two nuclei (instead of one moniliform macronucleus). It is not certain that he correctly identified the form.

Habitat.—Soil: MYSORE.

ZOOLOGICAL GARDEN CALCUTTA

4. Family STENTORIDÆ Claus, 1863.

Body free or in a gelatinous test, with fine cilia. Peristome at right angles to the long axis of the body or at a marked angle with it. Peristomial surface uniformly ciliated. No undulating membrane present. Adoral zone completely encircles the broad peristomial field at the anterior end of the body, and runs in a spiral course down to the oral funnel.

Key to Indian Genera.

1. Peristome not occupying the whole of the anterior end ..... CLIMACOSTOMUM. [p. 233.
2. Peristome occupying the whole of the anterior end, directed at right angles to the long axis of the body ..... STENTORELLA, p. 234.

Genus **CLIMACOSTOMUM** Stein, 1859.

Climacostomum Stein, 1859 *d*, pp. 55, 72, 78, 81, 83, 84, 86, 88, 95; 1867, p. 208; Bütschli, 1887–9, p. 1727; Hickson, 1903, p. 406; Calkins, 1926, pp. 107, 408; Lepsi, 1926 *a*, p. 66; Schoenichen, 1927, p. 222; Kahl, 1927, p. 191; 1930–5, p. 459.

Medium-sized. Body oval, persistent in form, about twice as long as broad, obliquely truncated anteriorly. Peristome short, harp-shaped, occupying the anterior third of the ventral side. Cytopharynx long, bent. Vacuole with two radiating canals. Macronucleus central and oval, or long, band-shaped and entwined.

136. **Climacostomum virens** (Ehrenberg) Stein. (Fig. 116.)

Bursaria spirigera, Ehrenberg, 1833, pp. 234, 252.
Spirostomum virens, Ehrenberg, 1838, p. 332, pl. xxxvi. fig. 1, *1–3*.
Bursaria spirigera, Dujardin, 1841, p. 511.
Climacostomum virens, Stein, 1859 *d*, pp. 55, 60, 64, 72, 78, 81, 83, 84, 86, 88, 95; 1867, pp. 210–15, pl. iv, figs. 2–9.
†*Spirostoma virens* (?), Carter, 1856 *b*, p. 248, pl. vii, fig. 84.
Leucophrys patula, Kent, 1880–2, p. 587, pl. xxix, fig. 18.
Leucophrys curvilata, Stokes, 1886.
Climacostomum virens, Bütschli, 1887–9, pl. lxviii, fig. 4; Penard, 1922, p. 208, fig. 204; Lepsi, 1926 *a*, p. 71, fig. 322; Schoenichen, 1927, p. 222, pl. xii, fig. 53; Kahl, 1927 *a*, pp. 191–2, fig. 36; 1930–5, pp. 459–60, fig. 76, *1–2*.

Body sac-like, somewhat pointed in front and rounded behind. Dorsal surface convex, ventral flat or slightly depressed. Ciliary lines longitudinal, with fine cilia. Peristome large, occupying one-fourth to one-third of the body, with a well-developed adoral band along its right border. No undulating membrane. Cytopharynx very long, bent behind,

and provided along both margins with short, fine cilia. Cytoplasm coloured green by zoochlorellæ. Contractile vacuole very large, terminal, provided with two radiating canals,

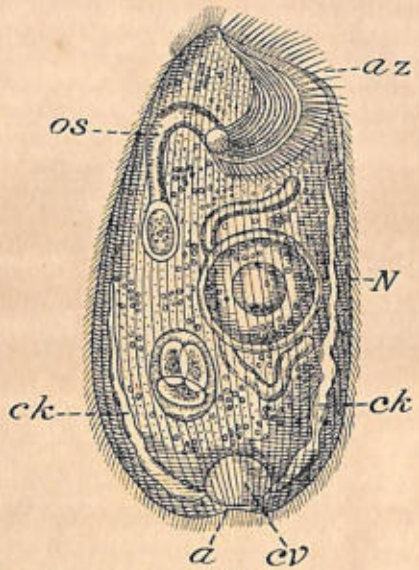


Fig. 116.—*Climacostomum virens* (Ehrbg.). *a*, anus; *az*, adoral zone; *ck*, radiating canals; *cv*, contractile vacuole; *N*, macronucleus; *os*, cytopharynx. (After Bütschli.)

which run forwards. Macronucleus elongated, band-shaped and twisted.

Dimensions.—Length 150–300 μ.

Habitat.—Fresh water: Bombay, Bombay.

Genus **STENTORELLA** Reichenbach, 1828

(=Stentor Oken, 1815, nom. preoccupied for a genus of Mammalia, E. Geoffrey, 1812).

Stentor, Oken, 1815, p. 45.
Stentorella, Reichenbach, 1828, p. 95.
Stentor, Ehrenberg, 1838, p. 261; Dujardin, 1841, p. 520; Claparède & Lachmann, 1858–61, p. 222; Stein, 1867, p. 220; Fromentel, 1874, p. 153; Kent, 1880–2, p. 588; Bütschli, 1887–9, p. 1727; Roux, 1901, p. 84; Hickson, 1903, pp. 405, 406; Minchin, 1912, pp. 439, 441, 445, 446; Calkins, 1926, p. 407; Wenyon, 1926, pp. 41, 61; Lepsi, 1926 *a*, p. 64; Schoenichen, 1927, p. 222; Knowles, 1928, p. 523; Reichenow, 1929, p. 1188; Kahl, 1930–5, p. 461.

Animalcules fixed or free-swimming at will, in the former

case attaching themselves by their softer adherent posterior extremity, which may develop weak pseudopodia for this purpose, to submerged aquatic objects and sometimes secreting a jelly-like sheath or lorica. Very large ; colourless, or blue, red, brown or green in colour. Body highly elastic and variable in form ; when swimming and contracted, purse-shaped or spherical ; when fixed and expanded, trumpet-shaped, broadly expanded anteriorly, tapering off and attenuate towards the attached posterior extremity. Cilia of the cuticular surface very fine, distributed in even longitudinal rows, occasionally supplemented by sparingly scattered hair-like bristles. The peristome takes up the whole of the anterior end of the body, and its margin shows a right-handed spiral of more than one full turn, and courses with the adoral cilia to the deepest part, where the cytostome lies followed by a tubular cytopharynx. Peristomial cilia cirrose, very large and strong. Anal aperture close behind the peristome on the left side. The contractile vacuole also on the left side, near the peristomial border with two radiating canals, one of them extending backwards along the left side of the body, and the other coursing along the peristomial border. Macronucleus rounded, elongate and band-shaped or moniliform ; micronuclei numerous. Locomotion in swimming stage moderately quick and revolving. Feeds on infusoria, flagellates, unicellular algæ and organic debris. Reproduction by transverse fission. Inhabiting fresh and salt water ; mostly social.

137. **Stentorella polymorphus** (O. F. Müller) Ehrenberg. (Fig. 117.)

Vorticella polymorpha, Müller, 1773, p. 98 ; 1786, p. 260, pl. xxxv, figs. 1–13.

Stentor polymorphus, Ehrenberg, 1831, pp. 43, 99, 152, pl. iii, fig. 3 ; 1833, p. 182, pl. iv, fig. 1 *a–e* ; 1838, p. 263, pl. xxiv, fig. 1, *1–5*.

Stentor mülleri, Ehrenberg, 1831, p. 99 ; 1833, p. 183, pl. v, fig. 1 *a–e* ; 1835, p. 165, pl. i, fig. xvi ; 1838, p. 262, pl. xxiii, fig. 1, *1, 3, 4*.

Stentor polymorphus, Dujardin, 1841, p. 523, pl. xv, fig. 2.

Stentor mülleri, Dujardin, 1841, p. 522.

Stentor vert, Dujardin, 1841, p. 523, pl. xv, fig. 2.

Stentor polymorphus, Claparède & Lachmann, 1858–61, p. 225 ; Stein, 1859 *d*, pp. 55, 60, 64, 72, 74, 78, 80, 86, 89, 90, 95 ; 1867, pp. 228–39, pl. v, figs. 1–12 ; Pritchard, 1861, p. 583, pl. xxix, fig. 7 ; Fromentel, 1874, pp. 253–4, pl. i, figs. 1–5 ; Kent, 1880–2, pp. 590–1, pl. xxx, figs. 10–20 ; Roux, 1901, p. 85, pl. v, fig. 6.

†*Stentor polymorphus*, Ghosh, 1921 *a*, p. 15 ; Bhatia, 1922, p. 32.

Stentor polymorpha, Calkins, 1926, p. 145, fig. 74.

Stentor polymorphus, Lepsi, 1926 *a*, p. 72, figs. 329, 330 ; Schenichen, 1927, p. 222.

†*Stentor polymorphus*, Bhatia and Mullick, 1930, p. 401.

Stentor polymorphus, Kahl, 1930–5, p. 463, fig. 76, *6*.

Very large. Body trumpet-shaped, colourless or yellow, sometimes green on account of zoochlorellæ. The expanded anterior end in the fully extended animal equalling in diameter one-third of the body-length. Contractile vacuole situated

Fig. 117.

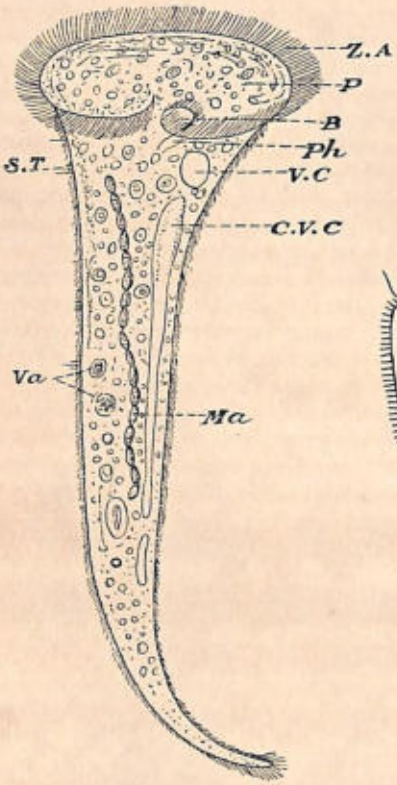


Fig. 118.

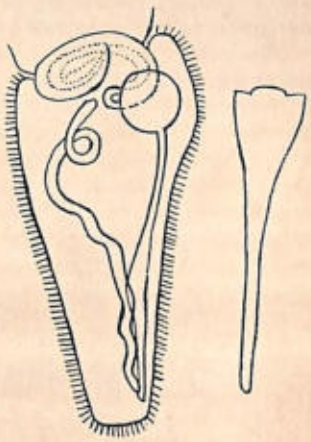


Fig. 117—*Stentorella polymorphus* (Müller). *B*, cytostome; *C.V.C*, radiating canal; *Ma*, macronucleus; *P*, peristome; *Ph*, cytopharynx; *S.T*, tactile bristles; *Va*, food-vacuoles; *V.C*, contractile vacuole; *Z.A*, adoral zone. (After Roux.)

Fig. 118.—*Stentorella viridis* Ghosh. (After Ghosh.)

near the mouth, with a backwardly directed canal. Macronucleus moniliform, consisting of rounded or oval beads. Solitary or social.

Dimensions.—Length when fully extended up to 1250 μ, in contraction 200 μ or more.

Remarks.—The specimens met with at Lahore have always belonged to the colourless variety (*Stentor mülleri* of Ehrenberg), and have been seen both singly and in the social condition. The presence of a moniliform nucleus, the absence of a gelatinous lorica, and of the hair-like bristles along the margins of the body or the circlet of finer setæ at the posterior extremity enables the form to be referred to *S. polymorphus*. It is less rounded anteriorly than *S. cæruleus*.

The specimens found at Srinagar were solitary, usually full of disc-shaped zoochlorellæ and appeared to be green; others were less full and appeared colourless. Body was metabolic, and when the organism was disturbed it contracted to form a small globule, then gradually expanded, swimming for some time in a half expanded condition. The peristomial field in a fully expanded organism was circular in outline, and the disc was raised in the centre. The adoral cilia were very long and strong. The peristomial margin was spirally coiled at its left extremity and formed a depression, at the bottom of which was the cytostome. The general surface of the body was covered wtth very fine cilia distributed along close set parallel lines. No stronger bristles were present on the body.

The specimens found by Ghosh at Calcutta were social, and were generally attached to submerged water-plants.

Habitat.—Standing water among vegetation: KASHMIR, Srinagar; PUNJAB, Lahore; BENGAL, Calcutta.

138. **Stentorella viridis** Ghosh. (Fig. 118.)

†*Stentor viridis*, Ghosh, 1921 *a*, p. 15, fig. 9.
Stentor ræseli, Kahl, 1930–5, p. 464, fig. 76, *10*, *12*, *17*, *20*, *23*, *24*.

Body elongately conical with a truncate apical end when fully expanded; ovoid to pyriform when contracted. Colour, yellow. Peristomial margin not expanded, and slightly less in width than the greatest width of the body. Pseudostome raised cushion-wise. Peristomial notch shallow. Longitudinal ciliary striæ distinct. Cilia over the general surface of the body fine and uniform, those at the truncate aboral end long and stout. Contractile vacuole irregularly spherical, placed immediately beneath the pseudostome, with a canal extending to the aboral pole and presenting a fusiform dilatation. Macronucleus ribbon-shaped, much coiled, and extending through the entire length of the body.

Dimensions.—Length 250–300 μ. Width 75–80 μ. Diameter of pseudostome 43 μ.

Remarks.—The animalcules are found in pond water amongst *Vorticella* and *Epistylis* colonies. They are never social. The species resembles *S. ræseli* and *S. barretti* in

the form of its macronucleus, but differs from them in its smaller size, and the absence of bristles and a gelatinous sheath. Kahl (1930–5) doubts the specific identity of the form and regards *S. barretti* Kent, *S. gracilis* Maskell, and *S. viridis* Ghosh as synonyms of *S. roeseli* Ehrbg.

Habitat.—Pond-water, among *Vorticella* and *Epistylis* colonies : BENGAL, Calcutta.

139. **Stentorella** sp.

†*Stentor* sp., Carter, 1856 *b*, p. 119.

Habitat.—Fresh water : Bombay.

5. Family FOLLICULINIDÆ Dons, 1912.

Marine forms, living in pseudochitinous tests. Peristome drawn out into two wings, with the adoral zone continued along the margin of both. Peristomial surface ciliated. No undulating membrane present.

Genus **FOLLICULINA** Lamarck, 1816.

Folliculina, Lamarck, 1815–16, ii, p. 29.
? *Folliculina*, part, emend. Bory, 1824.
Freia, Claparède & Lachmann, 1858–61, p. 217; Stein, 1867, p. 272; Fromentel, 1874, p. 150.
Folliculina, Kent, 1880–2, p. 596; Bütschli, 1887–9, p. 1728; Hickson, 1903, p. 407; Dons, 1912, pp. 73–93; Penard, 1919, pp. 305–19, pls. i, ii; Calkins, 1926, p. 407; Lepsi, 1926 *a*, p. 64; Reichenow, 1929, p. 1189; Kahl, 1930–5, p. 469.

Body highly elastic and contractile, secreting a horny sheath or lorica, to which it remains fixed by its posterior extremity. Peristome occupying the whole of the anterior extremity, prolonged into two elongate and usually symmetrical, flattened, lappet-like lobes, the cleft between which is deepest on the ventral side; peristomial fringe originating on the ventral side at the base of the right-hand lobe, skirting the entire margin of the bilobate frontal border, descending in a shortly revolute spiral manner into the oral aperture on arriving at the base of the left-hand lobe. Peristomial or adoral cilia very long, those of the general cuticular surface exceedingly fine, disposed in even longidudinal rows. Anal aperture situated close to the base of the left-hand peristomial lobe. Contractile vacuole central or absent. Macronucleus oval, central, or elongated and moniliform. Mostly inhabiting salt water.

140. **Folliculina ampulla** (O. F. Müller) Lamarck. (Fig. 119.)

Vorticella ampulla, O. F. Müller, 1786, pp. 283–5, pl. xl, figs. 4–7.
Folliculina ampulla, Lamarck, 1815–16, ii, p. 30.
Freia ampulla, Claparède & Lachmann, 1858–61, pp. 221–2, pl. ix, figs. 6, 7.
Freia aculeata, Claparède & Lachmann, 1858–61, p. 221, pl. x, figs. 5, 6, 8.
Folliculina ampulla, Stein, 1867, pp. 275–89, pls. x, xi; Kent, 1880–2, pp. 597–8, pl. xxix, figs. 21–28; Bütschli, 1887–9, pl. lxix, fig. 3.
†*Folliculina ampulla*, Annandale, 1907, pp. 37, 143.
Folliculina ampulla, Dons, 1912, p. 81; Sahrhage, 1916, pp. 139–74, pls. x, xi; Lepsi, 1926 *a*, p. 73, figs. 338–40; Calkins, 1926, p. 160, fig. 84 B; Reichenow, 1929, p. 1189, fig. 1172; Kahl, 1930–5, p. 470, fig. 77, *5*, *5 a*.

Very large. Body lodged in a sheath or lorica, which is deep blue-green or sea-green, flask-shaped, attached laterally, with the neck bent upwards. Neck short in young individuals, but becoming much prolonged with age and usually ornamented

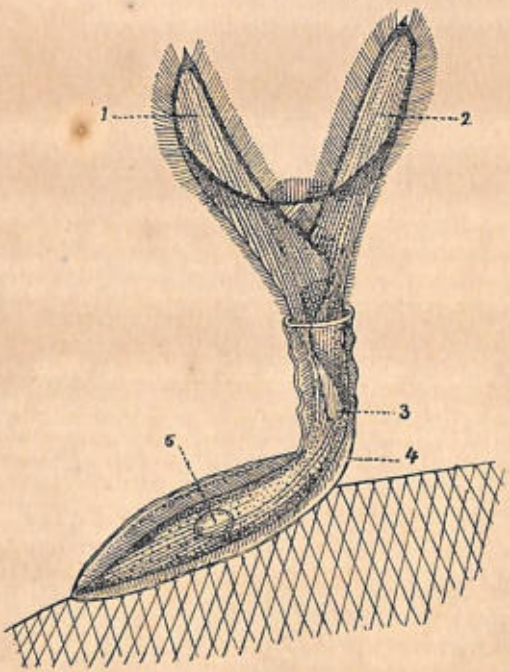


Fig. 119.—*Folliculina ampulla* (O. F. Müll.). 1, 2, wing-like outgrowths on which the adoral zone is extended; 3, cytostome at the bottom of the peristomial funnel; 4, flask-shaped test in which the animal can withdraw itself; 5, macronucleus. (From Reichenow, after Stein.)

with either horizontal or spirally ascending annulations or with longitudinal flutings ; margin of aperture even, circular. Animalcules similar in colour to the sheath. Peristome reaches deep in the anterior part of the neck, and bears two similar wing like lobes, which are from three to six times as long as broad and bluntly or sharply pointed at their end, and which bear an adoral zone of membranelles. Cytostome at the bottom of the peristomial funnel. Macronucleus spherical. Length of the lorica up to 1000μ. Marine.

Remarks.—Annandale noted the occurrence of *F. ampulla* without mentioning the name of the author of the species. According to Kahl (1930–5) *F. ampulla* (O. F. Müll.) ; *F. mœbiusi* Kahl (=*Frei ampulla* Möbius ; *F. ampulla* Sahrhage); *F.* (*Freia*) *aculeata* (Cl. & L.) (=*ampulla* St. partim) ; and *F. boltoni* Kent (=*F. ampulla* Cl. & L., *F. simplex* Dons, *Ascobius lentus* Henneg.) are distinct species.

Habitat.—Brackish water pond : Lower Bengal, Port Canning. In close association with the hydroid stage of *Irene ceylonensis* (=*Campanulina ceylonensis*).

6. Family BURSARIDÆ Perty, emend. Kahl.

Body finely ciliated. Peristome forming a sac-like depression of the anterior end, which is provided with a ventral slit. Adoral zone runs in this depression and is continued into the bent oral funnel. Peristomial surface is not ciliated.

Genus **BURSARIA** O. F. Müller, 1773.

Bursaria, O. F. Müller, 1773, p. 62 ; part, Ehrenberg, 1838, p. 325 ; part, Dujardin, 1841, p. 508 ; emend. Claparède & Lachmann, 1858–61, p. 251 ; Stein, 1867, p. 297 ; Kent, 1880–2, p. 575 ; Schuberg, 1886, p. 335 ; Bütschli, 1887–9, p. 1726 ; Roux, 1901, p. 82 ; Hickson, 1903, pp. 405, 406 ; Minchin, 1912, p. 439 ; Penard, 1922, pp. 205–8 ; Lepsi, 1926 *a*, p. 65 ; Calkins, 1926, p. 408 ; Schoenichen, 1927, p. 220 ; Kahl, 1927 *a*, p. 198 ; 1930–5, pp. 476–9 ; Reichenow, 1929, p. 1190.

Animalcules free swimming, very large, colourless or brownish ; form constant, flexible, when moderately extended purse-shaped, ventral surface somewhat flattened. Anterior extremity broadly truncate, posterior extremity broad, rounded or somewhat pointed. The chief feature is the great and characteristic development of the peristomial field. Peristome is wide, funnel-shaped, and extends to even further back than the middle of the body ; the posterior tube-like

narrower portion of the peristome usually bends over to the left; enclosed in the peristome is an elongated and very narrow mouth-cleft, running almost the whole length of the peristome along the right side. An adoral zone, consisting of very broad membranelles, extends on the left side along the whole length of the peristome, but does not extend over its anterior border. Anal aperture postero-terminal. Contractile vacuoles usually absent, but sometimes many distributed all over the body. Macronucleus long, band-shaped, and meandering; micronuclei numerous. Cysts spherical with a double coat. Inhabiting fresh water.

Remarks.—Writers prior to Stein, and Claparède and Lachmann included in the genus *Bursaria* a large number of widely diverse forms, now distributed, with one or two exceptions, among the genera *Plagiotoma*, *Nyctotherus*, *Leucophrys*, *Ophryoglena*, *Balantidium*, *Paramecium*, and *Opalina*. Out of a score of species associated with the title *Bursaria* by Ehrenberg, only one, *Bursaria truncatella* Müller, is now left to represent the genus.

141. **Bursaria truncatella** O. F. Müller. (Fig. 120.)

Bursaria truncatella, O. F. Müller, 1773, p. 62; 1786, p. 115, pl. xvii, figs. 1–4; Ehrenberg, 1831, p. 110; 1838, p. 326, pl. xxxiv, fig. v, 1, 2.

Bursaria vorticella, Ehrenberg; 1838, p. 326, pl. xxxiv, fig. vi, 1–3.

Bursaria decora, Claparède & Lachmann, 1858–61, p. 252, pl. xiii, fig. 1.

Bursaria truncatella, Stein, 1859 *d*, pp. 78, 81, 95, 100; 1867, pp. 300–9; Kent, 1880–2, p. 576, pl. xxix, figs. 1 & 2; Schuberg, 1886, pp. 333–65, pls. xix, xx; Bütschli, 1887–9, p. 1726, pl. lxvii, fig. 6; pl. lxviii, fig. 1; Roux, 1901, p. 83, pl. v, fig. 4; Hickson, 1903, p. 407, figs. 59, 60.

†*Bursaria truncatella*, Bhatia, 1922, p. 30.

Bursaria truncatella, Penard, 1922, pp. 205–8, fig. 203; Lepsi, 1926 *a*, p. 71, fig. 318; Calkins, 1926, p. 160, fig. 84 A; Schoenichen, 1927, p. 220, pl. xii, fig. 52; Kahl, 1927, pp. 198–9, fig. 40; 1930–5, pp. 476–9, fig. 78, *1–4*; Reichenow, 1929, p. 1190, fig. 1173.

Body broadly ovate, purse- or sac-shaped, the ventral surface flattened, the dorsal convex; scarcely one and a half times as long as broad, widest posteriorly, narrowed slightly at the truncate anterior extremity, the frontal angles rounded. The margin of the right side convex, usually longer than that of the left, the margin of the shorter left side slightly concave. Contractile vacuoles many, distributed all over the body. Macronucleus long, band-like, and meandering; micronuclei numerous. Pond and marsh water. Feeds on diatoms and organic debris, etc. Movements swift, with rotation on the longitudinal axis.

Dimensions.—Length up to 1·5 mm.

Remarks.—As observed by Kent, the species is apparently by no means cosmopolitan, but when present usually occurs in considerable abundance. Specimens were found in considerable numbers at Lahore, and were of a large size, easily visible to the naked eye and opalescent white in appearance, creeping about slowly. Various authorities, Bütschli (1889), Hickson (1903), Lang (1913), Doflein (1916), seem to differ in their interpretation of the same figure which they reproduce from Schuberg. Bhatia (1922) has fully discussed these differences of interpretation.

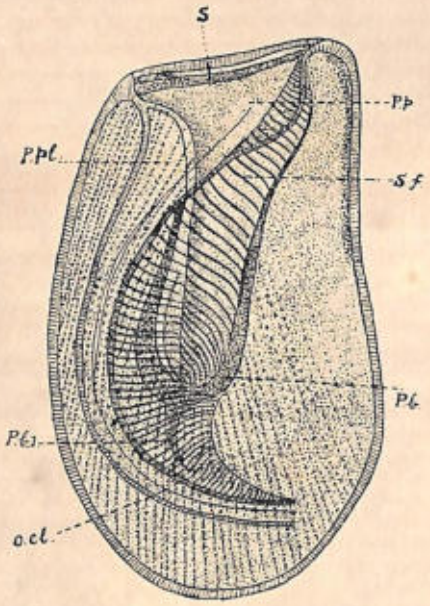


Fig. 120.—*Bursaria truncatella* O. F. Müller. *o.cl.*, oral cleft; *P.b.*, peristomial band; *P.b.*1, posterior prolongation of the peristomial band; *Pp.*, peristomial depression; *P.pl*, peristomial plate; *S*, sphincter myophan band; *Sf*, peristomial striations. (After Schuberg.)

Although there is a posterior tube-like continuation of the peristome, it seems best to say that there is no gullet, as, properly speaking, there is no cytopharynx following a definite cytostome, the gutter-like cleft serving the purpose of a mouth-opening. Kahl (1927), contrary to the opinion of all other observers, states that he is unable to find an oral cleft, but that in pressed animals there is a cleft-like folding of the neighbouring plate.

Again, Bütschli writes: "Ciliation moderate; the peristomial field unciliated. Undulating membrane wanting." Lang (1913, fig. 155, *10*) indicates a "peristomplatte," which is finely ciliate along the free edge, while Hickson (1903, fig. 59), referring to the peristomial cavity, says: "a thin vertical fold projects into this cavity on the right side (left in the figure) and a thicker striated fold projects into it on the left side." In my specimens I was not able to make out this vertical fold on the right side, though there was a distinct flap along the left of the peristomial field, and this flap bore fine cilia along its free edge in the prominent anterior portion only. The cavity of the peristome is the entire area enclosed between the two cross-striated lines curving backwards from the anterior margin of the body and not merely the space enclosed between the so-called peristomial bands represented dark in the figure as here reproduced (fig. 120).

Habitat.—Pond water: PUNJAB, Lahore.

INCERTÆ SEDIS.

Genus **PARABURSARIA** Ghosh, 1921.

Parabursaria, Ghosh, 1921 *a*, p. 12.

Agrees with *Balantidium* in having a cup-shaped peristome at the anterior end, but is said to differ from it in having an adoral zone of cilia outside the peristome (*sic*). It differs from *Bursaria* Müller and *Bursaridium* Lauterborn in having no cytopharynx, and from the latter in having no membranelles and in the presence of the adoral zone of cilia.

Remarks.—In my opinion the genus is not sufficiently characterized and the species is inadequately observed and described. I do not consider the genus as a valid one, but have quoted the description from the original author for convenience of reference.

142. **Parabursaria pheretima** Ghosh. (Fig. 121.)

†*Parabursaria pheretima*, Ghosh, 1921 *a*, pp. 12–13, fig. 10.

Body irregularly spherical, with an annular constriction in the middle and a rounded prominence on one side of the anterior portion. Peristome cup-shaped, occupying the truncate anterior end. No cytopharynx. Posterior end rounded. Minute cilia arranged closely in longitudinal rows. An adoral zone of long cilia extending from the left side of the peristome backwards beyond the middle of the body and then nearly horizontally from left to right round the body, for about one-third its circumference. Contractile vacuole single, subcentral.

Measurements not stated.

Habitat.—In the seminal vesicles of *Pheretima posthuma* (L. Vaill.) : BENGAL, Calcutta.

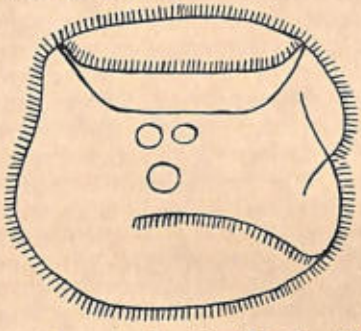


Fig. 121.—*Paraburs aria pheretima* Ghosh. (After Ghosh.)

7. Family BALANTIDIIDÆ Reichenow, 1929.

Body finely ciliated. Peristome forms a cleft, broader anteriorly and extending from the anterior pole of the body more or less backwards towards the ventral surface. Dorsal wall of the peristome provided with an adoral row of long cilia. Peristomial surface not ciliated. Cytostome situated at the bottom of the peristome and may be followed by a distinct cytopharynx. Endoparasitic.

Genus **BALANTIDIUM** Claparède & Lachmann, 1858, emend. Stein.

Bursaria, part, Ehrenberg, 1838, p. 325.
Leucophrys, part, Stein, 1859 *d*, pp. 72, 80, 88, 95.
Plagiostoma, part, Claparède & Lachmann, 1858–61, p. 241.
Balantidium, Claparède & Lachmann, 1858–61, p. 247; Stein, 1867, p. 309; Fromentel, 1874, p. 186; Kent, 1880–2, p. 577; Bütschli, 1887–9, p. 1724.
Balantidopsis, Bütschli, 1887–9, p. 1725.
Balantidium, Hickson, 1903, pp. 405, 406; Bezzenberger, 1904, p. 157; Minchin, 1912, pp. 439, 440; Hegner & Taliaferro, 1924, pp. 387, 415–33; Calkins, 1926, p. 408; Wenyon, 1926, p. 1201; Bhatia & Gulati, 1927, p. 102; Knowles, 1928, p. 527; Abé, 1928–9, p. 89; Reichenow, 1929, p. 1190; Thomson & Robertson, 1929, pp. 268–74; Kudo, 1931, p. 374.
Balantidiopsis, Kudo, 1931, p. 374.
Balantidium, Hegner, 1934, pp. 38–67.

Body ovate or pear-shaped, completely covered by spirally-arranged parallel rows of cilia. Anterior end slightly truncate; peristome straight, somewhat triangular, widest

anteriorly, beginning at the anterior end of the body, and with its narrow posterior end on the ventral surface. Cytostome situated in the depression of the peristome and followed by a cytopharynx which ends blindly in the endoplasm. An adoral row of long cilia commences at the posterior end of the peristome, passes along the right margin of the peristome, across its anterior margin, and then backwards along the left margin to a point near where it started : it then passes into the cytostome, and is continued backwards in the same spiral manner till it reaches half-way down the cytopharynx, where it ends. Contractile vacuoles one or many. Anal aperture postero-terminal. Macronucleus sausage-shaped or spherical, with a small micronucleus closely applied to it. Multiplication by transverse fission ; conjugation has been repeatedly observed in *B. coli*. Transmission to other hosts through formation of spherical cysts. Occurring as parasites within the intestinal viscera of many vertebrate and invertebrate hosts.

Remarks.—Bhatia and Gulati (1927) have reviewed the literature on this genus. *Bursaria entozoon* of Ehrenberg was made the type of the genus *Balantidium* by Claparède and Lachmann. Bütschli established a new genus, *Balantidiopsis*, for *B. duodeni*. The genus *Balantidiopsis* is distinguished as broadly egg-shaped, flattened, with spherical macronucleus and a single contractile vacuole at the posterior end. Schaudinn amalgamated the two again. Schweier, apparently without knowledge of Schaudinn's work, adhered to Bütschli's arrangement of the species in two genera. Bezzenberger discussed the reasons for which the two genera cannot be recognized as distinct and re-grouped all the species under *Balantidium*. Abé (1928–9) has reclassified all the species of *Balantidium* and referred them to three genera, viz., *Balantidium*, *Balantidiopsis*, and *Protobalantidium*, the last being newly established by him and characterized by having an oval, egg-shaped, or elongated cylindrical body, circular or oval in section, with the peristome bearing membranelles, undulating membrane, or a row of cilia on its inne wall. I do not propose to follow this classification, and have grouped all the species under the generic title of *Balantidium*.

Up to 1933 thirty-two species, together with some doubtful ones, had been described as belonging to this genus. Of these two are from Cœlentrates, and of these one is also found in Annelids ; one from a Turbellarian, six from Arthropods, two from Molluscs, two from Fishes, twelve from Amphibia, one from a Reptile, and six from Mammals. Hegner in 1934 reviewed the data on which specificity is based in this genus and described six new species. Three of these are from monkeys, one from the camel, one from the opossum, and one from the ostrich.

Key to Indian Species.*

1 (17).	Peristome not reaching the middle of the body	2.
2 (12).	Body round in transverse section. ...	3–11.
3.	Contractile vacuole 1. Macronucleus spherical. Body irregularly pyriform. Length 90 μ	[p. 249. *B. blattarum* Ghosh.
4.	Contractile vacuole 1 or more. Macronucleus kidney-shaped. Body elongated egg-shaped, 76–130 μ by 50–70 μ	*B. helenæ* Bezz., p. 259.
5.	Contractile vacuoles 2. Macronucleus oval. Body cylindrical. Transverse diameter throughout similar. Length to breadth as 10 : 1 up to 6 : 1. 130–360 μ by 25–36 μ	*B. gracile* Bezz., p. 258.
6.	Body cylindrical. Transverse diameter wider near hinder end. Length 2½ to 3 times the width. 90–142 μ by 33–62 μ (Stein and Bhatia & Gulati). According to Kent, length equals 208–292 μ.....	[p. 256. *B. elongatum* Stein,
7.	Body egg-shaped, broader, 30–200 μ by 20–70 μ	[p. 249. *B. coli* (Malmsten),
8.	Body egg-shaped, greatest width in the middle, 60–120 μ by 44–90 μ. Macronucleus ribbon-like with folded ends.	[p. 253. [Cooper & Gulati, *B. coli* var. *bovis*,
9.	Contractile vacuoles 3. Macronucleus broadly oval. Body torpedo-shaped, with axial and peripheral fibres in the peristomical area, 150–319 μ by 35–65 μ.....	[p. 264. *B. sushilii* Ray,
10.	Body large, oval. Peristome wide, cylindrical, obliquely directed. Macronucleus oval	[p. 266. *B. testudinis* Chagas,
11.	Contractile vacuoles 4. Macronucleus oval or kidney-shaped. Body egg-shaped, 205 μ by 133 μ	[p. 257. *B. giganteum* Bezz.,
12 (2).	Body oval in transverse section	13–16.
13.	Contractile vacuole 1, subcentral. Macronucleus oval. Body oval with a deep concavity on the ventral surface, 50–63 μ by 37 μ	[p. 253. *B. depressum* (Ghosh),
14.	Contractile vacuole 1. Macronucleus broadly oval. Body ovate. Length 85 μ.....	[p.261. *B. ovatum* Ghosh,
15.	Contractile vacuole 1. Macronucleus oval. Body almond-shaped, 50 by 35 μ.....	[Gulati, p. 247. *B. amygdalli* Bhatia &
16.	Contractile vacuole 1. Macronucleus circular and disc-like. Body ovate, 10–11 μ by 5 μ	[p. 262. *B. rhesum* Ghosh,
17 (1).	Peristome reaching the middle of the body or further	18.

* A key to all the species of the genus known up to 1926, and the list of hosts are given in Bhatia & Gulati (1927).

18 (23). Body flattened ..... 19–22.

19. Contractile vacuole 0. Macronucleus oval. Body egg-shaped, anterior end broader, 40–50 μ by 29–40 μ. Peristome showing two depressions or bays ..... [Gulati, p. 248. *B. bicavata* Bhatia &

20. Contractile vacuole 1. Macronucleus round or oval. Body ovate, with a granular area in the anterior half. Length 41–62 μ (Stein), 74–115 μ (Bhatia & Gulati), 86–130 μ (Kent). Width 37–52 μ (Stein), 53–71 μ (Bhatia & Gulati). Dobell gives 75 μ by 56 μ for his form ..... [p. 254. *B. duodeni* Stein,

21. Contractile vacuole 1. Macronucleus oval. Body round or broadly egg-shaped, 56 μ by 44 μ. Peristome slit-like..... [p. 263. *B. rotundum* Bezz.,

22. Contractile vacuole 1. Macronucleus rounded or broadly oval. Body ovate, 40 μ by 25 μ. Peristome large, ovate. [p. 260. *B. knowlesii* Ghosh,

23 (18). Body rounded in transverse section .. 24.

24. Contractile vacuoles 2. Macronucleus oval. Body oval, anteriorly tapering to a blunt point, 65 μ by 40 μ ..... [p. 262. *B. ranarum* Ghosh.

143. **Balantidium amygdalli** Bhatia & Gulati. (Fig. 122.)

†*Balantidium amygdalli*, Bhatia & Gulati, 1927, p. 110, fig. 11.
Protobalantidium (?) *amygdalli*, Abé, 1928–9, p. 89.
Balantidium amygdalli, Hegner, 1934, p. 49, fig. 46.

Body almond-shaped, narrow anteriorly and broadest behind the middle. Length of the body one and a half times the width. Peristome very small, extending a very short distance from the anterior end and narrowing posteriorly.

Fig. 122. Fig. 123.

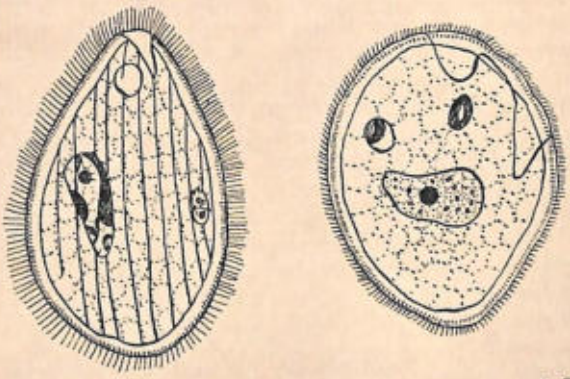


Fig. 122.—*Balantidium amygdalli* Bh. & G. (After Bhatia & Gulati.)
Fig. 123.—*Balantidium bicavata* Bh. & G. (After Bhatia & Gulati.)

Contractile vacuole anterior. Macronucleus ellipsoidal. Micronucleus rounded or somewhat oval.

Dimensions.—Length 50μ, maximum width 35μ.

Remarks.—The cytoplasm is granular and the ectoplasm clearly marked off from the endoplasm. Cilia are fine and close set and are disposed in longitudinal rows on the surface of the body. Just internal to the basal granules is a layer of trichocysts. The contractile vacuole is placed close to the peristome. The macronucleus contains several large deeply staining chromatin masses in its interior. The micronucleus shows fine chromatin particles in it.

The form somewhat resembles *B. ovatum* Ghosh, described from the cockroach, *Periplaneta americana*, in the shape of the body, but differs from it in the shape of the macronucleus, which is oval and not spherical, and in the contractile vacuole being situated anteriorly. It further differs from that species in the absence of the canal leading from the contractile vacuole, which is characteristic of that species.

Habitat.—Rectum of *Bufo macrotis* Bouleng.: PUNJAB, Sialkot.

144. **Balantidium bicavata** Bhatia & Gulati. (Fig. 123.)

†*Balantidium bicavata*, Bhatia & Gulati, 1927, p. 109, fig. 10.
Protobalantidium (?) *bicavata*, Abé, 1928–9, p. 89.
Balantidium bicavata, Hegner, 1934, p. 48, fig. 47.

Body oval in form, anterior end broadly rounded, posterior end somewhat narrower, with the greatest width in the anterior half of the body, from one and a quarter to one and a half times as long as wide. Peristomial field excavate in front, and, instead of running as a single furrow or groove, shows two depressions or bays on the ventral surface, extending up to the middle of the body. Contractile vacuole absent. Macronucleus oval. Micronucleus oval.

Dimensions.—Length 40–50μ, maximum width 29–40μ.

Remarks.—The cytoplasm has a granular appearance. There is no marked differentiation between cortex and medulla. The cilia are fine and close set and are disposed in oblique longitudinal rows. Trichocysts are present and form a distinct row just beneath the outer layer. The macronucleus contains a dark centrally placed chromatin mass and other irregularly scattered chromatin particles. The micronucleus is placed in the anterior half of the body.

This species differs from the others in the form of the body, the character of the peristome, and the form and structure of the macronucleus.

Habitat.—Rectum of *Bufo melanostictus* Schneid.: PUNJAB, Lahore.

145. **Balantidium blattarum** Ghosh. (Fig. 124.)

†*Balantidium blattarum*, Ghosh, 1922 *a*, pp. 15–16, fig. 1; Bhatia & Gulati, 1927, p. 111.
Balantidium blattarum, Hegner, 1934, p. 49, fig. 39.

Body irregularly pyriform, slightly less than twice as long as its greatest transverse diameter, and circular in transverse section. Anterior end tapering and rounded, posterior end obliquely truncate. Body cilia small and closely arranged. Peristome small, about one-third the body in length, somewhat cylindrical and directed backwards and medianwise. A large undulating membrane along the anterior margin of the peristome, and a row of stout cilia along its posterior margin. Endoplasm coarsely granular and surrounded by a distinct

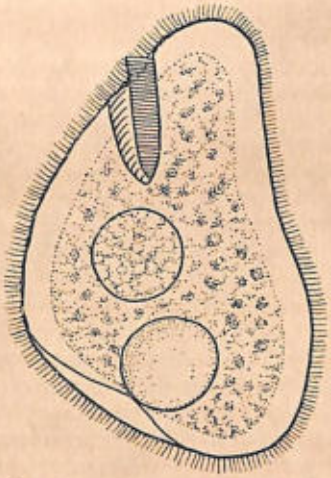


Fig. 124.—*Balantidium blattarum* Ghosh. (After Ghosh.)

hyaline ectoplasm. Contractile vacuole large, posterior. Macronucleus spherical, central.

Dimensions.—Length 90 μ.

Habitat.—Intestine of *Periplaneta americana*: PUNJAB, Lahore; BENGAL, Calcutta.

146. **Balantidium coli** (Malmsten). (Fig. 125.)

Paramæcium (?) *coli*, Malmsten, 1857, pp. 302–9, figs. 1–6.
Plagiostoma coli, Claparède & Lachmann, 1858–61, pp. 241–3, pl. xi, fig. 10.
Leucophrya coli, Stein, 1860 *b*, p. 47.
Paramæcium (?) *coli*, Leuckart, 1861, pp. 80–6, pl. v, figs. A, B; 1863, pp. 146–51, fig. 21.

Balantidium coli, Stein, 1867, pp. 320–5, pl. xiv, figs. 10, 14–18; Kent, 1880–2, p. 578, pl. xxix, figs. 16, 17; Mitter, 1891, pp. 1–41, 1 pl.; Noc, 1908, pp. 878–80; Brumpt, 1909, pp. 103–5; Minchin, 1912, p. 440; Walker, 1913, pp. 333–49, 7 pls.
†*Balantidium coli*, Castellani & Chalmers, 1919, pp. 247–8, fig. 200.
Balantidium coli, Dobell & O'Connor, 1921, p. 107, pl. vii, fig. 100; McDonald, 1922, pp. 243–300, pls. xxvii, xxviii.
†*Balantidium coli*, Sinton, 1923, p. 432.
Balantidium coli, Hegner & Holmes, 1923, pp. 252–63, pls. v, vi; Hegner & Taliaferro, 1924, pp. 416–27, figs. 161, 162 *a*, 163, 164; Lepsi, 1926 *a*, p. 70, fig. 309; Wenyon, 1926, pp. 1201–1210; Nöller, 1926, pp. 89, 90, figs. 28, 29, *1–3*; Craig, 1926, pp. 518–23, figs. 89, 90.
†*Balantidium coli*, Knowles, 1928, pp. 527–530, figs. 133, 134; Chatterjee, 1928, p. 79.
Balantidium coli, Reichenow, 1929, pp. 1192–4, figs. 1174–6; Thomson & Robertson, 1929, pp. 268–73, figs. 173, 175–8, 181; Kudo, 1931, p. 374, fig. 161, *b*, *c*; Hegner, 1934, pp. 41–6, figs. 1, 4, 14, 17.

Body egg-shaped, slightly broader at the posterior end, narrowed and pointed at the anterior end. Cilia over the entire body arranged in longitudinal rows with a slightly spiral course. Peristome on the ventral surface, at the anterior end, placed somewhat obliquely, varying in its appearance with the constant changes in the shape of the anterior end of the body from a wide open depression to a longitudinal groove or slit. Adoral zone of cilia passes round the peristome and through the cytostome into the cytopharynx. Cytostome can be closed by a very mobile non-ciliated oral plug. Cytopharynx short. Ectoplasm clear. McDonald (1922) has described in association with the cytostome and adoral cilia a neuro-motor system of fibres and a co-ordinating centre or motorium, which is embedded in the ectoplasm near the cytopharynx. Endoplasm varying with the state of nutrition. Sometimes with numerous vacuoles, each of which contains a highly refractile globule; at other times the vacuoles contain red blood-corpuscles, leucocytes, or other débris. Contractile vacuoles two, one at the posterior end and the other near the middle of the body. Anal aperture present at the posterior end of the body. Macronucleus sausage-shaped or bean-shaped, lying more or less transversely at the middle of the body, with a small micronucleus close to it. Reproduction by transverse fission preceded by division of the two nuclei. Repeated and rapid binary fissions lead to the formation of "nests" of parasites in the tissues of the host. Cysts of two types have been reported. Two Ciliates become attached to one another by their peristomes and enclosed in a cyst. Exact details of conjugation within the cyst not known. More frequently, single individuals become encysted.

Dimensions.—Size from 30 to 200μ or more in length and from 20 to 70μ in breadth. The usual range is 50–70μ long

by 40–60μ wide. Cysts measure 50–60μ in length, and slightly less in breadth.

Remarks.—*B. coli* is widely distributed throughout the world, and has been recorded from man, monkeys, and pigs. In human beings infection is most common in individuals who come into association with pigs, and it is believed that the Ciliate is a common parasite of the pig and occasionally infects man and monkeys. A second widely different species, *B. suis*, also occurs in the pigs, but is not known to infect man.

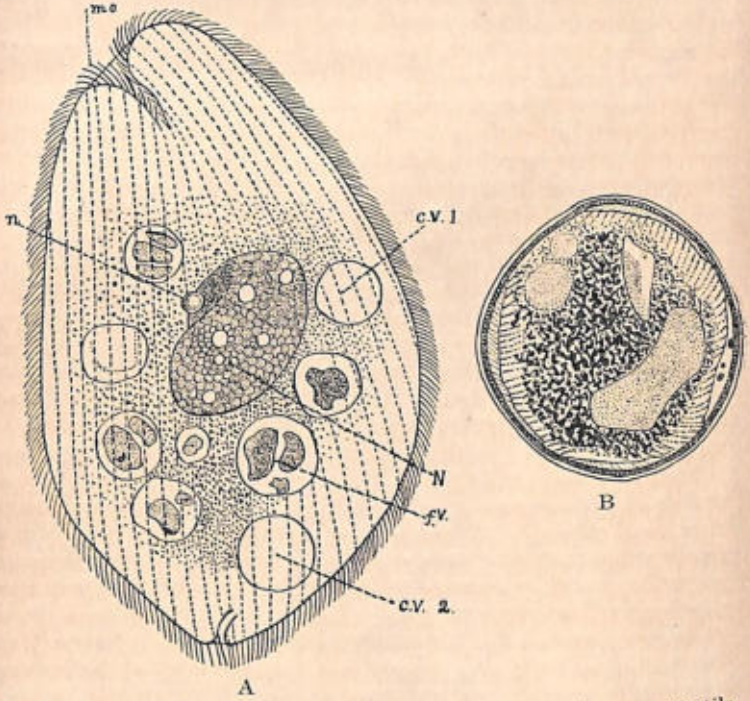


Fig. 125.—A. *Balantidium coli* (Malm.). *c.v.*1, anterior contractile vacuole; *c.v.*2, posterior contractile vacuole; *f.v.* food-vacuole; *mo*, peristome leading to the mouth; *N*, macronucleus; *n*, micronucleus. B. Encysted form. (After Dobell & O'Connor.)

Wenyon (1926) has given an excellent summary of all that is known about this species. The supposed pathogenicity, pathology, experimental work to test the susceptibility of different animals, and the action of various drugs are all fully discussed in his work. Hegner (1934) has summed up the present position of the species occurring in man, chimpanzee, and pig.

Records from India are scanty. Sinton (1923) recorded a symptomless infection with *B. coli* in a Pathan prisoner in the Lahore jail. Ramsay informed Knowles that infection is not uncommon in the Cachar tea-gardnes. Shanks also informed him of a fatal case of balantidial dysentery that occurred at the Calcutta Medical College, and Knowles himself observed a case of infection. As remarked by Knowles (1927), "Balantidium infection is usually symptomless and is present in the 'carrier state,' and only occasionally does it give rise to dysentery. When dysentery does set in, however, it is apt to be very severe; extensive necrosis and sloughing of the mucous membrane of the colon takes place and mortality rates are apt to be high."

Cultivation.—Prowazek (1913) kept *B. coli* from man alive for seven days by mixing physiological saline with fæces. Barret and Yarbrough (1921) used a mixture of 0·5 per cent. sodium chloride solution and inactivated human serum in the proportion of 16 : 1, and were able successfully to cultivate the Ciliate for thirty-eight days, during which time eleven transplants were made. In 1923 Van der Reis attempted to cultivate *Balantidia* from man, using a medium composed of 5·0 per cent meat bouillon and 0·5 per cent. saline combined with human blood serum in the proportion of 10 : 1 or 15 : 1. He had no success until he added 24-hour cultures of *Bacillus fecalis alkaligenes* to his culture of *Balantidium*, but by this addition he was able to maintain the culture for thirty-two days. Rees (1927) and Jameson (1927) were both successful in cultivating *Balantidium* from the pig for some time. Rees employed Ringer's solution in place of 0·5 per cent. saline used by Barret and Yarbrough, combining it with either horse or human blood-serum, or Loeffler's dehydrated blood-serum in the proportion of 9 : 1. He also found that the addition of sterile rice starch to this medium aided materially in the cultivation of *Balantidium*. Jameson cultivated the organism for about three months, using a modification of the medium devised for the cultivation of intestinal amœbæ, a slant of coagulated horse-serum covered with Ringer's solution, with or without egg-white. He also found addition of rice starch essential for the cultivation of this Ciliate. Schumaker (1931 *a*) has also cultivated *B. coli* successfully, using the technique of Rees and of Jameson. He used for each tube 10 c.c. of a medium consisting of 1 c.c. of sterile horse-serum and 9 c.c. of sterile Ringer's solution of the formula :—NaCl, 6·50 g.; KCl, 0·14 g.; $CaCl_2$, 0·12 g.; $NaHCo_3$, 0·20 g.; NaH_2PO_4, 0·01 g.; distilled water 1000 c.c. He, too, found the addition of sterile rice starch essential.

Habitat.—Human stools: PUNJAB, Lahore; BENGAL, Calcutta; ASSAM, Cachar; CEYLON.

147. **Balantidium coli** var. **bovis** Cooper & Gulati. (Fig. 126.)

†*Balantidium coli*, var. *bovis*, Cooper & Gulati, 1926, pp. 192–3, pl. xi.
Balantidium coli var. *bovis*, Hegner, 1934, p. 49, fig. 33.

Body egg-shaped, narrower, and tapering anteriorly, broad and rounded posteriorly. Length and breadth in the ratio of 4 : 3. Greatest width in the middle of the body. Body covered with fine, small, and close-set cilia, arranged in longitudinal parallel rows. Adoral cilia distinctly longer. Peristome short and funnel-like, situated near the anterior pole, but not quite terminal, inclined towards the median plane.

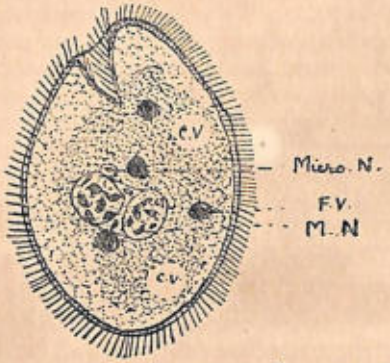


Fig. 126.—*Balantidium coli* v. *bovis* C. & G. *c.v*, contractile vacuole; *F.V.*, food-vacuole; *M.N*, macronucleus; *Micro.N*, micronucleus. (After Cooper & Gulati.)

Contractile vacuoles two. Macronucleus a ribbon-like structure folded at each end, appearing oval or bean-shaped in a darkly stained specimen, in which case the folds at the two ends cannot be seen. Micronucleus adjacent.

Dimensions.—Length 60–120 μ, breadth 44–90 μ.

Remarks.—This variety differs from *B. coli* from man, in that the greatest width of the organism is in the middle of the body, and the macronucleus is ribbon-shaped with folded ends.

Habitat.—Intestine of cattle: ASSAM.

148. **Balantidium depressum** (Ghosh). (Fig. 127.)

†*Balantidiopsis depressum*, Ghosh, 1921 *a*, p. 13, fig. 12.
Balantidium depressum, Bhatia & Gulati, 1927, p. 104.
Protobalantidium depressum, Abé, 1928–9, p. 89.

Body simply or elongately oval, slightly narrowed, and rounded anteriorly, wide and tapering to a point posteriorly;

oval in transverse section. A deep concavity on the ventral surface, occupying the posterior third of the body. Longitudinal ciliary striæ distinct and close to one another. Peristome small and fusiform, about one-fifth of the body-length and directed obliquely backwards. A row of longer cilia placed along its left margin. Contractile vacuole posterior and lateral. Macronucleus oval and central. Micronucleus spherical and placed at the side of the macronucleus.

Dimensions.—Length 50–63 μ ; breadth 37 μ.

Remarks.—Dr. H. N. Ray, who has re-examined the form, informs me in a personal communication that Ghosh's description of the species is wrong in certain respects. According to him the body is slightly pointed at either end, is circular in transverse section, both the lateral margins are symmetrical, and there is no concavity on the ventral surface. The macronucleus is bean-shaped and variable in position. Micronucleus is oval or spindle-shaped and usually lies in the notch of the macronucleus. He further adds that both axial and peripheral systems of fibres are present, and a boring apparatus is situated at the anterior extremity of the axial system of fibres on the left side of the peristome.

Habitat.—Rectum of *Pila* (*Ampullaria*) *globosa* (Swainson) : Bengal, Calcutta.

149. **Balantidium duodeni** Stein. (Fig. 128.)

Balantidium duodeni, Stein, 1867, pp. 325–6 ; pl. xiv, figs. 19–23 ; Kent, 1880–2, p. 578.
Balantidiopsis duodeni, Bütschli, 1887–9, p. 1725, pl. lxviii, fig. 3.
Balantidium duodeni, Bezzenberger, 1904, p. 157.
†*Balantidium hyalinum*, Dobell, 1910, p. 75, fig. 19.
Balantidium duodeni, Lepsi, 1926*a*, p. 70, figs. 311, 312 ; Wenyon, 1926, p. 1210 ; Nöller, 1926, p. 90.
†*Balantidium duodeni*, Bhatia & Gulati, 1927, pp. 105–6, fig. 7.
Balantidium duodeni, Reichenow, 1929, p. 1191.
Balantidiopsis duodeni, Kudo, 1931, p. 375, fig. 161, *d*.
Balantidium duodeni, Hegner, 1934, p. 49, fig. 42.

Body ovate, flattened ; length from only slightly more than the width up to one and a half times. Peristome narrow, cleft-like, and reaching to the middle of the body. Contractile vacuole single, posterior. Macronucleus oval or kidney-shaped. Micronucleus close behind. Cysts spherical.

Dimensions.—Length 74–115 μ (Stein and Kent, 86–130 μ), breadth 53–68 μ (Stein, 77–109 μ).

Remarks.—Dobell (1910) described a species, *B. hyalinum*, from the duodenum of *R. tigrina* in Ceylon, and stated that his form did not differ markedly from other duodenal forms, viz., *B. duodeni* Stein and *B. rotundum* Bezz. ; but the protoplasm was stated to be more hyaline. In the anterior region there is a striated or granular triangular area, which is also

characteristic of *B. duodeni* and *B. rotundum*. As in these forms, the cilia are long and well developed over the whole body. The average dimensions are *ca.* 74 μ by 56 μ, which fall well within the dimensions as recorded by Stein or Kent for *B. duodeni*, or as found by Bhatia and Gulati for their specimens of *B. duodeni*. On carefully comparing Dobell's figure of *B. hyalinum* with those of *B. duodeni* in the works of Stein and other authors, the two are seen to be almost identical. The only difference appears to be that the macronucleus is placed more posteriorly in the body and the micronucleus shown near the anterior end of the macronucleus. I do not consider *B. hyalinum* as specifically distinct from *B. duodeni*.

Fig. 127.



Fig. 128.

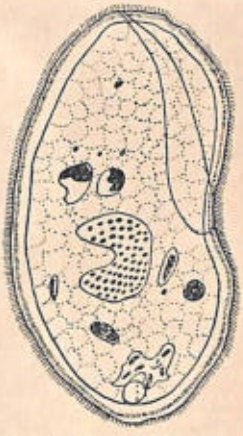


Fig. 127.—*Balantidium depressum* (Ghosh). (After Ghosh.)
Fig. 128.—*Balantidium duodeni* St. (After Bhatia & Gulati.)

In the form met with at Lahore the body is flat and oval, anteriorly narrower, with the greatest width near the posterior end. The length of the body is one and a half times the width. The peristomial field is excavate, nearly straight or bent a little at its posterior end, and reaches the middle of the body. The peristome is not followed by a cytopharynx. The cytoplasm is not clearly differentiated into cortical and medullary regions and has a dense granular appearance. The anterior region shows a striated triangular area.

Habitat.—Duodenum and small intestine of *Rana tigrina* Daud. : PUNJAB, Lahore ; CEYLON.

150. **Balantidium elongatum** Stein. (Fig. 129.)

Balantidium elongatum, Stein, 1867, pp. 319–20, pl. xiv, figs. 11–13 ; Kent, 1880–2, p. 577 : Bezzenberger, 1904, p. 157 ; Lepsi, 1926*a*, p. 70, fig. 308 ; Nöller, 1926, p. 90.
†*Balantidium elongatum*, Bhatia & Gulati, 1927, pp. 107–8, fig. 8.
Protobalantidium elongatum, Abé, 1928–9, p. 89.
Balantidium elongatum, Reichenow, 1929, p. 1191 ; Jirovec, 1930, p. 20, fig. 2 ; Hegner, 1934, p. 49, fig. 38.

Body elongate, cylindrical, from two to three times as long as broad, anterior end pointed or more or less rounded, posterior end drawn out. Peristome long, triangular, extending up to about one-fourth of the length of the body. Contractile vacuoles two, median and posterior. Macronucleus oval or kidney-shaped. Micronucleus adjacent.

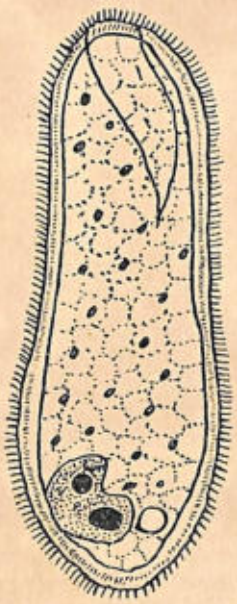


Fig. 129.—*Balantidium elongatum* St. (After Bhatia & Gulati.)

Dimensions.—208–297 μ by 69–130 μ (Stein), 90–124 μ by 39–53 μ (Bhatia and Gulati), 215 μ by 63·5 μ (Jirovec).

Remarks.—In the specimens examined at Lahore, the length of the body is two and a quarter to three times the width, and the greatest width is behind the middle of the body. The cytoplasm is not clearly marked into cortical and medullary regions, and the medullary region has a dense granular appearance. Cilia are of uniform length, fine and close-set, and arranged in longitudinal rows. The anus is situated near

the posterior end of the body. The posterior contractile vacuole lies a little in front of the anus, and at the moment of its contraction is seen to be connected by a canal with the anal opening. The macronucleus is oval in outline, sometimes notched, and is situated near the posterior end or in the posterior half of the body. The micronucleus lies close to the macronucleus. These specimens measured only 90–124 μ by 39–53 μ. The size of the species thus appears to vary a good deal.

Habitat.—Intestine of *Rana tigrina* Daud.; PUNJAB, Lahore.

151. **Balantidium giganteum** Bezzenberger. (Fig. 130.)

†*Balantidium giganteum*, Bezzenberger, 1904, pp. 148, 150–1, figs. 9, 10.
Balantidium giganteum, Nöller, 1926, p. 90; Bhatia & Gulati, 1927, p. 111; Hegner, 1934, p. 59, fig. 52.

Body regularly egg-shaped, round in transverse section. Body surface covered with short cilia arranged in distinct

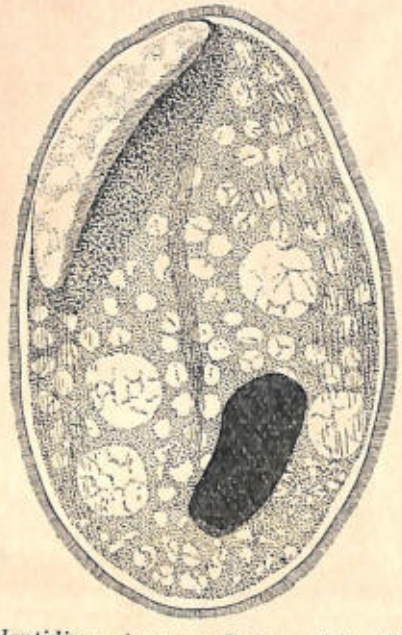


Fig. 130.—*Balantidium giganteum* Bezz. (After Bezzenberger.)

rows. Peristome is a moderately large, broad and deep pocket and does not extend to the middle of the body; the left lip carries membranelles which do not cover the whole width

of the peristomial field. Contractile vacuoles four. Macronucleus is kidney-shaped or oval; the micronucelus lies in the notch if the macronucleus is kidney-shaped, or near one end if the latter is oval.

Dimensions.—Length 205 μ, width 133 μ.

Habitat.—Cloaca of *Rana esculenta* var. *chinensis* Osb. : Asia (exact locality not cited by Bezzenberger).

152. **Balantidium gracile** Bezzenberger. (Fig. 131.)

†*Balantidium gracile*, Bezzenberger, 1904, pp. 152–3, pl. xi, figs. 2–3.
Balantidium gracile, Nöller, 1926, p. 90.
†*Balantidium gracile*, Bhatia & Gulati, 1927, pp. 108–9, fig. 9.
Protobalantidium gracile, Abé, 1928–9, p. 89.
†*Balantidium gracile*, de Mello, 1932, p. 109, pl. xiii, figs. 7, 8.
Balantidium gracilis, Hegner, 1934, p. 59, fig. 50.

Body cylindrical, tapering, and rounded at both ends; six to twelve times as long as wide. Peristome excavate,

Fig. 131.



Fig. 132.

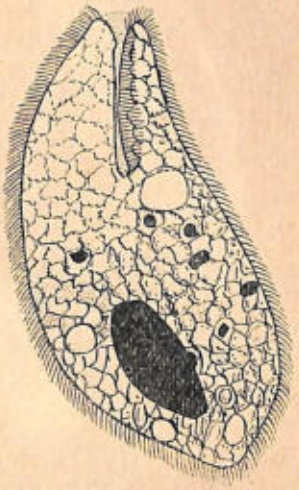


Fig. 131.—*Balantidium gracile* Bezz. (After Bhatia & Gulati.)
Fig. 132.—*Balantidium helenæ* Bezz. (After de Mello.)

extending up to about one-seventh of the length of the body. Contractile vacuoles two. Macronucleus oval. Micronucleus rounded.

Dimensions.—Length 132–210 μ, width 25–36 μ (Bezzenberger gives 360 μ by 30 μ); de Mello gives minimum length

75μ, maximum length 175μ, most commonly 94–112μ in length and 18–30μ in width.

Remarks.—The body is round in transverse section, and the transverse diameter is practically the same throughout the whole length. In the somewhat contracted condition the body is seen to be curved in an elegant manner. The peristome is short and bottle-shaped, and bears long and abundant cilia along one of its borders. The cytoplasm is alveolar and clearly defined into cortical and medullary regions, the latter being loose and very clear round the nucleus, and also contains mitochondria. The two contractile vacuoles lie in the anterior part of the body. The macronucleus is oval and granular, and lies mostly in the posterior half or in the middle, rarely in the anterior half. The micronucleus is rounded and placed in a depression of the posterior part of the macronucleus, or sometimes at some distance from the macronucleus.

Habitat.—Rectum of *Rana cyanophlyctis* Schn. and *R. hexadactyla* Lesson : Asia (exact locality not cited by Bezzenberger) ; rectum of *R. hexadactyyla* Lesson : Punjab, Lahore ; small intestine of *R. tigrina* Daud. : Nova Goa.

153. **Balantidium helenæ** Bezzenberger. (Fig. 132.)

†*Balantidium helenæ*, Bezzenberger, 1904, pp. 151–2, pl. xi, fig. 1.
†*Balantidium ovale*, Dobell, 1910, p. 74.
Balantidium helenæ, Nöller, 1926, p. 90.
Balantidium ovale, Nöller, 1926, p. 90.
†*Balantidium helenæ*, Bhatia & Gulati, 1927, p. 106 ; de Mello, 1932, pp. 105–8, pl. xiii, figs. 1–3, 6, pp. 117, 119.
Balantidium helenæ, Hegner, 1934, p. 49, fig. 37.

Body ovoid, anterior pole narrow, posterior wider ; length of the body only a little more than the width. Peristome excavated, not reaching up to the middle. Contractile vacuole single or variable number irregularly distributed in the body. Macronucleus kidney-shaped, with a rounded micronucleus lying in its notch.

Dimensions.—Minimum 45 by 30μ, maximum 175 by 62μ, usually between 75–125μ in length. Macronucleus 31–37μ in length, 10–18μ in width, on an average 29·2μ by 14·6μ. Micronucleus 5μ by 2·5μ. Width between ciliary lines 3·5μ.

Remarks.—In the forms examined at Lahore the body is broadly oval with the posterior end projecting like a knob. The length of the body is only a little more than the width. The cytoplasm is clearly defined into cortical and medullary portions. The cortical portion appears to be structureless, but the medullary portion is densely granular. Cilia arise from definite elongated granules lying within the pellicle.

Bezzenberger gives the dimensions as 110–130μ in length and 60–70μ in width. The specimens examined at Lahore measured *ca.* 76μ in length and 52μ in width, and were thus considerably smaller.

Dobell (1910) described from the same host in Ceylon a form which he named *B. ovale*. It differs from *B. helenæ* Bezz. only in size. The average size of his forms was about 80μ by 50μ. Bhatia and Gulati (1927) consider this form as belonging to the same species as *B. helenæ*. De Mello (1932) encountered in the same host forms that were oval like *B. ovale* Dobell, and forms that were elongated like *B. helenæ* Bezz. The former measured 36–90μ in length and 28–66μ in width, or on an average 55–70μ by 45–50μ; the latter measured 45–100μ in length and 30–65μ in width, or on an average 60μ by 45μ. From a detailed study he found that the structure of the two forms is identical; and the position of the nucleus, as also the occurrence of numerous transitional forms, leads him to accept the opinion expressed by Bhatia and Gulati that the two species are one and the same.

Habitat.—Rectum of *Rana tigrina* Daud.: ASIA (exact locality not cited by Bezzenberger); rectum of *R. tigrina* Daud.: PUNJAB, Lahore; CEYLON. Intestine of *R. tigrina* Daud., *R. cyanophlyctis* Schn., and *R. limnocharis* Wiegm.: NOVA GOA.

154. **Balantidium knowlesii** Ghosh. (Fig. 133.)

†*Balantidium knowlesii*, Ghosh, 1925, p. 189, fig. 1.
Balantidium knowlesii, Wenyon, 1926, p. 1211.
Balantidium sp., Knowles, 1928, p. 533.
Protobalantidium knowlesii, Abé, 1928–9, p. 89.
Leptoglena knowlesii, Grasse & Boissezon, 1929, p. 191.
Balantidium knowlesii, Hegner, 1934, p. 49, fig. 45.

Body broadly ovate, wider posteriorly than anteriorly, slightly less than twice as long as wide. Anterior end narrow



Fig. 133.—*Balantidium knowlesii* Ghosh. (After Ghosh.)

and tapering, posterior end rounded. Dorsal surface convex, more prominent posteriorly and with several faint longitudinal grooves. Ventral surface flattened. Peristome large, cup-like, ovate in shape and occupying the ventral surface, leaving a narrow space all round except on the right lateral margin. Adoral row of cilia not well developed. No distinct undulating membrane. Body completely ciliated, anterior body cilia long. Ectoplasm thin. Endoplasm coarsely granular. Contractile vacuole, single, posterior. Macronucleus rounded or broadly oval, placed in the middle of the body. Micronucleus single, lodged in a depression of the macronucleus.

Dimensions.—Length 40μ, greatest width 25μ.

Remarks.—The species resembles *B. rotundum* in having a large wide peristome, but differs from that species in (i) the peristome occupies nearly the entire ventral surface, (ii) the macronucleus is spherical and central, and (iii) the contractile vacuole is posterior.

Habitat.—In the cœlomic cavity of *Culicoides peregrinus*: Bengal, Calcutta.

155. **Balantidium ovatum** Ghosh. (Fig. 134.)

†*Balantidium ovatum*, Ghosh, 1922 *b*, p. 371, fig. 1.
Balantidium ovatum, Wenyon, 1926, p. 1211; Bhatia & Gulati, 1927, p. 111.
Protobalantidium ovatum, Abé, 1928–9, p. 89.
Balantidium ovatum, Hegner, 1934, p. 49, fig. 48.

Body elongately oval, wider posteriorly than anteriorly, slightly less than twice as long as its greatest diameter and broadly oval in transverse section. Anterior end rounded, posterior end abruptly tapering to a point. Body cilia long, a row of longer and stouter cilia at the anterior end. Peristome small, tubuliform, about one-fifth the length of the body, directed backwards and mesially. There is an undulating membrane running along the postero-lateral portion of the peristome, and a row of stouter cilia in its anterior portion, continuous with the long anterior body cilia. Ectoplasm thin, except near the anterior and posterior ends of the body. Endoplasm densely filled with coarse granules. Contractile vacuole large, posterior, with an anal canal opening in front of the posterior end. Macronucleus broadly oval, situated in the middle of the body.

Dimensions.—Length 85μ.

Remarks.—This species is said to differ from all other known species of the genus in possessing an anal canal in connection with the contractile vacuole. It is distinguished from *B. blattarum* by its shape, the position of the undulating membrane, and in the thinness of the ectoplasm; but as the

description is based on a single specimen, Wenyon thinks it doubtful whether these two species, *B. blattarum* and *B. ovatum*, are specifically distinct.

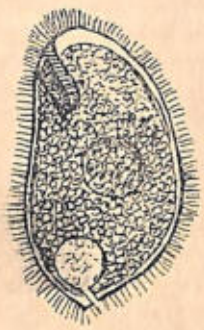


Fig. 134.—*Balantidium ovatum* Ghosh. (After Ghosh.)

Habitat.—Intestine of *Periplaneta americana*: BENGAL, Calcutta.

156. **Balantidium ranarum** Ghosh.

†*Balantidium ranarum*, Ghosh, 1921 *a*, p. 14.
Balantidium ranarum, Bhatia & Gulati, 1927, p. 112.

Body elongately to broadly oval, tapering to a blunt point anteriorly and obliquely truncate or rounded at the posterior end. Body more or less rounded in transverse section, sometimes with a slight depression posteriorly on one side. Peristome extending from the anterior end to beyond the middle of the body, and provided with a distinct adoral row of long and stout cilia. Body cilia long and uniformly arranged in meridional rows. Contractile vacuoles two and postero-lateral, one on each side. Macronucleus oval and variable in position, mostly in the middle and on one side, sometimes more anterior or posterior. Micronucleus adjacent.

Dimensions.—Length 65 μ, breadth 40 μ.

Habitat.—Rectum of *Rana tigrina* Daud.: BENGAL, Calcutta.

157. **Balantidium rhesum** Ghosh. (Fig. 135.)

†*Balantidium* sp., Knowles, 1928, p. 533.
†*Balantidium rhesum*, Ghosh, 1929 *a*, p. 14, fig. 1.

Body ovate, nearly or less than twice as long as broad, anteriorly tapering and blunt, posteriorly broad and rounded. Body oval in transverse section. Peristome triangular, placed in front and somewhat laterally, and extending to one-fourth

the length of the body. Contractile vacuole single, postero-terminal. Macronucleus circular and disc-like with convex side, placed about the middle to one side, and containing a chromatin mass in the centre.

Dimensions.—Length 10–11 μ, breadth 5 μ.

Remarks.—The measurements as given by Ghosh are: length 0·01–0·117 mm.; breadth 0·0054–0·00525 mm. Hegner (1934) is of the opinion that his measurements are obviously

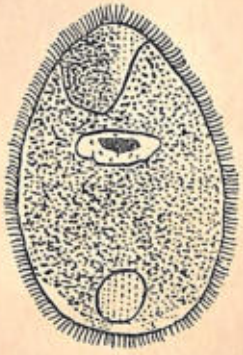


Fig. 135.—*Balantidium rhesum* Ghosh. (After Ghosh.)

incorrect, and his description and illustration (as reproduced above) are so inadequate that this species (?) cannot be considered seriously. He is further of the opinion that *B. simile* Cunha & Muniz, 1930, from Rhesus monkeys imported into Brazil, is a valid species, and is characterized by a thickened cortical layer at the anterior end: but as this character is not shown by Ghosh, this form cannot be identified with *B. simile* without further investigation.

Habitat.—Intestine of *Macacus rhesus*: BENGAL, Calcutta.

158. **Balantidium rotundum** Bezzenberger. (Fig. 136.)

†*Balantidium rotundum*, Bezzenberger, 1904, pp. 153–4, pl. xi, fig. 4.

Balantidium rotundum, Nöller, 1926, p. 90; Bhatia & Gulati, 1927, p. 112; Hegner, 1934, p. 59, fig. 53.

Body round or compactly egg-shaped, strongly compressed dorso-ventrally, with a marked bulging on the ventral surface in contrast to the plane dorsal surface. Cilia extraordinarily long and fine. Peristome slit-like, beginning near the anterior pole of the body and extending backwards along the right margin, but stopping short in front of the middle of the body; the left peristomial margin carries long and thick adoral cilia.

Contractile vacuole single, lying in the right lower quadrant of the body. Macronucleus is oval or slightly kidney-shaped, never spherical, and lies close to the margin in the left lower quadrant of the body. Micronucleus is distinct and lies in the notch if the macronucleus is kidney-shaped, and in the middle or near one end if the latter is oval.

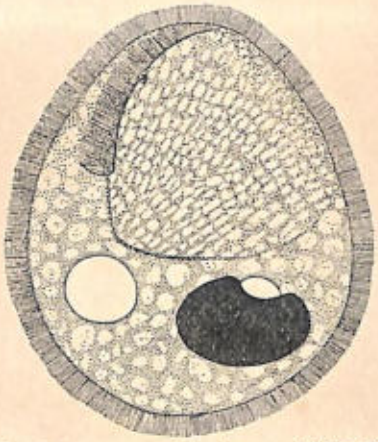


Fig. 136.—*Balantidium rotundum* Bezz. (After Bezzenberger.)

Dimensions.—Length 56 μ, width 44 μ.

Habitat.—Small intestine of *Rana esculenta* Linn. var. *chinensis* Osb.: Asia (exact locality not cited by Bezzenberger).

159. **Balantidium sushilii** Ray. (Fig. 137.)

†*Balantidium sushilii*, Ray, 1932, pp. 374–82, figs. 1–5 & 1 pl.; Chakravarti, 1933, pp. 345–6, figs. 1–3.
Balantidium sushilii, Hegner, 1934, pp. 58–60, fig. 49.

Body torpedo-shaped, circular in transverse section. Peristome begins as a narrow groove, gradually widening as it passes backwards, not reaching the middle of the body. Left peristomial wall carries long cilia, the left peristomial lip bears an undulating membrane. Morphonemes arranged in two conspicuous arches at the anterior end. A boring apparatus present. Contractile vacuoles three, two lateral and one terminal. Macronucleus broadly oval, and very variable in position. Micronucleus lateral to the macronucleus.

Dimensions.—Length 150–319·44 μ, width 35–65 μ.

Remarks.—Ray has described a system of axial and peripheral fibres in the peristomial area. Placed slightly towards the left of the peristome and embedded in the cytoplasm are three or four fibres which are either parallel or twisted after

the manner of a rope. They originate from just below the pellicle at the anterior end and extend posteriorly to a short distance behind the mouth. A clear knob-like structure or " borer " is attached at the anterior termination of these fibres by means of a short neck. The axial fibres together with the borer constitute the boring apparatus. The borer has been found embedded in the intestinal epithelium of the host and serves to puncture the gut-wall. The peripheral system of fibres, arranged in two conspicuous arches along the

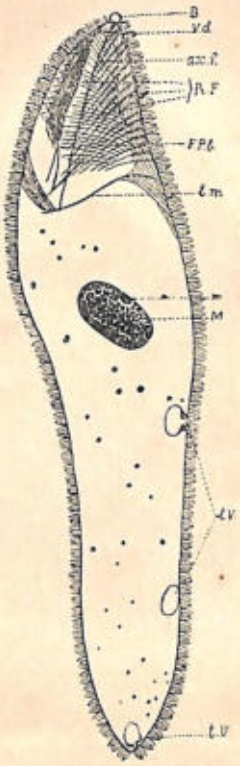


Fig. 137.—*Balantidium sushilii* Ray. *ax.f.*, axial system of fibres; *B*, borer; *F.P.b.*, fibres attached to post-peristomial border; *l.m.*, limiting membrane; *l.V.*, lateral vacuoles; *M*, macronucleus; *m*, micronucleus; *Pr.F.*, peripheral system of fibres; *t.v.*, terminal vacuole; *V.d.*, V-shaped depression. (After Ray.)

left anterior border, is considered as serving the purpose of maintaining the rigidity of the peristomial area, and are therefore termed " morphonemes."

Habitat.—Intestine of *Rana tigrina* Daud.: BENGAL, Calcutta.

long stiff springing bristles developed around the equatorial region of the body. Locomotion restless, extremely violent, shooting or springing forwards, with momentary pauses during which the animal remains stationary.

161. **Halteria grandinella** (O. F. Müller). (Fig. 139.)

Trichoda grandinella, O. F. Müller, 1773, p. 77; 1786, p. 160, pl. xxiii, figs. 1–3.
Trichodina grandinella, Ehrenberg, 1838, p. 267, pl. xxiv, fig. 5.
Halteria grandinella, Dujardin, 1841, p. 415, pl. xvi, fig. 1.
Trichodina grandinella, Claparède & Lachmann, 1858–61, p. 369, pl. xiii, figs. 8, 9.
Halteria grandinella, Stein, 1867, p. 162; Fromentel, 1874, p. 262, pl. xxiv, figs. 1, 1 *a*; Kent, 1880–2, p. 632, pl. xxxii, figs. 35–8; Bütschli, 1887–9, p. 1732, pl. lxix, fig. 6; Roux, 1901, p. 93, pl. v, fig. 15.
†*Halteria grandinella*, Bhatia, 1920, p. 262.
Halteria grandinella, Penard, 1922, pp. 224–6; Fauré-Fremiet, 1923, pp. 61–2, fig. 20; Hegner & Taliaferro, 1924, pp. 387–8, fig. 146.
†*Halteria grandinella*, Gulati, 1925, p. 9, fig. 21.
Halteria grandinella, Lepsi, 1926 *a*, p. 76, figs. 361, 362; Sandon, 1927, p. 191, pl. vi, fig. 9; Schoenichen, 1927, p. 225, pl. xiii, fig. 2; Reichenow, 1929, p. 1195; Kahl, 1930–5, p. 504, fig. 82, *1*.

Body subglobose, transparent, terminating posteriorly in somewhat narrower obtusely rounded point. Springing

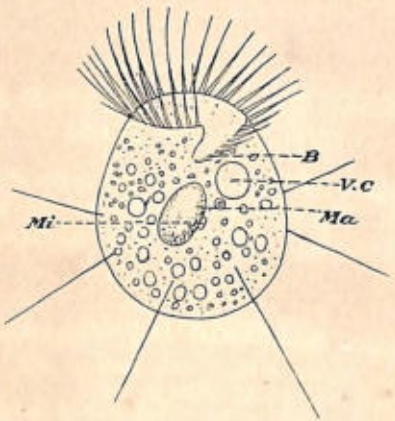


Fig. 139.—*Halteria grandinella* (O. F. Müll.) *B*, cytostome; *Ma*, macronucleus; *Mi*, micronucleus; *V.C*, contractile vacuole. (After Roux.)

bristles very long and fine, forming a central girdle, but not situated in an equatorial groove or furrow. Macronucleus oval to kidney-shaped. Contractile vacuole in the anterior half of the body. Common in stagnant water of ponds.

Dimensions.—Length up to 40μ.

Remarks.—The specimens examined at Lahore were rounded and measured only 25μ in length. The organism possessed comparatively few central bristles, and only a few (6 or 7) of the larger cilia at the anterior end.

This species was originally included in the genus *Trichoda* O. F. Müll., but Dujardin (1841), recognizing the differences as regards the position of the mouth and the arrangement of the adoral ciliary wreath, made *Trichoda grandinella* O. F. Müll. the type of the new genus *Halteria*.

Habitat.—Pond water : PUNJAB, Lahore.

162. **Halteria** sp.

†*Halteria* sp., Chaudhuri, 1929, p. 54, pl. iii, fig. 9.

Habitat.—Soils from N.W. FRONTIER PROVINCE, Peshawar, and CENTRAL INDIA, Indore.

2. Family TINTINNIDÆ Claparède & Lachmann, 1858.

With a gelatinous or pseudochitinous lorica, to the bottom of which the contractile posterior end of the body is attached by an elongated stalk The oral funnel lies within the adoral zone, which forms a complete ring. The family is rich in marine plankton forms, and includes only a few freshwater forms.

Kofoid and Campbell (1929) raise the family to the status of a suborder, and divide it into a number of families. Their work should be referred to for a monographic treatment of the group.

Genus **TINTINNOPSIS** Stein, 1867.

Tintinnus, part, Ehrenberg, 1840 ; Claparède & Lachmann, 1858–61, p. 195.
Tintinnopsis, Stein, 1867, pp. 154, 168.
Codonella, Häckel, 1873 *b*, v, vii, p. 565.
Tintinnopsis, Kent, 1880–2, p. 617 ; Bütschli, 1887–9, p. 1735 Häkson, 1903, p. 409 ; Calkins, 1926, p. 409 ; Lepsi, 1926 *a*, p. 75 ; Kahl, 1930–5, p. 516.

Body campanulate or pyriform, attached posteriorly by a slender retractile pedicle within a membranous cylindrical lorica without a neck-like portion ; lorica wall single, simple, with numerous adherent sand-grains or other foreign particles. Peristomial cilia forming two complete and independent

ciliary circlets, those of the outer series flexible and tentaculiform, those of the inner short and cirrose. General surface of the body traversed longitudinally from one end to the other by rows of short cilia, between which intervene bare interspaces of considerable extent.

Marine or freshwater.

163. **Tintinnopsis lacustris** (Entz sen.). (Fig. 140.)

Codonella lacustris, Entz sen., 1885, pp. 196–200, pl. xiii, figs. 10–16.
†*Codonella lacustris*, Daday, 1898, p. 8.
Tintinnopsis lacustris forma *lævis*, Entz jun., 1909 *b*, p. 207, pl. iv, fig. 2; Fauré-Fremiet, 1923, pp. 87–90, fig. 28.
Codonella lacustris, Lepsi, 1926 *a*, p. 79, fig. 385.
Codonella cratera, Kahl, 1930–5, p. 517, fig. 82, *25*, *42*, *43*.

Body cylindroid, nearly truncated anteriorly by the edge of the peristomial lip, acuminated posteriorly, and with a short pedicle. Lorica cylindrical, with a round base, rigid, and encrusted with foreign particles or clearly arenaceous. In freshwater plankton.

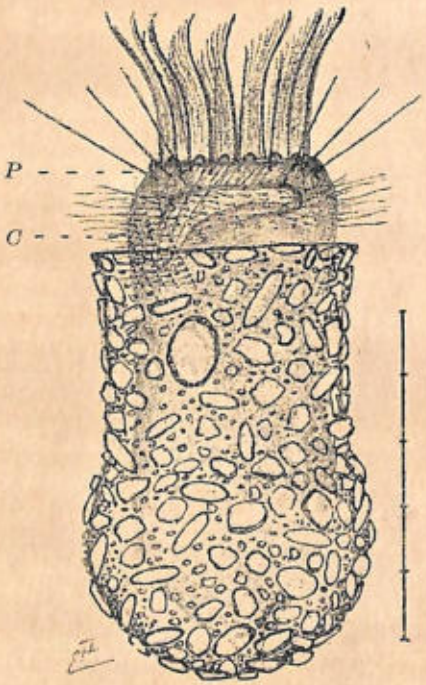


Fig. 140.—*Tintinnopsis lacustris* (Entz sen.). *P*, peristomial lip showing the bristles on its external border; *C*, body cilia. (After Fauré-Fremiet.)

Dimensions.—Length of the animal about 80μ; length of the lorica about 65μ, width 40μ.

Remarks.—*Tintinnopsis lacustris* is a widely distributed species which has often been described (as, for instance, by Daday and Lepsi) under the name *Codonella lacustris*. In both *Codonella* and *Tintinnopsis* the test is rigid and chitinous, and is open at the anterior end only. In *Codonella* the test shows a definite neck-like portion, and the anterior decorations and openings are absent or feeble. The species, as described by Entz sen. (1885) and observed by Daday (1898), should be referred to the genus *Tintinnopsis*. Entz jun. has shown that there are two distinct forms of the species, the one described by Entz sen., as defined above and which he named forma *lævis*, and another in which the lorica is abruptly narrowed in the form of a cone, and presents a clearly reticulate structure, forma *reticulata*. Fauré-Fremiet (1923) has given a full description of the former, and the figure given is taken from his work.

Habitat.—Ceylon, swamp of Madatugama and neighbourhood of Kalawewa Lake.

164. **Tintinnopsis ovalis** Daday. (Fig. 141.)

†*Tintinnopsis ovalis*, Daday, 1898, p. 8.
Tintinnopsis ovalis, Kahl, 1930–5, p. 517, fig. 82, *46*.

Lorica uniformly oval, widening from the oral end, and broadly rounded posteriorly.

Length 38–45μ.

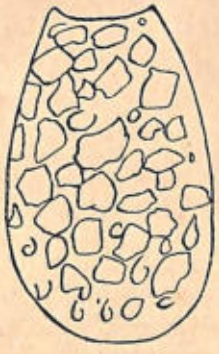


Fig. 141.—*Tintinnopsis ovalis* Daday. Lorica only shown. (After Daday.)

Remarks.—Entz jun. regards this form as a modification of *Tintinnopsis* (*Codonella*) *lacustris*.

Habitat.—Swamp of Madatugama : Ceylon.

INCERTÆ SEDIS.

Genus **OCTOCIRRUS** Madhava Rao, 1928.

Characters of the genus not given.

165. **Octocirrus sphæratus** Madhava Rao. (Fig. 142.)

†*Octocirrus sphæratus*, Madhava Rao, 1928, p. 116, pl. ii, figs. 3–5.

Body somewhat ovoid, broadly rounded anteriorly and narrower posteriorly. At the anterior end and helping in locomotion there are eight cirri as long as the body. Cytoplasm differentiated into ectoplasm and endoplasm. Contractile vacuole single, median. Macronucleus and micronucleus not observed. Encysts under unfavourable conditions, and immediately after encystment it exhibits short cilia all round the body (*sic*).

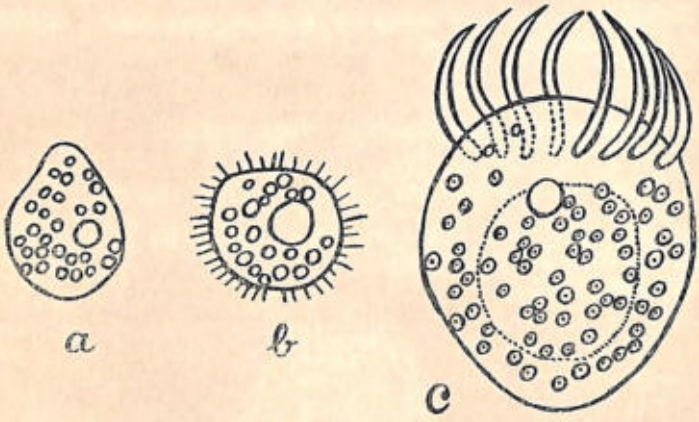


Fig. 142.—*Octocirrus sphæratus* Madhava Rao. *a*, cyst; *b*, stage, with cilia all round; *c*, adult stage. (After Madhava Rao.)

Dimensions.—Length of the body 30 μ.

Remarks.—This form is not adequately characterized, for such important characters as the peristome, macronucleus and micronucleus are not described. The encysted condition is described as ciliated, which is very unusual. It may have been an imperfectly observed *Strombidium*.

Habitat.—Soil: MYSORE.

ZOOLOGICAL GARDEN CALCUTTA

III. Suborder *ENTODINIOMORPHA* Reichenow.

Body generally oval, often somewhat dorso-ventrally flattened. Body cilia generally absent. The adoral zone consists of cirri, forms a complete circle round the peristome, and is continued further backwards for a short extent. In certain genera one or more additional zones of cirri present on different parts of the body, quite apart from the peristome. Contractile vacuoles one or more. Macronucleus usually band-shaped, elongated in the direction of the long axis of the body, lying between the oral funnel and the dorsal wall of the body. Micronucleus single, lying close to or in a depression of the macronucleus. The posterior end of the body often drawn into spines and processes of various forms and arrangement. Endoparasites, almost exclusively of the Ungulate mammals. They occur in the rumen or the reticulum of the stomach of the ruminants, in the cæcum of the horse, or the intestine of the chimpanzee and gorilla, and certain small rodents of South America.

The rumen (paunch) and the reticulum (honeycomb) of the ruminant stomach are œsophageal derivatives, and as such contain no glands to secrete either acid or ferments. The contents consist of water and large quantities of saliva mixed with the partially triturated food of the animal, which consists of succulent or dried plants and grain. The fluid serves as an ideal medium for the growth of Ciliates, Flagellates, amœbæ, and Bacteria, and there is a Protozoan fauna more or less specific to the ruminants.

By some these organisms are regarded not as parasites, but as symbionts that assist in digestion and are themselves digested lower down the alimentary canal. The few that escape being digested pass out with the fæces and encyst on the grass. The cysts are swallowed with the grass and infect other hosts.

Identification Table of Families.

1 (2). Adoral zone of membranelles always present, and in addition a dorsal zone of membranelles which are directed forwards, or a number of accessory membranelle zones may be present ..... [St., p. 274. **Ophryoscolecidæ**

2 (1). Besides the adoral zone at least two broad rows of cirri present, which spring from the anterior wall of the furrow and have their points directed backward... **Cycloposthidæ*** Poche.

Family OPHRYOSCOLECIDÆ Stein, 1867.

Parasitic forms of curious shapes with a thick periplast and a retractile peristome. Cilia generally absent. The adoral zone of membranelles is a complete circle, and in some genera there is an additional ring of cirri, also directed forwards, situated at the bottom of a furrow. These cirri are also capable of being drawn backwards, in which condition the margins of the groove close over them. Posterior end of the body often drawn out into spines or other processes of peculiar form and arrangement. The family is almost entirely confined to the stomach of ruminants.

The original genera included in the family Ophryoscolecidæ—*Entodinium*, *Diplodinium*, and *Ophryoscolex*—have continually been split up and recombined as our knowledge of their morphology has increased. The genus *Diplodinium* was established by Schuberg (1888) to include species of Ophryoscolecidæ having a short dorsal membranelle zone in addition to the adoral membranelle zone. Crawley (1923) set up the genus *Epidinium*, including in it species with the dorsal zone located considerably behind the level of the adoral zone, thus separating Sharp's *Diplodinium ecaudatum* from *Diplodinium* s. str. The main skeletal complex of *Epidinium* is similar to that of *Ophryoscolex*, being composed of three plates in each. Two species of *Epidinium*, in which the main skeletal complex consists of five plates, have been separated into a new genus *Epiplastron* by Kofoid and MacLennan (1933). Awerinzew and Mutafowa (1914) described the genus *Metadinium*, which Buisson (1923) and Dogiel (1927) considered unjustified, but Kofoid and MacLennan (1932) have re-established it. *Diplodinium* was further revised by Dogiel (1927) and divided into four subgenera—*Anoplodinium*, *Eudiplodinium*, *Polyplastron*, and *Ostracodinium*—without retaining the name *Diplodinium* for one of the subgenera, as required by the International Rules of Zoological Nomenclature. Since the type-species *D. dentatum* falls within the subgenus *Anoplodinium*, Kofoid and MacLennan consider the name *Anoplodinium* as a synonym of *Diplodinium*, the true name of the typical subgenus.

Kofoid and MacLennan consider that the four subgenera established by Dogiel show important differences in nuclear structure and skeletal parts which distinctly separate them; they therefore raise these subgenera to full generic rank. As they found two distinct groups of species included in *Diplodinium* s. str., *Diplodinium* is further restricted, and a

new genus, *Eodinium*, described. *Eudiplodinium* has been restricted, and a new genus, *Eremoplastron*, established. Lastly, Dogiel's original description of *Polyplastron* has been retained, and the species described by him later (1928) has been put in a genus *Elytroplastron*.

In the two genera *Polydinium* and *Elephantophilus* recently described by Kofoid (1935) there are numerous accessory membranelle zones extending spirally over the elongated body. The family Ophryoscolecidæ may be divided into two subfamilies as follows :—

1 (2).	With an adoral membranelle zone, and with or without a dorsal zone. One to five skeletal plates. Contractile vacuoles usually one to twelve in number, located on the dorsal side adjacent to the macronucleus	[Kofoid, p. 275. OPHRYOSCOLECINÆ
2 (1).	With an adoral membranelle zone, but without a dorsal zone. With numerous accessory membranelle zones in a descending right spiral over the elongated body. One to three skeletal plates. Contractile vacuoles numerous, in irregular rows posterior to the accessory membranelle zones	[Kofoid, p. 356. POLYDINIINÆ

1. Subfamily OPHRYOSCOLECINÆ Kofoid, 1935.

Ophryoscolecidæ with an adoral membranelle zone and with or without a dorsal zone. One to five skeletal plates present. Contractile vacuoles usually one to twelve in number, located on the dorsal side adjacent to the macronucleus.

Key to Indian Genera.

1	(3).	With only one adoral membranelle zone, no dorsal membranelle zone....	2.
2.		No skeletal plates ; only one contractile vacuole ; macronucleus simple, band-shaped, rarely oval ; with or without posterior spines	[p. 277. ENTODINIUM St.,
3	(1).	With a short dorsal membranelle zone in addition to the adoral zone.....	4.
4	(20).	With dorsal membranelle zone on the same level as the adoral zone.....	5.
5	(8).	No skeletal plate	6.
6	(7).	Macronucleus straight, rod-like, beneath the dorsal surface of the body ; two contractile vacuoles	[MacL., p. 309. EODINIUM Kof. &
7	(6).	Macronucleus with its anterior third bent ventrally at an angle of 30°–90°, beneath the right surface of the body ; two contractile vacuoles	[p. 312. DIPLODINIUM Schub.,

8 (5).	With one or more skeletal plates	9.
9 (15).	With a single skeletal plate beneath the right surface	10.
10 (13).	Skeletal plate narrow	11.
11 (12).	Macronucleus triangular or rod-like, with its anterior end often bent ventrally ; two contractile vacuoles .	[& MacL., p. 324. EREMOPLASTRON Kof.
12 (11).	Macronucleus rod-like, with its anterior end enlarged to form a hook with its concavity towards the dorsal aspect ; cuticle and ectoplasm thick ; two contractile vacuoles	[p. 330. EUDIPLODINIUM Dog.,
13 (10).	Skeletal plate broad	14.
14.	Two to six contractile vacuoles in a row beneath dorsal surface ; œsophageal fibres heavy and extending to posterior end of the body.....	[p. 335. OSTRACODINIUM Dog.,
15 (9).	With two or more skeletal plates	16.
16 (19).	With two skeletal plates beneath the right surface	17.
17 (18).	Macronucleus large, with two or three prominent dorsal lobes ; contractile vacuoles two, lying close to the macronucleus ; cuticle and ectoplasm heavy	[Mutaf., p. 332. METADINIUM Awer. &
18 (17).	Macronucleus narrow, rod-like ; contractile vacuoles two, separated from the macronucleus ; cuticle and ectoplasm thin	[& MacL., p. 329. DIPLOPLASTRON Kof.
19 (16).	With two skeletal plates beneath right surface, a small plate beneath ventral surface, and a long plate beneath the left surface ; cuticle and ectoplasm heavy ; conspicuous œsophageal fibrils	[Kof. & MacL., p. 334. ELYTROPLASTRON
20 (4).	With dorsal membranelle zone located farther back on the body.	
21 (22).	Dorsal membranelle zone behind the anterior end of the body ; main skeletal complex composed of three plates not extending into the main caudal spine ; two contractile vacuoles	[p. 343. EPIDINIUM Crawley.
22 (21).	Dorsal membranelle zone forming a girdle extending three-fourths the distance around the middle of the body ; skeletal complex of three plates extending the length of the right ventral side, even into the main caudal spine ; 9–15 vacuoles ranged round the body in two transverse rows	[p. 352. OPHRYOSCOLEX St.,

Genus **ENTODINIUM** Stein, 1858.

Entodinium, Stein, 1858, p. 69; 1859 *a*, p. 58; 1867, pp. 164, 168; Kent, 1880–2, p. 653; Schuberg, 1888, pp. 366–7; Bütschli, 1887–9, p. 1738; Dogiel, 1925 *d*, pp. 43–65; 1927, pp. 35–71; 1928 *b*, pp. 328–9; Calkins, 1926, p. 409; 1933, p. 513; Wenyon, 1926, p. 1211; Reichenow, 1929, p. 1199; Kofoid & MacLennan, 1930, pp. 471–544, pls. xlix–lii & 17 text-figs; Kofoid & Christenson, 1934, pp. 347–52; Das-Gupta, 1935, pp. 160–5.

Body ovoid, anterior end with a spiral row of cirri (adoral

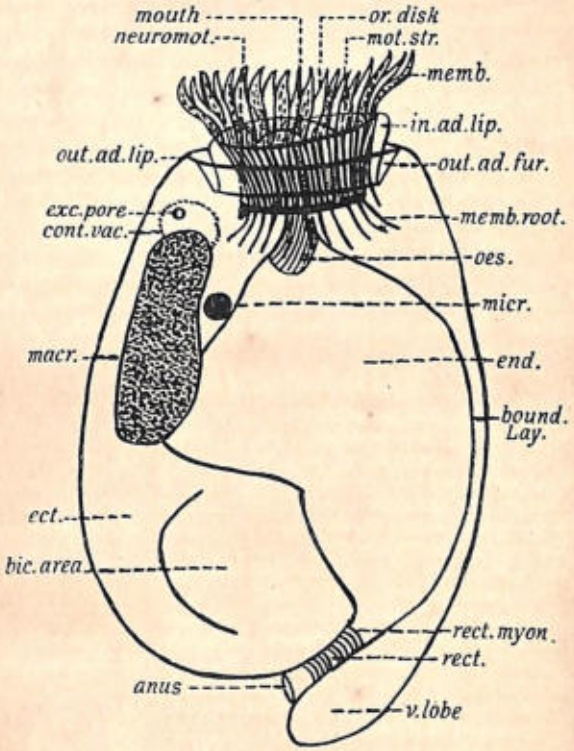


Fig. 143.—*Entodinium biconcavum* Kof. & MacL. Semidiagrammatic lateral view showing location and structure of the principal organelles. The surface striations are omitted for the sake of clearness. ×2000. *anus*, anus; *bic.area*, biconcave area; *bound.lay.*, boundary layer; *cont.vac.*, contractile vacuole; *ect.*, ectoplasm; *end.*, endoplasm; *exc.pore*, excretory pore; *in.ad.lip*, inner adoral lip; *macr.*, macronucleus; *memb.*, membranelle; *memb.root*, membranelle rootlet; *micr.*, micronucleus; *mouth*, cytostome; *mot.str.*, motor strand; *neuromot.*, neuromotorium; *oes.*, œsophagus; *or.disk*, oral disk; *out.ad.fur.*, outer adoral furrow; *out.ad.lip*, outer adoral lip; *rect.myon.*, rectal myoneme; *rect.*, rectum; *v.lobe*, ventral lobe. (After Kofoid & MacLennan.)

membranelle zone) leading to a cytostome and œsophagus. No dorsal membranelle zone. No skeletal plates. Only one contractile vacuole. Macronucleus simple band-shaped, rarely oval; micronucleus ventral and situated somewhat to the left of the macronucleus. With or without posterior spines. Small to medium-sized (20–120 μ long).

The principal features of structure can be clearly seen from the accompanying figure, and a careful study of this figure will be useful in following the descriptions of various species.

Remarks.—Jameson (1925) recorded *E. bursa* Stein and *E. dubardi* Buisson, and described *E. ovale* from the stomach of the mouse-deer from Ceylon; Kofoid and MacLennan (1930) have described twenty species from the stomach of *Bos indicus* from India and Ceylon. Kofoid and MacLennan have been able to arrange more than half of these species in groups, each consisting of two or more species, which show a marked similarity in a number of different structures, particularly in the shape and position of the macronucleus and contractile vacuole, the shape of the endoplasmic sack, and the structure of the rectum, and which differ from one another in only one or two features, usually spines, size, shape, or proportions. These groups are adopted in the following pages.

Key to Indian Species.

1 (28).	Without caudal processes	2.
2.	Very small to medium sized, body laterally compressed, not curved	3.
3 (5).	Macronucleus bent anteriorly in a hook-like manner	4.
4.	Very small, oval, 20–40 μ	*E. ovale* Jameson, [p. 303.
5 (3).	Macronucleus not bent	6.
6 (8).	Macronucleus not extending beyond the anterior half of the body	7.
7.	Medium sized, oval, 51–80 μ macronucleus short and massive, scarcely reaching the middle	*E. anteronucleatum* [*læve* Dog., p. 294.
8 (6).	Macronucleus extending beyond the anterior half of the body	9.
9 (22).	Very small or small	10.
10 (13).	Very small	11.
11 (12).	Ovoid, 22–32 μ; macronucleus narrow and long, over $\frac{1}{2}$ body-length	*E. nanellum* Dog., [p. 302.
12 (11).	Elongated oval, tapering posteriorly, 26–35 μ; macronucleus ovoidal or spherical, situated about the middle of the body	*E. chatterjeei* Das- [Gupta, p. 297.
13 (10).	Small, over 30 μ	14.
14 (21).	Body ovoid	15.
15 (16).	Small, markedly elongated (ratio of length to breadth 2·35); endoplasmic sack with a characteristic concavity.	*E. elongatum* Dog., [p. 291.
16 (15).	Small, not markedly elongated (ratio of length to breadth 1·5–1·7), endoplasmic sack without a concavity	17.

17 (18). Body broad (ratio of length to breadth 1·5–1·6); dorsal and ventral sides convex ..... [p. 284. *E. dubardi* Dog.,

18 (17). Body less broad (ratio of length to breadth 1·7–1·75) ..... 19.

19 (20). Dorsal and ventral sides nearly parallel..... *E. simplex* Dog., p. 308.

20 (19). Dorsal and ventral sides convex..... *E. ovoideum* Kof. & [MacL., p. 305.

21 (14). Small, pyriform, 39–46 μ; macronucleus curved, club-shaped, long. $\frac{2}{3}$ body-length ..... *E. contractum* Kof. & 23. [Chr., p. 298.

22 (9). Medium sized or large ..... 24.

23. Medium sized, ellipsoid, above 50 μ ..

24 (25). Macronucleus long, beginning close to the anterior end of the body and extending $\frac{2}{3}$ body-length ..... [p. 304. *E. ovinum* Dog.,

25 (24). Macronucleus long, over $\frac{3}{4}$ body-length ..... 26.

26 (27). Mouth smaller, sides of the body more strongly convex ..... [MacL., p. 284. *E. ellipsoideum* Kof. &

27 (26). Mouth larger, sides of the body less convex ..... *E. bursa* St., p. 282.

28 (1). With caudal lobes or spines..... 29.

29 (46). With only one caudal process ..... 30.

30 (38). Caudal process in the form of a prominent ventral lobe ..... 31.

31 (36). Posterior dorsal region not with biconcave areas ..... 32.

32 (35). Small ..... 33.

33 (34). Ellipsoid, 39–51 μ, macronucleus long, from $\frac{2}{3}$ to $\frac{3}{4}$ body-length ..... [Dog., p. 286. *E. longinucleatum*

34 (33). Rhomboid, 30–47 μ, macronucleus thin, wedge-shaped, from $\frac{1}{2}$ to $\frac{2}{3}$ body-length ..... [& MacL., p. 306. *E. rhomboideum* Kof.

35 (32). Medium sized, 52–82 μ; pre-anal lobe obliquely truncated; macronucleus not extending beyond the middle of the body..... [p. 295. [*monolobum* Dog., *E. anteronucleatum*

36 (31). Posterior dorsal region with bilateral biconcave areas..... 37.

37. Small, oval, 28–41 μ; macronucleus short stumpy to long band-like, set at an angle to the dorsal mid-line .. [& MacL., p. 290. *E. biconcavum* Kof.

38 (30). Caudal process in the form of a pre-anal spine ..... 39.

39 (41). Ventral spine small, parallel to main axis ..... 40.

40. Very small, oval, 24–30 μ; macronucleus broad, wedge-shaped, from $\frac{1}{2}$ to $\frac{2}{3}$ body-length ..... [MacL., p. 296. *E. brevispinum* Kof. &

41 (39). Ventral spine large, curved dorsally .. 42.

42 (45). Very small ..... 43.

43 (44). Elongated oval, 28–41 μ; macronucleus narrow, band-like, from $\frac{1}{2}$ to $\frac{3}{4}$ body-length ..... [p. 288. *E. rostratum* Fior.,

44 (43). Oval, 25–32 μ; macronucleus broad, elongated, from $\frac{1}{2}$ to $\frac{2}{3}$ body-length.. [MacL., p. 301. *E. laterospinum* Kof. &

45 (42). Small, rotund, 40–53 μ; macronucleus slightly curved, rod-like, about $\frac{1}{2}$ body-length ..... [p. 283. *E. curtum* Kof. & Chr.,

46 (29).	With more than one caudal process...	47.
47 (66).	With two caudal processes	48.
48 (64).	With dorsal and ventral spines or processes	49.
49 (52).	With two spines, one dorsal and one ventral	50.
50 (51).	Small, 38–58 μ, with distinct dorsal fin with a sharp dorsal spine at its posterior end, and a small ventral spine; macronucleus band-like, $\frac{1}{2}$ body-length	[MacL., p. 287. *E. pisciculum* Kof. &
51 (50).	Small, 38–51 μ, with heavy dorsal and ventral spines; macronucleus band-like, $\frac{3}{4}$ body-length	[MacL., p. 300. *E. gibberosum* Kof. &
52 (49).	With two processes, one dorsal and one ventral	53.
53 (55).	Only one of the processes lobe-like....	54.
54.	Small, broad, 30–46 μ; pre-anal process rounded, lobe-like, post-anal pointed spine; macronucleus elongated	[Dog., p. 285. *E. loboso-spinosum*
55 (53).	Both processes more or less lobe-like ..	56.
56 (62).	Macronucleus elongated, sausage-shaped	57.
57 (59).	Macronucleus not extending beyond the middle	[p. 295.
58.	Medium-sized, both lobes short	58. [*dilobum* Dog., *E. anteronucleatum*
59 (57).	Macronucleus extending beyond the middle	60.
60 (61).	Very small, subspherical, posteriorly narrowed, 30–40 μ; caudal lobes transversely truncated, lying close to each other, separated by a narrow slit; macronucleus elongated	[p. 295. *E. bimastus* Dog.,
61 (60).	Short and broad, 42–55 μ; caudal lobes more or less pointed, separated by a distinct bay	[p. 299. *E. furca dilobum* Dog.,
62 (56).	Macronucleus spherical, situated about the middle of the body	63.
63.	Medium sized, broad, 50–60 μ; caudal lobes small and pointed	[p. 307. *E. setnai* Das-Gupta,
64 (48).	With two caudal spines, one on each side of the ventral lobe	65.
65.	Very small, oval, 31–40 μ, posterior dorsal region depressed laterally, forming bilateral biconcave areas; macronucleus short ovoid to long band-like, set at an angle to the dorsal mid-line	[p. 291. *E. bifidum* (Dog.),
66 (47).	With three caudal processes	67.
67 (82).	With one dorsal and two ventral spines, one on each side of ventral lobe.....	68.
68 (71).	Contractile vacuole in the middle of the left lateral surface	69.
69 (70).	Very small, ellipsoid, 19–28 μ, right ventral spine a small triangular flap; macronucleus broad, wedge-shaped, $\frac{1}{2}$ to $\frac{2}{3}$ body-length	[MacL., p. 292. *E. laterale* Kof. &
70 (69).	Very small to small, broad, 29–45 μ, right ventral spine broad flange-like;	

	macronucleus broad, wedge-shaped, ½ to ⅔ body-length	[& MacL., p. 293. *E. rectangulatum* Kof.
71 (68).	Contractile vacuole to the left of the macronucleus	72.
72 (79).	Postero-dorsal region without bilateral biconcave areas.....	73.
73 (76).	Macronucleus elongated	74.
74 (75).	Very small, short and stout, 25–39 μ, strongly convex surfaces; macronucleus ⅓ of the body-length	[Kof. & MacL., p. 286. *E. acutonucleatum*
75 (74).	Medium sized to large, strongly convex surfaces; macronucleus may or may not extend beyond the middle of the body	*E. caudatum* St., p. 296.
76 (73).	Macronucleus ovoid, not extending beyond the middle.	
77 (78).	Very small, broadly oval, 25–30 μ; dorsal spine as long as the body	[Das-Gupta, p. 305. *E. ovoido-nucleatum*
78 (77).	Very small, broadly oval, 30–35 μ; dorsal spine not very long, arising from the right lateral surface	[Gupta, p. 299. *E. ekendræ* Das-
79 (72).	Postero-dorsal region with bilateral biconcave areas.....	80.
80 (81).	Small, oval, 32–42 μ; dorsal spine broad, triangular, ventral spines large; macronucleus short to long band-like, ½ to ⅔ of the body-length, set at an angle to dorsal mid-line	[MacL., p. 289. *E. acutum* Kof. &
81 (80).	Small oval, 34–40 μ, dorsal spine short, narrow, ventral spines large, the right ventral simple or bifurcate; macronucleus short, broad, ½ to less than ⅔ the body-length, set at an angle to the dorsal mid-line	[MacL., p. 289. *E. aculeatum* Kof. &
82 (67).	With one dorsal spine, one ventral spine, and one lateral lobe or spine..	83.
83 (84).	Very small, short, broad, ellipsoid, 22–33 μ, with three prominent ribs running the length of the body, dorsal and left ventral ribs terminating in caudal spines, thin blade-like right ventral rib in the lateral lobe; macronucleus very short, stout, ⅔ to almost the body-length, following the spiral course of the dorsal rib....	[MacL., p. 308. *E. tricostatum* Kof. &
84 (83).	Small, broad, 25–40 μ, spines long, triangular, one dorsal, one ventral, and one large spine on the left side; macronucleus wedge-shaped, ½ to ¾ body-length	[MacL., p. 301. *E. indicum* Kof. &

"BURSA" GROUP.—The features of this group are stated to be their large size (60–122 μ) and their habit of eating other Ciliates. The macronucleus, the vacuole, and the heavy slit rectum furnish evidence of close relationship. *E. bursa* and *E. ellipsoideum* belong to this group, and *E. curtum*, *E. dubardi*, and *E. loboso-spinosum*, though smaller in size, may also be placed here.

166. **Entodinium bursa** Stein. (Fig. 144.)

Entodinium bursa, Stein, 1858, pp. 69–70 ; 1867, p. 164 ; Schuberg, 1888, pp. 366, 404–9, figs. 6, 29.
†*Entodinium bursa*, Jameson, 1925, p. 407.
†*Diplodinium bursa*, Jameson, 1925, p. 408.
Entodinium vorax forma *vorax*, Dogiel, 1925 *a* ; 1927, pp. 46–7, fig. 10, *a*, *b*.
Entodinium bursa, Dogiel, 1927, p. 68, fig. 35 ; Kofoid & MacLennan, pp. 496–7.
†*Entodinium vorax*, Das-Gupta, 1935, p. 160.

Body stoutly ellipsoid, with relatively plane surfaces ; length 1·4 times the dorso-ventral diameter, the anterior end flattened to form the oral area ; posterior end rounded. Cytostome relatively large. Contractile vacuole single, lateral, somewhat behind the anterior end. Anal groove leads into

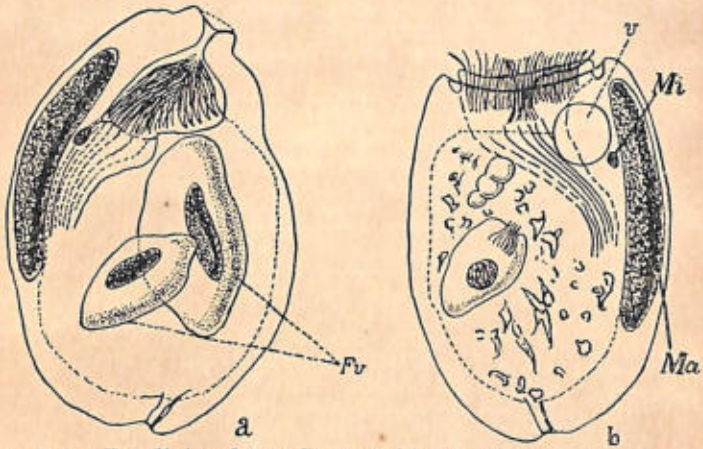


Fig. 144.—*Entodinium bursa* St. *a*, with retracted ; *b*, with expanded adoral zone. *Fv*, small *Entodinium* specimens in the endoplasmic sack ; *Ma*, macronucleus ; *Mi*, micronucleus ; *v*, contractile vacuole. (After Dogiel.)

a depression at the posterior end of the body. Macronucleus large, cylindrical, extending from a little distance behind the oral end to almost the posterior end of the body. Micronucleus small, lying close beside the macronucleus.

Dimensions.—Length 80–121 μ ; breadth 52–83 μ.

Feeds on other Ciliates.

Remarks.—Dogiel (1927) lists *E. bursa* among the "species incertæ," and thinks that the form described under this name by Schuberg was a complex of species, all of which are now listed under different names, e. g., *E. simplex*, *E. ovinum*, *E. dubardi*, *E. parvum* and *E. vorax*, and, further, that there is now left no non-caudate form to which the name *E. bursa*

could apply. Dogiel has ignored the accepted principle of nomenclature, that in revising a species some part must be left under the original name. Kofoid and MacLennan (1930) consider *E. vorax vorax* Dogiel, 1925, to be a synonym of *E. bursa* Stein.

In *E. bursa* the cytostome is larger than in *E. ellipsoideum*, and in expanded forms the sides are nearly parallel. The Ceylonese form closely resembles the European form, but the nucleus is bigger.

Habitat.—Stomach of *Tragulus meminna* Milne-Edwards (mouse-deer) : Ceylon. The material was collected by Dobell (1910). Also rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

167. **Entodinium curtum** Kofoid & Christenson. (Pl. X, fig. 2.)

†*Entodinium curtum*, Kofoid & Christenson, 1934, pp. 350–1, pl. xxv, fig. 5 ; fig. A, 5, 6.

Body rotund and stout, 1·21–1·56 dorso-ventral diameters in length. Dorsal and ventral surfaces convex, with the ventral convexity more prominent. One short ventral spine at the posterior end. Oral area circular and occupying a large part of the anterior face of the animal. Cytostome tilted to the left. Œsophagus is long, and curving to the right and dorsalwards ends on a level with the posterior third of the macronucleus. Its wall is composed of a number of feebly staining longitudinal fibrils. Boundary layer enclosing the endoplasmic sack lies directly underneath the pellicle on the lateral and ventral surfaces of the body, but forms a concavity dorsally for the ventral face of the macronucleus and the contractile vacuole. Contractile vacuole to the left of the anterior end of the macronucleus. Rectum sloping, with the anal opening at the extreme posterior end of the animal, just dorsal to the small spine. Macronucleus a slightly curved, stout, rod-like structure, rounded at both ends, lying in the dorsal middle line and extending about four-fifths of the length of the body. Micronucleus small, subspherical, close to the ventral surface of the macronucleus, at about one-fourth its length from its anterior end.

Dimensions.—Length 40–53 μ.

Feeds on Bacteria and very small pieces of plant débris.

Remarks.—*E. curtum* closely resembles *E. ellipsoideum* in general body form and proportions, in shape of the macronucleus and type of œsophagus, but differs in its smaller size and the possession of a short ventral spine.

Habitat.—Stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

168. **Entodinium dubardi** Buisson. (Fig. 145.)

Entodinium dubardi, Buisson, 1923 *b*, p. 98.
†*Entodinium dubardi*, Jameson, 1925, p. 407.
Entodinium dubardi forma *dubardi*, Dogiel, 1927, p. 42, fig. 5.
Entodinium dubardi dubardi, Wertheim, 1935, pp. 228–9, fig. 5.
†*Entodinium dubardi*, Das-Gupta, 1935, p. 160.

Body oval, length 1·55 times the dorso-ventral diameter, the anterior end truncated, strongly flattened laterally. Cytostome relatively small. Contractile vacuole single, situated to the left of the anterior end of the macronucleus. Macronucleus large, band-shaped or sausage-shaped, somewhat narrowed posteriorly. Micronucleus elongated, situated at or in front of the middle of the macronucleus.

Dimensions.—Length 30–40 μ, width 20–25 μ.

Remarks.—The relatively large ectoplasmic expansions of the sides and the prominent anal canal are the characteristic features of the species. In the forms from Ceylon the



Fig. 145.—*Entodinium dubardi* Buisson. (After Buisson.)

nucleus is larger, occupying the whole length of one side, and, as a rule, does not taper to a point. In addition no striping could be detected on the cuticle. In the specimens from *Capra hircus* the macronucleus is variable in size and usually reaches the middle of the dorsal side.

Habitat.—Stomach of *Tragulus meminna* Milne-Edwards (mouse-deer): CEYLON. The material was collected by Dobell (1910). Also rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

169. **Entodinium ellipsoideum** Kofoid & MacLennan. (Pl. IV, fig. 17.)

†*Entodinium ellipsoideum*, Kofoid & MacLennan, 1930, pp. 499–500, pl. lii, fig. 17; fig. F.

Body a stout ellipsoid, length 1·20–1·67 times the dorso-ventral diameter, the anterior end flattened to form the oral area, laterally compressed. Cytostome relatively small (0·38–

0·64 dorso-ventral diameters in diameter). Contractile vacuole to the left of the macronucleus, somewhat below the anterior end. Anus a narrow transverse slit. Macronucleus large, triangular, extending along the dorsal mid-line from the oral region past the middle of the body. Micronucleus ellipsoidal, lying in the middle half on the left side of the macronucleus, or slightly ventral.

Dimensions.—Length 65–120 μ.

Voracious feeder.

Remarks.—The species is distinguishable from *E. bursa* by the smaller cytostome and more strongly convex sides of the body.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

170. **Entodinium loboso-spinosum** Dogiel. (Fig. 146).

Entodinium dubardi (part), Buisson, 1923 *b*.
Entodinium dubardi forma *spinosum*, Dogiel, 1925 *a*, pp. 119–20.
Entodinium loboso-spinosum, Dogiel, 1927, pp. 60–1, fig. 27, *a–c*.
†*Entodinium loboso-spinosum*, Das-Gupta, 1935, p. 160.

Body moderately short and broad, both dorsal and ventral surfaces distinctly convex. Anterior end truncated, posterior

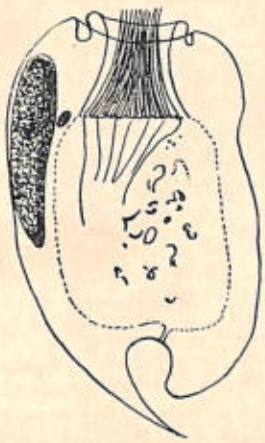


Fig. 146.—*Entodinium loboso-spinosum* Dogiel. (After Dogiel.)

end provided with two processes. One of these processes is pre-anal and is gently rounded at the end ; the other process arises from the dorsal (postanal) part of the posterior end of the body, is broad at its base, elegantly curved, and narrows sharply into a spine. Ciliary apparatus and endoplasmic sack do not present any characteristic feature. Macronucleus elongated, dorso-ventrally compressed, and closely

fitting against the dorsal surface of the body. Micronucleus lies about the middle of the macronucleus.

Dimensions of the examples from cattle and sheep:—Length 30–46 μ, breadth 20–31 μ; ratio of length to breadth 1·5.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

"LONGINUCLEATUM" GROUP.—This group is characterized by a long macronucleus extending along the length of the dorsal mid-line, a heavy boundary layer, and a well-developed slit-like rectum. Its members are short and stout, with strongly convex surfaces. *E. acutonucleatum* and *E. longinucleatum* belong to this group.

171. **Entodinium acutonucleatum** Kofoid & MacLennan. (Pl. I, fig. 1.)

†*Entodinium acutonucleatum*, Kofoid & MacLennan, 1930, pp. 503–4, pl. xlix, fig. 1; fig. G, 1, 2; Kofoid & Christenson, 1934, 1934, pp. 347–8, pl. xxv, fig. 1, fig. A, 1, 2, 13–18.

Body short and stout, length 1·10–1·44 times the dorso-ventral diameter, laterally compressed. Dorsal surface continued posteriorly in a sharp, but relatively broad, dorsal spine curving ventrally. Ventral lobe present, but relatively small, with two small spines, one on each side, curving dorsalward. Oral area inclined ventrally. Endoplasmic sack fairly clearly defined by the boundary layer. Contractile vacuole close to the left of the anterior end of the macronucleus. Rectum a wide thin-walled slit, opening by a small oval anus. Macronucleus elongated, extending along four-fifths of the dorsal mid-line. Micronucleus a small, ellipsoidal to spherical body, lying on the left ventral side of the anterior quarter of the macronucleus.

Dimensions.—Length 25–39 μ.

Feeds on plant débris, particularly pollen grains.

Remarks.—The specimens from *B. gaurus* show greater variation in size and shape of the extremities of the macronucleus, the spines are relatively longer, and the notch between the ventral spines is deeper than in those from *B. indicus*.

Habitat.—Stomach of *Bos indicus* Linn.; MADRAS, Coonoor; CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore.

172. **Entodinium longinucleatum** Dogiel. (Pl. I, fig. 2.)

Entodinium longinucleatum, Dogiel, 1925*d*, pp. 47–8, fig. 6; 1927, pp. 48–9, fig. 12.

†*Entodinium longinucleatum*, Kofoid & MacLennan, 1930, pp. 501–2, pl. xlix, fig. 2, fig. G, 3, 4; Kofoid & Christenson, 1934, pp. 351–2, pl. xxv, fig. 3, fig. A, 3, 4; Das-Gupta, 1935, p. 160.

Body ellipsoid, length 1·21–1·52 times the dorso-ventral diameter, anterior end broad and blunt, flattened laterally. Oral area relatively small. Ventral lobe prominent. Endoplasmic sack has a distinct boundary layer. Contractile vacuole close against the left side of the macronucleus, slightly anterior to the micronucleus. Rectum a broad transverse slit. Anus a narrow elliptical opening on the dorsal side of the base of the ventral spine. Macronucleus elongate, extending along the dorsal mid-line from two-thirds to three-quarters of the length of the body. Micronucleus small, spherical or ovoid, on the ventral side of the anterior quarter of the macronucleus.

Dimensions.—Length 39–51 μ.

Feeds on plant débris, particularly pollen grains.

Remarks.—This species differs from *E. acutonucleatum* in that the only caudal structure present is the ventral lobe instead of a lobe plus two lateral spines as in that species.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

"ROSTRATUM" GROUP.—This group is marked by a straight rod-like macronucleus, with the contractile vacuole lying anterior to it, and by the presence of a conspicuous excretory canal. The boundary layer is very weak and the rectum a simple cylinder with two steeply spiral myonemes rising from it. It includes *E. pisciculum* and *E. rostratum*.

173. **Entodinium pisciculum** Kofoid & MacLennan. (Pl. II, fig. 9.)

†*Entodinium pisciculum*, Kofoid & MacLennan, 1930, pp. 507–8, pl. I, fig. 9; fig. H, 3, 4.

Body long and slim, length 1·76–2·38 times the dorso-ventral diameter, gracefully tapering posteriorly to form the ventral spine, laterally compressed. Dorsal surface convex; ventral surface nearly plane. A thin cuticular flange along the dorsal mid-line with a fusiform projection near the anterior end and a sharp dorsal spine on the posterior end. Cytostome in contracted specimens a narrow transverse slit. Contractile vacuole directly anterior to the macronucleus. Rectum in the base of the ventral spine, with a small circular anus. Macronucleus straight, rod-like or band-like, extending along the dorsal mid-line in the middle half of the body, four to six times as long as wide. Micronucleus in a small depression in the macronucleus along the middle of the left ventral edge.

Dimensions.—Length 38–58 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—The shape of the body, with the prominent dorsal "fin," gives *E. pisciculum* a strikingly fish-like appearance. It is a large *E. rostratum*, whose morphology has been complicated by the addition of a flange along the dorsal mid-line.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

174. **Entodinium rostratum** Fiorentini. (Pl. II, fig. 6.)

Entodinium rostratum, Fiorentini, 1889, p. 19, pl. iv. *a*, fig. 3; Eberlein, 1895, pp. 270–1, pl. xviii, fig. 22; Schweier, 1900, pp. 92–3, pl. ii, fig. 36; Buisson, 1923 *b*, pp. 93–5, fig. 31.

Entodinium rostratum forma *rostratum*, Dogiel, 1927, pp. 52–3, fig. 18, *a–f*.

†*Entodinium rostratum*, Kofoid & MacLennan, 1930, pp. 505–7, pl. l, fig. 6; fig. H, 1, 2.

Non *Entodinium rostratum*, Gunther, 1900, pp. 640–8, figs. 12–14.

Body rather long and slim, length 1·50–2·18 times the dorso-ventral diameter. Dorsal surface convex, ventral surface concave. The dorsal side terminates in a short, broad dorsal lobe, the ventral side in a heavy, blunt spine. Cytostome in contracted forms a narrow transverse slit, in expanded forms circular. Contractile vacuole directly anterior to the macronucleus. Rectum at the base of the ventral spine, anus between the ventral spine and the dorsal lobe. Macronucleus straight, rod-like, extending along dorsal mid-line in the middle half of the body, four to six times as long as wide. Micronucleus in a small depression in the macronucleus, along the middle of the left ventral edge.

Dimensions.—Length 28–41 μ.

Feeds entirely on Bacteria and small Flagellates.

Remarks.—The length of the tail and the degree of concavity of the ventral surface vary widely in this species. The Indian specimens are of the short-tailed form.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

"BICONCAVUM" GROUP.—This group possesses a macronucleus of ordinary length but set at an angle to the dorsal mid-line. The endoplasmic sack tapers posteriorly to form a cone, and the rectum is stout and cylindrical, reinforced with transverse, circular myonemes. *E. aculeatum*, *E. acutum*, *E. biconcavum*, *E. bifidum*, and *E. elongatum* are included in this group.

175. **Entodinium aculeatum** Kofoid & MacLennan. (Pl. III, fig. 12.)

†*Entodinium aculeatum*, Kofoid & MacLennan, 1930, pp. 515–17, pl. li, fig. 12; fig. K.

Body oval, length 1·31–1·43 times the dorso-ventral diameter, strongly compressed laterally. Dorsal surface strongly convex, anterior portion of ventral surface convex, posterior portion flat or slightly concave. A short narrow dorsal spine; two large caudal spines, one on each side of the reduced ventral lobe. The right ventral spine extends farther towards the dorsal side, and may or may not be bifurcated. Cytostome a small opening in the anterior projection. Endoplasmic sack with its anterior portion shorter than in the other species of the group, but with the conical portion as long as in the other species. Rectrum narrow, cylindrical, opening to the exterior by the anus. Contractile vacuole near the dorsal mid-line, to the left of the macronucleus, somewhat behind its anterior tip. Macronucleus a short, broad body, located along the dorsal border, extending from near the anterior end to past the middle of the body, set at an angle to the dorsal mid-line. Micronucleus near the left ventral border of the middle third of the macronucleus.

Dimensions.—Length 34–40 μ.

Feeds on small plant débris, rarely on Bacteria or Flagellates.

Remarks.—Throughout the Ophryoscolecidæ a major trend in their evolution is the increasing complexity of the caudal ornament accompanied by a considerable variation in the details of the spines among individuals of the same species. The variation in a spine from simple to bifurcate, as seen in this species, has been described before by Dogiel from species of other genera.

Habitat.—Stomach of *Bos indicus* Linn.: Ceylon, Colombo.

176. **Entodinium acutum** Kofoid & MacLennan. (Pl. III, fig. 15.)

†*Entodinium acutum*, Kofoid & MacLennan, 1930, pp. 514–15, pl. li, fig. 15; fig. I, 3, 4.

Body oval, length 1·25–1·68 times the dorso-ventral diameter, laterally compressed. Convex on both dorsal and ventral surfaces. Three spines of nearly equal length—a broad triangular postero-dorsal spine and two large caudal spines, one on each side of the reduced ventral lobe. Cytostome a small opening in the anterior projection. Endoplasmic sack wide, tapering posteriorly to a cone. Rectum narrow, cylindrical, opening to the exterior by the anus. Contractile vacuole near the dorsal mid-line to the left of the macro-

nucleus somewhat behind its anterior tip. Macronucleus varies from a short form to a long band, on the average longer than in the other species of this group; located along the dorsal border, extending from near the anterior end past the middle of the body, and set at an angle to the dorsal mid-line. Micronucleus spherical, near the left ventral border of the middle half of the macronucleus.

Dimensions.—Length 30–42 μ.

Feeds on small plant débris, rarely on Bacteria or Flagellates.

Remarks.—The posterior biconcave region, as present in *E. biconcavum* and *E. bifidum*, is represented in this species by a biconcave region with the heavy dorsal rim prolonged into a dorsal spine; there is, however, no tendency for the right ventral spine to become bifurcated as in *E. aculeatum*.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

177. **Entodinium biconcavum** Kofoid & MacLennan. (Pl. III, fig. 14; fig. 143.)

†*Entodinium biconcavum*, Kofoid & MacLennan, 1930, pp. 509–11, pl. li, fig. 14; fig. 1, 1, 2; Das-Gupta, 1935, p. 164.

Body oval, length 1·15–1·52 times the dorso-ventral diameter, laterally compressed. Strongly convex on both dorsal and ventral surfaces; posterior dorsal region of the body depressed laterally, forming bilateral concave areas. A small blunt ventral lobe is the only caudal projection. Anterior end truncated at right angles to the main axis to form the broad oral area; adoral lips relatively heavy. Endoplasmic sack wide, tapering posteriorly to form a cone. Rectum narrow, cylindrical, pointing dorsally and opening to the exterior by the anus. Contractile vacuole at the left of the anterior end of the macronucleus near the dorsal mid-line. Macronucleus from a short stumpy to a long, thin band-like structure, extending along the dorsal border from the level of the attachment of the œsophagus to about the middle of the body, and set at an angle to the dorsal mid-line. Micronucleus small, spherical, near the left ventral border of the anterior third of the macronucleus.

Dimensions.—Length 28–41 μ.

Feeds on small plant débris, rarely on Bacteria or Flagellates.

Remarks.—This species is very similar to *E. elongatum* Dogiel in the general shape of the body and macronucleus, conical endoplasmic sack, cylindrical rectum, small food particles and ventral lobe; but it differs from that species in size, relative body proportions and in having both surfaces convex; in *E. elongatum* the dorsal side is convex and the ventral flat.

The specimens from *Capra hircus* are larger, measuring 39–45 μ in length and 30–34 μ in dorso-ventral diameter, and the macronucleus is narrow towards its anterior end and massive towards the posterior.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

178. **Entodinium bifidum** (Dogiel). (Pl. III, fig. 13.)

Entodinium rostratum forma *bifidum*, Dogiel, 1927, pp. 53–4, fig. 19, *a–c*.
Entodinium rostratum forma *bifidum*, aberration *æquicauda*, Dogiel, 1927, p. 54, fig. 19, *d*.
†*Entodinium bifidum*, Kofoid & MacLennan, 1930, pp. 511–13, pl. li, fig. 13; fig. J.

Body oval, length 1·50–1·90 times the dorso-ventral diameter, laterally compressed. Strongly convex on both dorsal and ventral surfaces; posterior dorsal region of body depressed laterally, forming bilateral concave areas. Two caudal spines, one on each side of the ventral lobe. Anterior end sharply truncated at right angles to the main axis to form a broad oral area; adoral lips relatively light. Endoplasmic sack wide, with a posterior cone. Rectum narrow, cylindrical, pointing dorsalwards, and opening to the exterior by a small circular anus situated between the ventral lobe and the posterior portion of the biconcave area. Contractile vacuole on the left of the anterior end of the macronucleus near the dorsal mid-line. Macronucleus from a short ovoid to a long, thin, band-like body, along the dorsal border, but set at an angle to the dorsal mid-line. Micronucleus small, spherical, near the left ventral border of the middle half of the body.

Dimensions.—Length 31–40 μ.

Feeds on small plant débris, rarely on Bacteria or Flagellates.

Remarks.—The caudal spines vary from short, insignificant projections to rather large spines.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor.

179. **Entodinium elongatum** Dogiel. (Fig. 147.)

Entodinium elongatum, Dogiel, 1927, pp. 45–6, fig. 9, *a–c*.
†*Entodinium elongatum*, Das-Gupta, 1935, p. 161.

Body very elongated, ventral surface almost flat, dorsal surface slightly convex. Posterior end of the body unarmed, somewhat obliquely truncated. Endoplasmic sack not symmetrically oval, but showing a dorsal diverticulum at its hinder end. Anal tube long, thin, and extending quite up to the posterior end. Contractile vacuole close to the anterior

end of the macronucleus. Macronucleus short and thick, symmetrically rounded at both poles, and not thickened at its anterior pole. Micronucleus lies about the middle of the macronucleus.

Dimensions.—Length 41–50 μ; breadth 17–22 μ; ratio of length to breadth 2·35.

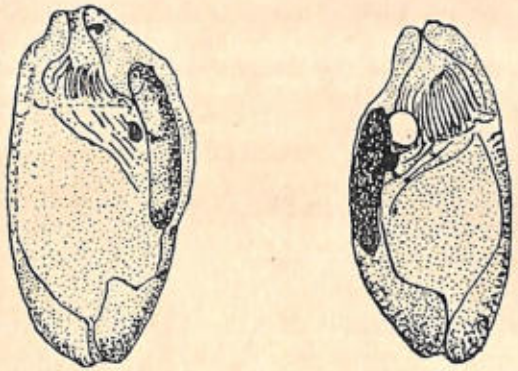


Fig. 147.—*Entodinium elongatum* Dogiel. *a*, left view; *b*, right view. (After Dogiel.)

Remarks.—This species is very similar to *E. nanellum*, but larger in dimensions, and the endoplasmic sack is relatively clearer.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

"LATERALE" GROUP.—This group is distinguished principally by the location of the contractile vacuole in the middle of the left lateral surface, by a conspicuous lateral flattening, and the short, stout, almost rectangular proportions of the body in side view. *E. laterale* and *E. rectangulatum* belong to this group.

180. **Entodinium laterale** Kofoid & MacLennan. (Pl. IV, fig. 16.)

†*Entodinium laterale*, Kofoid & MacLennan, 1930, pp. 518–19, pl. lii, fig. 16; fig. L, 1, 2; Das-Gupta, 1935, p. 163.

Body short and fairly broad, truncated ellipsoid in lateral outline, length 1·05–1·55 times the dorso-ventral diameter, laterally compressed. Dorsal and ventral surfaces both

convex, the dorsal more so than the ventral. The broad posterior part of the body terminates in three spines; the dorsal spine is long, thin and flattened laterally; left ventral spine fleshy; right ventral spine a small triangular flap. The broad oral area tipped ventrally at a slight angle. Endoplasmic sack a laterally compressed cylinder, ending anteriorly just behind the oral apparatus and posteriorly just above the base of the spines. Rectum slit-like, opening by a small oval anus. Contractile vacuole located in the middle of the left side just opposite the œsophagus. Macronucleus a broad wedge-shaped body, two to three times as long as wide, broader anteriorly, located along the dorsal mid-line. Micronucleus small, spherical, on the mid-region of the left ventral side of the macronucleus.

Dimensions.—Length 19–28 μ.

Feeds on Flagellates, amœbæ and plant débris.

Remarks.—The caudal spination of this species resembles that of *E. caudatum* Dogiel. The laterally flattened dorsal spine, the triangular right ventral spine and the rounded left ventral spine are present in both species. The contractile vacuole, however, lies at the left of the anterior end of the macronucleus in *E. caudatum* and in the middle of the left side of the body in *E. laterale*.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

181. **Entodinium rectangulatum** Kofoid & MacLennan. (Pl. IV, fig. 19.)

†*Entodinium rectangulatum*, Kofoid & MacLennan, 1930, pp. 519–21, pl. lii, fig. 19; fig. L, 3, 4; Das-Gupta, 1935, p. 163.

Body stout and heavy, length 1·07–1·48 times the dorsoventral diameter, laterally compressed. Dorsal and ventral surfaces equally convex; lateral surfaces almost flat. Posterior end of the body truncated, with three caudal spines; dorsal spine flattened laterally; left ventral spine fleshy; ventral and right side of the body continued posteriorly in a flange-like right ventral spine occupying one-third of the circumference of the body. The broad, shallow oral area set at right angles to the main axis, or slightly tipped ventrally. Endoplasmic sack a laterally compressed cylinder. Rectum slit-like, opening by a small oval anus. Contractile vacuole in the middle of the left side just opposite the œsophagus. Macronucleus broad, wedge-shaped, two to four times as long as wide, broader at the anterior end, and located along the

dorsal mid-line. Micronucleus small, ovoidal, on the mid-region of the left ventral side of the macronucleus.

Dimensions.—Length 29–45 μ.

Feeds on Flagellates, Bacteria, amœbæ and plant débris.

Remarks.—The specimens from *Capra hircus* differ from the description given above in their dimensions, measuring 40–50 μ in length and 25–30 μ in dorso-ventral diameter. The micronucleus is placed near the anterior end instead of near the middle of the macronucleus.

Habitat.—Stomach of *Bos indicus* Linn.: Madras, Coonoor; Ceylon, Colombo; rumen of *Capra hircus* Linn.: Bengal, Calcutta.

Unallocated Species.—The remaining species of *Entodinium* do not show any close relationships with one another, and cannot be arranged in groups.

182. **Entodinium anteronucleatum** forma **læve** Dogiel. (Fig. 148, *a*.)

Entodinium anteronucleatum forma *læve*, Dogiel, 1927, pp. 49–50, fig. 14.

†*Entodinium læve*, Das-Gupta, 1935, p. 162.

Body elongated oval, usually slightly compressed laterally, with the posterior end rounded. Endoplasmic sack usually

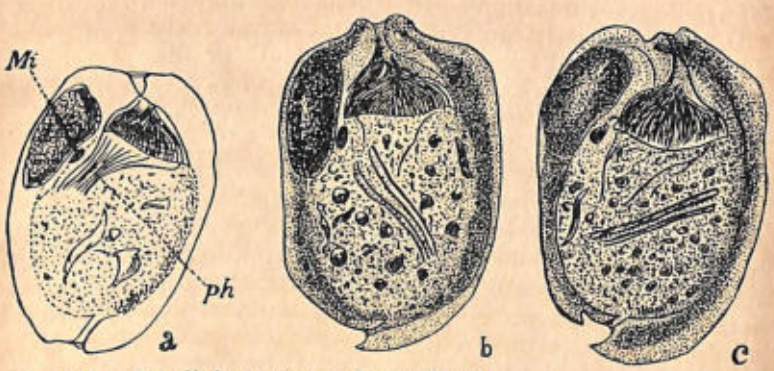


Fig. 148.—*Entodinium anteronucleatum* Dogiel. *a*, forma *læve*; *b*, forma *monolobum*; *c*, forma *dilobum*. *Mi*, micronucleus; *ph*, œsophagus. (After Dogiel.)

filled with food particles, consisting of chlorophyll granules, shreds of moss, etc. Macronucleus short and massive, is situated at some distance from the anterior end, and does not extend beyond the middle of the body. Micronucleus

oval and situated ventral to the posterior part of the macronucleus.

Dimensions.—Length 51–80 μ, breadth 39–49 μ; ratio of length to breadth 1·45.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

183. **Entodinium anteronucleatum** forma **monolobum** Dogiel. (Fig 148, *b*.)

Entodinium anteronucleatum forma *monolobum*, Dogiel, 1927, p. 50, fig. 15.
†*Entodinium monolobum*, Das-Gupta, 1935, p. 161.

General organization as in *E. anteronucleatum* forma *læve* except that the body is provided with a very short ventral lobe at the posterior end. The lobe is pre-anal and is bent dorsalwards in a hook-like manner.

Dimensions.—Length 52–82 μ, breadth 39–50 μ; ratio of length to breadth 1·45.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

184. **Entodinium anteronucleatum** forma **dilobum** Dogiel. (Fig. 148, *c*.)

Entodinium anteronucleatum forma *dilobum*, Dogiel, 1927, pp. 50–51, fig. 16.
†*Entodinium anteronucleatum*, Das-Gupta, 1935, pp. 161–2.

General organization as in *E. anteronucleatum* forma *monolobum* except that the posterior end of the body is provided with two lobes. The ventral pre-anal lobe is more prominent, and the dorsal lobe is only slightly developed, sometimes so slightly as to be scarcely recognizable.

Dimensions as in forma *monolobum*.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

185. **Entodinium bimastus** Dogiel. (Pl. II, fig. 10.)

Entodinium bimastus, Dogiel, 1927, pp. 55–6, fig. 21, *a–c*.
†*Entodinium bimastus*, Kofoid & MacLennan, 1930, pp. 528–30, pl. 1, fig. 10; fig. O, 3, 4.

Body subspherical, length 1·00–1·33 times the dorso-ventral diameter, flattened laterally. Oral area relatively small, with deep furrows but rather small lips. Posterior part of the body tapers rapidly to form a broad, roughly rectangular caudal lobe, distinctly divided into a dorsal and ventral half by the rectum. Contractile vacuole large, to the left of the anterior end of the macronucleus. Macronucleus flattened, wedge-shaped, broader anteriorly, four to

seven times as long as thick, closely following the curve of the body along the dorsal mid-line. Micronucleus on the left ventral edge of the middle part of the macronucleus.

Dimensions.—Length 30–40 μ.

Feeds on Bacteria and plant débris.

Remarks.—The subspherical body and broad rectangular caudal lobe serve to distinguish this species from all others of this genus.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

186. **Entodinium brevispinum** Kofoid & MacLennan. (Pl. IV, fig. 18.)

†*Entodinium brevispinum*, Kofoid & MacLennan, 1930, pp. 521–2, pl. lii, fig. 18; fig. M, 3–4.

Body small and oval, length 1·50–2·00 times the dorso-ventral diameter, laterally compressed, and with dorso-ventral diameter greatest near anterior end. Dorsal and ventral surfaces convex; ventral spine small, parallel to main axis. Oral area relatively large and tipped ventrally. Endoplasmic sack with well defined boundary layer. Rectum small, cylindrical, with a small circular or oval anus. Contractile vacuole lies to the left of the macronucleus slightly behind its anterior end. Macronucleus broad, wedge-shaped, two to four times as long as wide, from one-half to two-thirds of the length of the body, along the anterior part of the dorsal mid-line. Micronucleus small, spherical, on the left ventral surface of the anterior third of the macronucleus.

Dimensions.—Length 24–30 μ.

Feeds on Bacteria, Flagellates and small plant débris.

Remarks.—This species is similar in proportion, size, general appearance, and in the possession of a wedge-shaped macronucleus to *E. laterospinum* and *E. nanellum*. The shapes of the surfaces and the places of greatest curvature are, however, markedly different in each case, and they are, therefore, not considered to constitute a natural species-group.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

187. **Entodinium caudatum** Stein. (Fig. 149.)

Entodinium caudatum, Stein, 1858, p. 70; Kent, 1880–2, p. 654; Bütschli, 1889, pl. lxxii, fig. 10, *a*, *b*; Dogiel, 1927, pp. 61–2, fig. 28, *a*, *b*.

†*Entodinium caudatum*, Das-Gupta, 1935, p. 162.

Body oval, with three differently formed processes arising from the posterior end. The longest of these processes is dorsal and is an elongated, laterally flattened spine, which

is spirally curved towards the dorsal side. The length of this process varies within wide limits. The other two processes are pre-anal and lobe-like. The right lobe is triangular, with its pointed end directed backwards and to the left. The left lobe is not so broad and is more rounded than the right. Contractile vacuole to the left of the anterior end of the

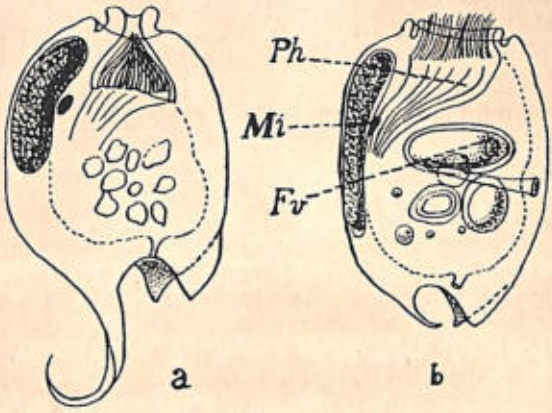


Fig. 149.—*Entodinium caudatum* Stein. *a*, with normal, *b*, with weakly developed dorsal spine. *Fv*, food-vacuole; *Mi*, micronucleus; *Ph*, œsophagus. (After Dogiel.)

macronucleus. Macronucleus sausage-shaped, fitting closely against the dorsal margin of the body. Micronucleus lies about the middle of the macronucleus.

Dimensions.—Length 35–50 μ, breadth 25–38 μ (after Dogiel); length 70–90 μ, breadth 30–50 μ (after Eberlein).

Feeds on vegetable particles and Bacteria.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

188. **Entodinium chatterjeei** Das-Gupta. (Fig. 150.)

†*Entodinium chatterjeei*, Das-Gupta, 1935, p. 165, fig. 6.

Body elongated oval, broad anteriorly and gradually tapering towards the posterior end. The posterior end is rounded and there is no process. The ventral side is slightly concave or flattened. Contractile vacuole situated near the anterior end of the body. Macronucleus ovoidal to spherical in shape and situated in the middle of the dorsal side. Micronucleus oval and situated towards the inner anterior end of the macronucleus.

Dimensions.—Length 26–35 μ, breadth 15–18 μ.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

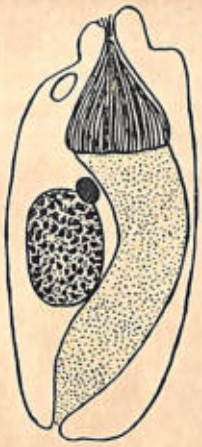


Fig. 150.—*Entodinium chatterjeei* Das-Gupta. (After Das-Gupta.)

189. **Entodinium contractum** Kofoid & Christenson. (Pl. X, fig. 1.)

†*Entodinium contractum*, Kofoid & Christenson, 1934, pp. 348–9, pl. xxv, fig. 4; fig. A, 9, 10.

Body pyriform in lateral outline and elongated, length 1·39–1·66 times the dorso-ventral diameter. Dorsal and ventral surfaces smoothly convex in anterior two-thirds of the body, levelling out gradually in posterior third ; posterior end of the body smoothly rounded. Oral region broad, occupying the anterior face. Cytostome tilted slightly ventrally and to the left. Œsophagus shows an elongated bundle of fibrils and extends backwards and dorsalwards to the right of the middle of the macronucleus. Endoplasmic sack spacious, with well-defined boundary layer. Rectum very short, with a relatively large funnel-shaped anus opening to the left of the posterior extremity. Contractile vacuole against the dorsal surface to the left of the anterior end of the macronucleus. Macronucleus a curved, club-shaped rod, broader and deeper in the anterior half, lying directly along the mid-dorsal line and extending from the base of the outer adoral to the posterior fourth of the body. Micronucleus small, ovoid to subspherical, lying beneath the left margin of the macronucleus, one-fourth the distance from its anterior end.

Dimensions.—Length 39–46 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—*E. contractum* is similar to *E. bimastus* Dogiel in general body form, shape of macronucleus and type of œsophagus, but differs in the posterior end of the body being

regularly tapered, and never drawn in to form a broad rectangular lobe as in the latter species.

Habitat.—Stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

190. **Entodinium ekendræ** Das-Gupta. (Fig. 151.)

†*Entodinium ekendræ*, Das-Gupta, 1935, pp. 163–4, fig. 4, *a*, *b*.

Body broadly oval, with three differently formed processes from the posterior end ; one of these, arising from the right side, is a long spine, 18–20 μ in length, the other two arise from the left side, are smaller and lobe-like. Dorsal side convex and ventral side flat. Endoplasmic sack clear.

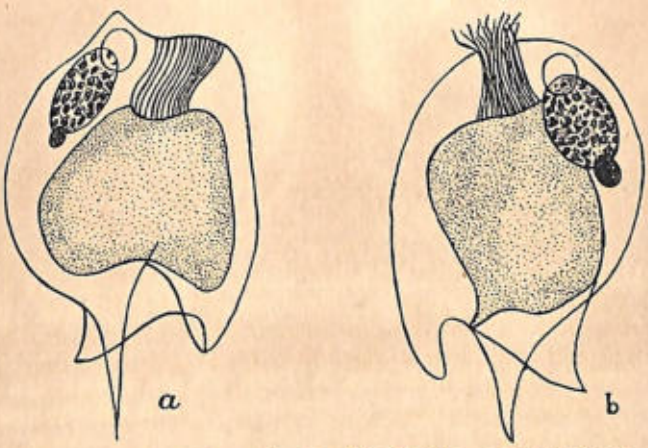


Fig. 151.—*Entodinium ekendræ* Das-Gupta. *a*, right view ; *b*, left view. (After Das-Gupta.)

Contractile vacuole close to the anterior end of the macronucleus. Macronucleus broadly oval, situated near the anterior end of the body, and never reaching beyond its middle. Micronucleus oval, at the posterior end of the macronucleus.

Dimensions.—Length 30–35 μ, breadth 28–30 μ.

Habitat.—Rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

191. **Entodinium furca** forma **dilobum** Dogiel. (Fig. 152.)

Entodinium furca, da Cunha, 1914, p. 65, pl. vii, fig. 4.
Entodinium furca forma *dilobum*, Dogiel, 1927, p. 57, fig. 23.
†*Entodinium dilobum*, Das-Gupta, 1935, p. 161.

Body elongated oval, not narrowing posteriorly, and broadest at the level of the posterior third of the body. The

two posterior processes are in the form of laterally flattened lobes which are convex along their outer margins and concave along the inner. Ciliary apparatus and the endoplasmic sack do not present any characteristic feature. Macronucleus sausage-shaped, extends about two-thirds the length of the dorsal margin of the body, and is not closely fitting the dorsal surface. Micronucleus lies somewhat anterior to the middle of the macronucleus.

Dimensions.—Length 42–55 μ, breadth 28–36 μ; ratio of length to breadth 1·6.

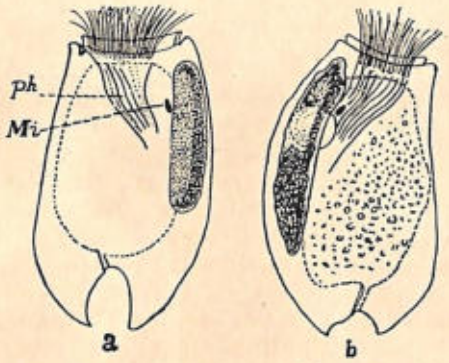


Fig. 152.—*Entodinium furca* forma *dilobum* Dogiel. *a*, left view; *b*, right view. *Mi*, micronucleus; *ph*, œsophagus. (After Dogiel.)

Remarks.—In the specimens from *Capra hircus* the two posterior lobes are slightly curved towards the middle and not so wide apart as in Dogiel's figure, reproduced above. The macronucleus is elongated (sometimes ovoidal) and extends slightly beyond the middle of the body.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

192. **Entodinium gibberosum** Kofoid & MacLennan. (Pl. IV, fig. 20.)

†*Entodinium gibberosum*, Kofoid & MacLennan, 1930, pp. 530–1, pl. lii, fig. 20; fig. P, 3, 4.

Body pyriform in a dorsal view, length 1·13–1·72 times the dorso-ventral diameter, smoothly rounded anteriorly, and tapering posteriorly to terminate in two heavy sharp-pointed caudal spines, one dorsal and one ventral. Dorsal surface strongly convex, nearly a semicircle, giving a humpbacked appearance. Cytostome located ventrally in the centre of the anterior margin, at the apex of a low, broad, conical oral chamber containing the retracted membranelles. Endoplasmic sack marked by a thin indistinct boundary layer. Rectum a thin-walled cylinder, flattened dorso-ventrally,

opening by a small elliptical anus. Contractile vacuole directly to the left of the anterior tip of the macronucleus. Macronucleus long, band-like, five to seven times as long as thick, with a deep notch in the anterior end, extending along the middle three-quarters of the dorsal mid-line. Micronucleus small, ellipsoidal, lying on the left ventral edge of the anterior quarter of the macronucleus.

Dimensions.—Length 38–51 μ.

Feeds on Bacteria and small Flagellates.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

193. **Entodinium indicum** Kofoid & MacLennan. (Pl. I, fig. 4.)

†*Entodinium indicum*, Kofoid & MacLennan, 1930, pp. 533–5, pl. xlix, fig. 4 ; fig. P, 1, 2 ; Kofoid & Christenson, 1934, p. 351, pl. xxv, fig. 2 ; fig. A, 7, 8.

Body oblong in lateral outline, length 1·13–1·56 times the dorso-ventral diameter, laterally compressed, tapered anteriorly toward the contracted oral opening, terminating posteriorly in three long triangular spines—one dorsal, one ventral, and one large spine on the left side. Dorsal and ventral surfaces straight. Oral area inclined dorsally ; cytostome a broad slit opening into the conical oral cavity containing the retracted membranelles. Endoplasmic sack with very indistinct boundary layer. Rectum a small tube in the base of the left spine, opening by a long narrow slit-like anus on the inner surface of the spine. Contractile vacuole close against the left side of the anterior tip of the macronucleus. Macronucleus wedge-shaped, dorso-ventrally compressed, three to six times as long as thick, situated in the dorsal mid-line. Micronucleus laterally compressed, lying in a small depression in the middle of the left side of the macronucleus.

Dimensions.—Length 25–40 μ.

Feeds on Bacteria and small Flagellates.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

194. **Entodinium laterospinum** Kofoid & MacLennan. (Pl. I, fig. 3.)

†*Entodinium laterospinum*, Kofoid & MacLennan, 1930, pp. 523–4, pl. xlix, fig. 3 ; fig. M, 1, 2.

Body small and wedge-like, with the anterior end larger than the posterior. Dorsal surface strongly convex, with the greatest curvature in the anterior half. Ventral surface flat or slightly concave. Lateral surfaces convex, with the greatest curvature in the front part. A curved ventral spine

pointing dorsally and to the right. Oral area relatively small, but the outer adoral furrow is deep and the inner adoral lip well developed. The oral area is tipped ventrally. Endoplasmic sack bounded by a weak boundary layer. Rectum nearly parallel to the main axis and opening by a small elliptical anus. Contractile vacuole on the left of the macronucleus, near its anterior end. Macronucleus wedge-shaped, broader at the anterior end, and extending up to two-thirds of the length of the body in the dorsal mid-line.

Dimensions.—Length 25–32 μ.

Feeds on Bacteria, small Flagellates and plant débris.

Remarks.—The wedge-shaped body and the deflection of the ventral spine from the direction of the main axis of the body distinctly separate this species from *E. brevispinum*.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo ; stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

195. **Entodinium nanellum** Dogiel. (Pl. II, fig. 8.)

Entodinium nanellum, Dogiel, 1922, pp. 96–7, fig. 1 ; 1925 *a*, pp. 117–18, 141, fig. 1, *a–c* ; 1925 *d*, p. 46 ; 1927, p. 40, fig. 2 ; Fantham, 1926, p. 566, fig. 1.

†*Entodinium nanellum*, Kofoid & MacLennan, 1930, pp. 524–5, pl. l, fig. 8 ; fig. N, 1, 2 ; Kofoid & Christenson, 1934, p. 352 ; Das-Gupta, 1935, p. 161.

Entodinium nanellum, Wertheim, 1935, pp. 228–9, fig. 3.

Body small and ovoid, length 1·50–2·00 times the dorso-ventral diameter, widest in the anterior half, laterally compressed, posterior end smoothly rounded. Dorsal and ventral surfaces convex, dorsal more convex in the anterior half and the ventral more convex in the posterior half. In the lateral surfaces the greatest curvature in the anterior half. Oral area inclined ventrally. Endoplasmic sack with thin but distinct boundary layer. Rectum a thin-walled cylinder, with a small elliptical anus opening at the extreme posterior end of the body. Contractile vacuole to the left of the anterior end of the macronucleus. Macronucleus thin, wedge-shaped, broader anteriorly, and four to seven times as long as thick, lying along the dorsal mid-line. Micronucleus small, ellipsoidal, located on the left ventral margin of the anterior third of the macronucleus.

Dimensions.—Length 20–35 μ, breadth 10–18 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—Specimens from *Bos gaurus* were relatively stouter than those from *Bos indicus*. In specimens from *Capra hircus* the sausage-shaped nucleus is often seen to lie towards the posterior end of the dorsal side.

Wertheim (1935) has more clearly defined this species and added some useful diagnostic characters, differentiating this species from *E. simplex* and *E. dubardi dubardi*.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo ; stomach of *Bos gaurus* H. Smith : Mulehole, Mysore ; rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

196. **Entodinium ovale** Jameson. (Fig. 153.)

†*Entodinium ovalis*, Jameson, 1925, pp. 407–8, figs. A, B.
Entodinium ovale, Dogiel, 1927, p. 67, fig. 34.

Body small, not dorso-ventrally flattened, the outline rounded oval when looked at from either end. Posterior end bluntly rounded and composed of ectoplasm only. A short,

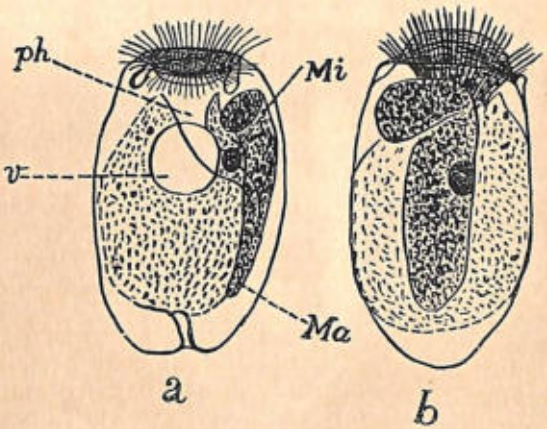


Fig. 153.—*Entodinuim ovale* Jameson. *a*, lateral view ; *b*, dorsal view. *Ma*, macronucleus ; *Mi*, micronucleus ; *ph*, œsophagus ; *v*, vacuole. (From Dogiel, after Jameson.)

nearly vertical anal canal runs through this into the endoplasm. Anterior end truncated, but only slightly obliquely, and when the wide cytostome is contracted the anterior end is markedly rounded. This rounding is caused by the lips, which close the cytostome, being very stoutly built, so that when they come together they form a broad dome-shaped prominence at the anterior end. Œsophagus long and curved to the left and dorsally. Contractile vacuole on the ventral side of the body towards the middle in the anterior half. Macronucleus very large, being both long and broad ; is actually longer than the body, so that it is bent at the anterior end into a right-angled hook. Micronucleus round or oval, situated as a rule to the inner side of the macronucleus and towards its anterior end.

Dimensions.—Length 20–40 μ, breadth 12–20 μ, the thickness being rather less, 10–18 μ.

Remarks.—The species was named *ovale* as the form has a characteristically oval outline when viewed from either side.

Habitat.—In the stomach of *Tragulus meminna* Milne-Edwards (mouse-deer) : Ceylon. The material was collected by Dobell (1910).

197. **Entodinium ovinum** Dogiel. (Fig. 154.)

Entodinium ovinum, Dogiel, 1927, pp. 44–5, fig. 8.
†*Entodinium ovinum*, Das-Gupta, 1935, p. 160.

Body very regularly oval, with somewhat truncated anterior end and rounded posterior end. Ciliary apparatus and endoplasmic sack do not present any characteristic feature. The latter contains numerous but never large food-particles. Contractile vacuole large and situated to the left of the anterior



Fig. 154.—*Entodinium ovinum* Dogiel. (After Dogiel.)

end of the macronucleus. Macronucleus sausage-shaped, beginning near the anterior end of the body and extending along the dorsal surface up to the posterior third of the body. Micronucleus lies about the middle of the macronucleus.

Dimensions.—Length 53–69 μ, breadth 32–41 μ; ratio of length to breadth 1·7.

Remarks.—The specimens from *Capra hircus* were considerably smaller, measuring 45–50 μ in length and 18–21 μ in breadth, but it is doubtful if they were correctly identified. Both the length and the breadth are considerably smaller than the dimensions as recorded by Dogiel, and the ratio of length to breadth works out at 2·5 as compared with 1·7 as recorded by Dogiel. Further, according to Dogiel *E. ovinum* was found in wild sheep and never in any domestic animal.

Habitat.—Rumen of *Capra hircus* Linn. : Bengal, Calcutta.

198. **Entodinium ovoideum** Kofoid & MacLennan. (Pl. III, fig. 11.)

†*Entodinium ovoideum*, Kofoid & MacLennan, 1930, pp. 526–7, pl. li, fig. 11; fig. N, 3, 4.

Body ovoidal, length 1·42–2·10 times the dorso-ventral diameter, with the greatest diameter in the posterior half. Anterior end truncated, posterior end smoothly rounded, with no indication of a ventral lobe. Oral area relatively small, with the outer adoral furrow shallow and the inner adoral lips only weakly developed. Endoplasmic sack bounded by a fairly distinct boundary layer. Rectum a wide thin-walled slit, with a transverse slit-like anus on the posterior end of the body. Contractile vacuole to the left of the macronucleus at its anterior end. Macronucleus long, slightly wedge-shaped, wider anteriorly, extending along the anterior two-thirds to three-fourths of the length of the body in the dorsal mid-line. Micronucleus small, ellipsoidal, on the left ventral side of the anterior third of the macronucleus.

Dimensions.—Length 30–50 μ.

Feeds on Bacteria, small Flagellates and plant débris.

Remarks.—This species resembles *E. laterospinum* in its smooth contours, shape of macronucleus, lack of posterior projections, and a weak dorso-ventrally compressed rectum. It is very similar in proportions and structure to *E. ovinum* Dogiel, and the two can be placed in the same species-group.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

199. **Entodinium ovoido-nucleatum** Das-Gupta. (Fig. 155.)

†*Entodinium ovoido-nucleatum*, Das-Gupta, 1935, pp. 162–3, fig. 3.

Body oval, with three differently formed processes arising from the posterior end. The longest one of these is dorsal, 28–30 μ in length, runs straight backwards and tapers to a point; the other two processes are pre-anal and lobe-like. The right lobe is triangular, with its pointed end slightly curved dorsalwards. The left lobe is smaller and more sharply pointed. Dorsal side slightly convex, ventral almost straight and flattened. Contractile vacuole situated on the outer anterior side of the macronucleus. Macronucleus ovoid and does not extend beyond the middle of the dorsal side of the body. Micronucleus also ovoid and situated close to the inner posterior side of the macronucleus.

Dimensions.—Length 25–30 μ, breadth 22–24 μ.

Remarks.—The species resembles *E. caudatum* very closely, but differs in the dorsal spine being not curved, in the form

and position of the macronucleus and in the position of the contractile vacuole.

Habitat.—Rumen of *Capra hircus* Linn. : BENGAL, Calcutta.



Fig. 155.—*Entodinium ovoido-nucleatum* Das-Gupta. (After Das-Gupta.)

200. **Entodinium rhomboideum** Kofoid & MacLennan. (Pl. II, fig. 7.)

†*Entodinium rhomboideum*, Kofoid & MacLennan, 1930, pp. 527–8, pl. I, fig. 7; fig. O, 1, 2.

Body rhomboid, comparatively long, length 1·40–1·73 times the dorso-ventral diameter, flattened laterally. The greatest diameter in the middle of the body, from that level the body tapers toward both anterior and posterior ends. Anterior end truncated to form the very narrow oral area. Posterior end terminates in a large smooth ventral lobe. Endoplasmic sack with a thin boundary layer. Rectum thin-walled, cylindrical, with a small oval anus at the base of the ventral lobe. Contractile vacuole at the left of the macronucleus just behind the level of its broad anterior end. Macro-

nucleus thin, wedge-shaped, broader anteriorly, and extending one-half to two-thirds the length of the body, on the anterior part of the dorsal mid-line. Micronucleus small, ovoid, on the left ventral edge of the middle third of the macronucleus.

Dimensions.—Length 30–47 μ.

Feeds on Flagellates, Bacteria and amœbæ.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

201. **Entodinium setnai** Das-Gupta. (Fig. 156.)

†*Entodinium setnai*, Das-Gupta, 1935, pp. 164–5, fig. 5, *a*, *b*.

Body oval, anterior end broader than the posterior. Dorsal side convex anteriorly and ends in a blunt lobe posteriorly.

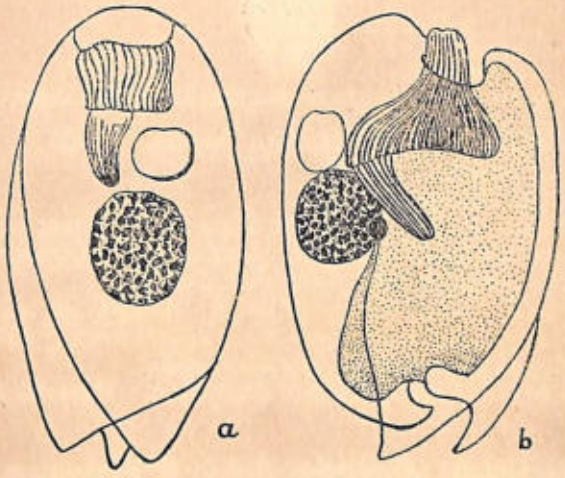


Fig. 156.—*Entodinium setnai* Das-Gupta. *a*, dorsal view ; *b*, view from the right side. (After Das-Gupta.)

Ventral side more or less straight and terminating in two small pointed lobes ; the right lobe has a broad base and the left lobe is more pointed than the right. Endoplasmic sack is clear. Contractile vacuole situated anterior to the macronucleus. Macronucleus spherical and situated in the middle of the dorsal side.

Dimensions.—Length 50–60 μ, breadth 26–30 μ.

Habitat.—Rumen of *Capra hircus* Linn. : BENGAL, Calcutta

202. **Entodinium simplex** Dogiel. (Fig. 157.)

Entodinium simplex, Dogiel, 1925 *d*; 1927, pp. 40–1, figs. 3, 4; Wertheim, 1935, pp. 238–9, fig. 4.
†*Entodinium simplex*, Das-Gupta, 1935, p. 160.

Body elongated oval, unarmed, with rounded posterior end. Adoral membranelle zone, endoplasmic sack and anal tube do not present any characteristic feature. Contractile vacuole situated to the left of the anterior end of the macronucleus Macronucleus band-shaped, closely applied against the dorsal surface of the body, and confined to its anterior two-thirds. Micronucleus small, oval, usually close to the middle of the macronucleus.



Fig. 157.—*Entodinium simplex* Dogiel. (After Dogiel.)

Dimensions.—Length 38–50 μ, breadth 21–29 μ; ratio of length to breadth 1·7–1·74.

Feeds on Bacteria.

Remarks.—In the specimens from *Capra hircus* the lateral sides are flattened and the macronucleus scarcely extends up to the posteroir half of the dorsal side.

Wertheim (1935) has more clearly defined the species and added some diagnostic characters, differentiating this species from *E. nanellum* and *E. dubardi dubardi*.

Habitat.—Rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

203. **Entodinium tricostatum** Kofoid & MacLennan. (Pl. I, fig. 5.)

†*Entodinium tricostatum*, Kofoid & MacLennan, 1930, pp. 532–3, pl. xlix, fig. 5; fig. Q.

Body short, broadly ellipsoid, length 0·88–1·10 times the dorso-ventral diameter, with three prominent ribs, one dorsal and two ventral, running the length of the body in a weak dextral spiral; the dorsal and the left ventral ribs terminate in the caudal spines, the thin blade-like right ventral rib in the lateral lobe. Adoral spiral narrow but relatively deep and strongly developed. Endoplasmic sack with a scarcely distinguishable boundary layer. Rectum a small inverted cone, opening by a circular anus in the middle of the posterior end of the body. Contractile vacuole at the left of the anterior end of the macronucleus in the dorsal rib. Macronucleus

very short, stout, narrower anteriorly, variable in shape, lying in the dorsal rib and following its spiral course. Micronucleus small, oval, on the left ventral edge of the middle of the macronucleus.

Dimensions.—Length 22–33 μ.

Feeds on Bacteria and small Flagellates.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

Genus **EODINIUM** Kofoid & MacLennan, 1932.

Anoplodinium, part, Dogiel, 1927, pp. 75–7, figs. 37–9.
Eodinium, Kofoid & MacLennan, 1932, pp. 69–74, pl. iv, figs. 3, 4, fig. B, 1–4 ; Calkins, 1933, p. 513 ; Kofoid & Christenson, 1934, pp. 362–5.

Ophryoscolecidæ with dorsal membranelle zone on the same level as the adoral zone. No skeletal plates. Contractile vacuoles two. Macronucleus a straight rod-like body beneath the dorsal surface of the body.

Remarks.—The genus is composed of a number of species, formerly included in Dogiel's subgenus *Anoplodinium*, which are related to the typical species of that group only by a single character, the lack of skeletal plates. The position and shape of the macronucleus clearly separates these forms from the other species of *Anoplodinium* (=*Diplodinium* Schuberg, emend. K. & M.). In addition, the relatively small operculum, simplicity of caudal armature, and weak development of the endoplasmic sack and rectum mark this genus off from *Diplodinium*. The range in size is markedly different in the two genera. The species of *Eodinium* average 48 μ in length, with a size range of from 32–60 μ ; the species of *Diplodinium*, on the other hand, average 100 μ, with a range of from 55–210 μ.

The genus *Eodinium* consists of three species included in the "*Posterovesiculatum*" group and two unallocated species.

Key to Indian Species.

1 (4). Body with one or more caudal lobes. Macronucleus rod-like, with two contractile vacuoles resting in depressions near its two ends ..... 2. [MacL., p. 310.
2 (3). With one ventral lobe ..... *E. lobatum* Kof. &
3 (2). With one dorsal and one ventral lobe .. *E. bilobosum* (Dog.), [p. 310.
4 (1). Body without any caudal lobe. Macronucleus short and tapering anteriorly, to right of dorsal mid-line. Contractile vacuoles on dorsal mid-line, anterior on level with anterior end and posterior some distance behind the level of the posterior end of the macronucleus..... [& MacL., p. 311. *E. rectangulatum* Kof.

"POSTEROVESICULATUM" GROUP.—The macronucleus is long and narrow. The anterior vacuole lies close against the left side of its anterior end; the posterior vacuole lies close to or behind the posterior end of the macronucleus.

204. **Eodinium bilobosum** (Dogiel). (Pl. X, fig. 3.)

Anoplodinium posterovesiculatum forma *bilobosum*, Dogiel, 1927, pp. 76–7, fig. 39, *a*, *b*.
Eodinium bilobosum, Kofoid & MacLennan, 1932, p. 72.
†*Eodinium bilobosum*, Kofoid & Christenson, 1934, pp. 362–5, pl. xxv, fig. 7; fig. B, 1, 2.

Body relatively stout, 1·22–1·50 dorso-ventral diameters in length, laterally compressed. Dorsal surface slightly convex, ventral surface somewhat flattened. A small inconspicuous operculum separates the adoral membranelle zone from the smaller dorsal zone, both of which lie on the same transverse level of the body. Two caudal lobes present, a smaller dorsal and a larger ventral lying in the same dorso-ventral plane, separated from each other by a deep concavity. Oral area tilted ventrally and to the left. Œsophagus a long curved structure marked by conspicuous transverse membranelles, giving a ladder-like appearance to it. Rectum short and opens to the exterior through an inconspicuous anus, lying at the base of the dorsal surface of the ventral lobe. Contractile vacuoles two and subequal, one lies close against the left antero-dorsal surface of the macronucleus and the other behind the posterior end. Macronucleus rod-like, nearly uniform in diameter, lying in the dorsal mid-line. Micronucleus small, ellipsoidal, and lies in a concavity in the middle of the dorsal surface of the macronucleus.

Dimensions.—Length 30–60 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—*E. bilobosum* is closely related to *E. posterovesiculatum* and to *E. lobatum* owing to the position of the posterior contractile vacuole being immediately behind the posterior end of the macronucleus.

Habitat.—In moderate numbers in the stomach of *Bos gaurus* H. Smith: Mulehole, Mysore.

205. **Eodinium lobatum** Kofoid & MacLennan. (Pl. V, fig. 3.)

†*Eodinium lobatum*, Kofoid & MacLennan, 1932, pp. 70–71, pl. iv, fig. 3; fig. B, 1, 2.

Body small and narrow, ellipsoid in dorsal view, length 1·51–1·97 times the dorso-ventral diameter, laterally compressed.

Cytostome small, inclined ventrally. Dorsal zone and dorsal disc small and inconspicuous. Dorsal membranelle zone at an angle with the main axis. Operculum very small. Dorsal and ventral surfaces in the middle half of the body only slightly convex and nearly parallel, converging suddenly towards the anus in the posterior quarter of the body; a distinct ventral lobe at the posterior end. Endoplasmic sack closely following the outline of the body. Rectum short, tubular, opening in the middle of the posterior surface through an elliptical anus. Contractile vacuoles two, lying in the anterior and posterior depressions on the dorsal side of the macronucleus. Macronucleus narrow, rod-like body, with three large depressions in its dorsal side, the anterior and posterior depressions lodging the vacuoles and the middle one the micronucleus. Micronucleus a small ellipsoid body.

Dimensions.—Length 44–66 μ.

Feeds on Bacteria, small Flagellates, &c.

Remarks.—*E. lobatum* is similar to *E. posterovesiculatum* (Dogiel, 1927) in all respects except for the absence of the ventral lobe in the latter species.

Habitat.—Stomach of *Bos indicus* Linn : MADRAS, Coonoor ; CEYLON, Colombo.

UNALLOCATED SPECIES :—

206. **Eodinium rectangulatum** Kofoid & MacLennan. (Pl. V, fig. 4.)

†*Eodinium rectangulatum*, Kofoid & MacLennan, 1932, pp. 72–4, pl. iv, fig. 4; fig. B, 3, 4.

Body somewhat rectangular in lateral view, length 1·63–1·95 times the dorso-ventral diameter; ellipsoid in dorsal view and compressed laterally. Oral area small and inclined ventrally. Dorsal zone small and inconspicuous; dorsal disk small; operculum of relatively medium size. Dorsal surface weakly convex, ventral surface slightly concave in its middle, lateral surfaces distinctly convex. No caudal lobes. Endoplasmic sack extending posteriorly to near the end of the body, with a distinct boundary layer. Rectum short, simple, slit-like, opening by a small elliptical anus. Two small contractile vacuoles on the dorsal mid-line, anterior at the level of the anterior end of the macronucleus and the posterior behind the level of its posterior end. Macronucleus relatively short, with its posterior end two to four times as large as the anterior end, located on the dorsal surface to the right of the

mid-line, but displaying no ventral curvature. Micronucleus a small spherical body.

Dimensions.—Length 35–70 μ.

Feeds on Bacteria and small Flagellates.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

Genus **DIPLODINIUM** Schuberg 1888, emend. Crawley, emend. Dogiel, emend. Kofoid & MacLennan.

Entodinium, part, Stein, 1858, p. 69 ; 1859 *a*, p. 58 ; 1867, pp. 164, 168.
Diplodinium, Schuberg, 1888, pp. 369, 404 ; Crawley, part, 1923, pp. 395, 400, pl. xviii, fig. C 2.
Metadinium, part, Crawley, 1923, p. 403, pl. xxviii, fig. C, 2.
Diplodinium, Wenyon, 1926, pp. 1213–14 ; Calkins, 1926, p. 409.
Anoplodinium, part, Dogiel, 1927, pp. 72–5, 77–105, figs. 40–56.
Diplodinium, Reichenow, 1929, p. 1199 ; Kofoid & MacLennan, 1932, pp. 74–87, pl. iv, figs. 1, 2, 5, 6 ; figs. B, 5–7, C, D, 1–4 ; Calkins, 1933, p. 513 ; Kofoid & Christenson, 1934, pp. 352–62 ; Das-Gupta, 1935, pp. 165–7.

Ophryoscolecidæ with dorsal membranelle zone on the same level as the adoral zone. No skeletal plates. Contractile vacuoles two. Macronucleus beneath the middle of the right surface of the body ; the anterior third of the dorsal surface of the macronucleus bent ventrally at an angle of 30°–90°.

The principal features of structure will be clearly seen from the accompanying diagram of the lateral view of the type-species (fig. 158).

Remarks.—The genus *Diplodinium*, as restricted by Kofoid and MacLennan, is easily distinguishable from *Eodinium* by the type and position of the macronucleus. Further, the operculum is relatively large and prominent ; caudal spines are common, and in many cases posesss a complex fibrillar system ; the boundary layer is heavy and the rectum is large and well developed, often showing a complex fibrillar structure. The species of *Diplodinium* range in size from 55 to 210 μ and average 100 μ, while those of *Eodinium* range from 32 to 60 μ and average only 48 μ.

Key to Indian Species.

1	(18).	Body without a caudal fan of spines ..	2.
2	(4).	Body with a broad posterior end	3.
3.		Body with a truncated posterior end, with six large, incurved caudal spines.	*D. dentatum* (Stein), [p. 313.
4	(2).	Body with a narrow posterior end....	5.
5	(6).	Body oval, posterior end rounded, with a long thin ventral spine	*D. consors* (Dogiel), [p. 320.
6	(5).	Posterior end of the body not rounded	7.
7	(15).	Posterior half of the body tapering and conical	8.

8 (13).	Only one caudal spine	9. [p. 319.
9 (10).	Ventral spine thin	*D. psittaceum* (Dogiel),
10 (9).	Ventral spine thick	11.
11 (12).	Shorter length of body and relatively larger ventral spine. Longitudinal cuticular groove along the right surface present	[(Dogiel), p. 316. *D. monacanthum*
12 (11).	Longer body and very small ventral spine. Longitudinal cuticular groove absent	[Christ., p. 315. *D. ceylonicum* Kof. &
13 (8).	More than one caudal spine	14. [(Dogiel), p. 317.
14 *a*.	Two caudal spines	*D. diacanthum* [(Dogiel), p. 317.
14 *b*.	Three caudal spines	*D. triacanthum* [(Dogiel), p. 318.
14 *c*.	Four caudal spines	*D. tetracanthum* [(Dogiel), p. 318.
14 *d*.	Five caudal spines	*D. pentacanthum* [da Cunha, p. 318.
14 *e*.	Six caudal spines	*D. anisacanthum*
15 (7).	Posterior half of the body triangular. Longitudinal cuticular line runs along the dorsal edge of the right lateral surface	
16 (17).	Body broadly oval, 80–180 μ in length; endoplasmic sack extends into the operculum	16. [p. 321.
17 (16).	Body oval, 53–90 μ; endoplasmic sack does not extend into the operculum.	*D. costatum* Dogiel, [p. 322. *D. minor* (Dogiel),
18 (1).	Body with a fan of caudal spines	19.
19 (20).	Left side extends posteriorly, forming a fan with 2 to 7 spines. No spines on dorsal surface	[p. 323. *D. crista-galli* Dogiel,
20 (19).	Right side extends posteriorly, forming a fan with 5 to 7 spines. Two small spines on posterior dorsal surface....	[MacL., p. 323. *D. flabellum* Kof. &

"DENTATUM" GROUP.—This group is marked by the posterior end of the body being broad and truncated and the spines being relatively long and heavy.

207. **Diplodinium dentatum** (Stein) Schuberg. (Pl. V, fig. 2; fig. 158.)

Entodinium dentatum, Stein, 1858, p. 70.
Diplodinium dentatum, Schuberg, 1888, p. 404.
Diplodinium denticulatum, Fiorentini, 1889, p. 15, pl. ii, figs. 4, 5.
Diplodinium dentatum, Eberlein, 1895, pp. 261–2.
Diplodinium dentatum var. *denticulatum*, Buisson, 1923 *b*, pp. 122–3, fig. 44.
Diplodinium denticulatum forma *denticulatum*, Dogiel, 1925 *c*, pp. 611–12, fig. 1.
Anoplodinium denticulatum forma *denticulatum*, Dogiel, 1927, pp. 84–6, fig. 44.
Diplodinium denticulatum, Becker & Talbot, 1927, p. 353, fig. 16.
†*Diplodinium dentatum*, Kofoid & MacLennan, 1932, pp. 75–7, pl. iv, fig. 2; figs. A, B, 5–7.

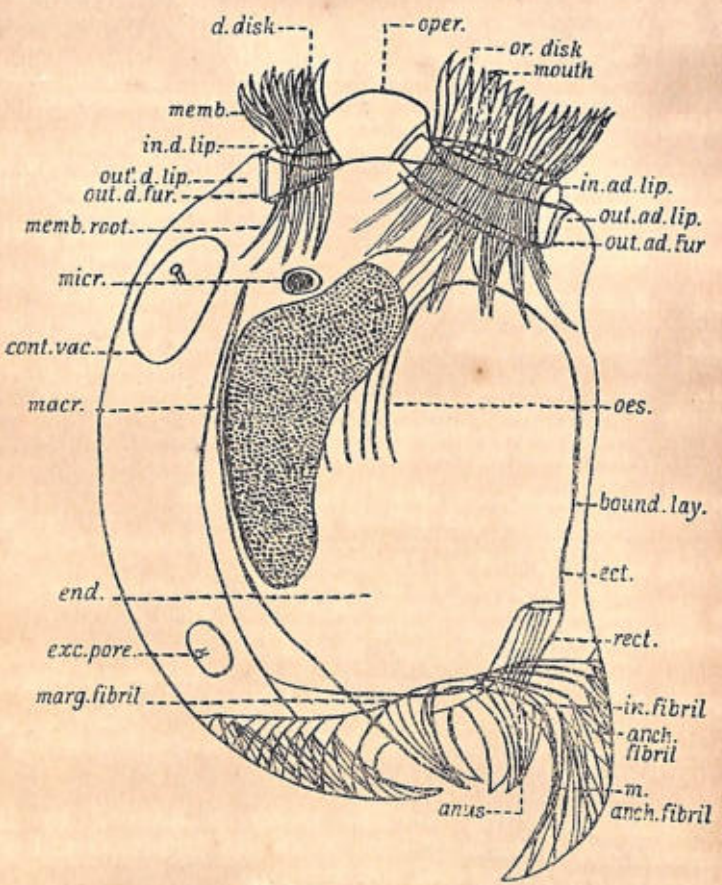


Fig. 158.—*Diplodinium dentatum* (Stein) Schuberg. Semidiagrammatic lateral view. The surface striations are omitted for the sake of clearness. ×1000. *anch.fibril*, anchoring fibril; *anus*, anus; *bound.lay.*, boundary layer; *cont.vac.*, contractile vacuole; *d.disk*, dorsal disk; *ect.*, ectoplasm; *end.*, endoplasm; *exc.pore*, excretory pore; *in.ad.lip*, inner adoral lip; *in.d.lip*, inner dorsal lip; *in.fibril*, inner fibril; *macr.*, macronucleus: *m.anch.fibril*, main anchoring fibril; *marg.fibril*, marginal fibril; *memb.*, membranelle; *memb.root*, membranelle root; *micr.*, micronucleus; *mouth*, cytostome; *oes.*, œsophagus; *oper.*, operculum; *or.disk.*, oral disk; *out.ad.fur.*, outer adoral furrow; *out.ad.lip*, outer adoral lip; *out.d.fur.*, outer dorsal furrow; *out.d.lip*, outer dorsal lip; *rect.*, rectum. (After Kofoid & MacLennan.)

Body relatively short and heavy, length 1·20–1·32 times the dorso-ventral diameter, sharply truncated at the anterior and posterior ends, compressed laterally. Dorsal surface convex, ventral surface concave, lateral surfaces convex. Six large incurved caudal spines, ventral spine longest; dorsal spine a continuation of a heavy longitudinal dorsal rib which arises near the dorsal membranelle zone. Oral area of medium size, inclined ventrally at an angle. Dorsal membranelle zone relatively short, the inner lip prominent, concealing the small dorsal disk. Outer lips of the two membranelle zones continuous, being connected along the right and left sides of the operculum by slight but distinct ridges. In a side view the operculum is broad, heavy, and prominent. Endoplasmic sack abruptly truncated posteriorly near the bases of the caudal spines, with the boundary membrane relatively thin and difficult to distinguish. Rectum short, thin-walled tube, with elliptical anus. The two contractile vacuoles lie in the dorsal rib slightly to the left of the mid-line, anterior a short distance behind the dorsal zone, posterior at the level of the posterior end of the macronucleus. Macronucleus heavy, rod-like, with its anterior third bent vertically at an angle, variable in length, and lying under the left surface with its dorsal edge along the deep lateral cleft. Micronucleus spherical or slightly ellipsoid, lying in a slight depression on the dorsal side of the macronucleus.

Dimensions.—Length 65–82 μ.

Feeds on Bacteria and small particles of cellulose.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

"ANACANTHUM" GROUP.—The group is marked by a tapering of the posterior half of the body, giving it a somewhat conical aspect. The development of the spines in different species presents a complete series, ranging from no caudal spine up to six caudal spines.

208. **Diplodinium ceylonicum** Kofoid & Christenson. (Pl. V, fig. 5.)

†*Diplodinium monacanthum*, Kofoid & MacLennan, 1932, pp. 78–80, pl. iv, fig. 5; fig. D, 1, 2.
Diplodinium ceylonicum, Kofoid & Christenson, 1934, p. 356.

Body relatively short and heavy, length 1·52–1·82 times the dorso-ventral diameter, tapering posteriorly, with a small spine, measuring about 6 μ, projecting from the posterior end of the ventral surface. Oral area of moderate diameter, lips weakly developed. Dorsal zone large and conspicuous,

inner dorsal lip well developed. Dorsal disk large, projecting above the inner dorsal lip. Operculum projects anteriorly for only a short distance. Surfaces convex, with the greatest curvature in the posterior third of the body. Endoplasmic sack extends posteriorly, closely following the contour of the body. Rectum a narrow slit ; anus just dorsal to the ventral spine. Two lenticular contractile vacuoles under the dorsal mid-line, located at each end of the middle third of the body. Macronucleus varies from a short stout body, only twice as long as its greatest diameter, to one five or six times as long as its greatest diameter, located under the right lateral surface, with its anterior third sloping ventrally. Micronucleus a small ellipsoid body, in a small depression of the dorsal surface of the anterior third of the macronucleus.

Dimensions.—Length 60–124 μ.

Feeds on small particles of plant material.

Remarks.—This species lacks the cuticular groove, is distinctly and consistently larger, and has a shorter spine than *D. monacanthum* (Dogiel).

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

209. **Diplodinium monacanthum** (Dogiel). (Fig. 159.)

Anoplodinium denticulatum forma *monacanthum*, Dogiel, 1927, p. 80, fig. 40 *b*.

†*Diplodinium monacanthum*, Kofoid & Christenson, 1934, pp. 355–6, pl. xxvi, fig. 9 ; fig. C, 1, 2.

Body relatively short and heavy, 1·30–1·62 dorso-ventral diameters in length, tapering posteriorly, with a caudal spine measuring 10–17 μ in length. There is a longitudinal cuticular groove along the right dorso-lateral surface.

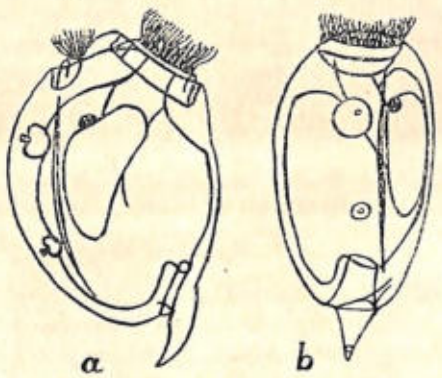


Fig. 159.—*Diplodinium monacanthum* (Dogiel). *a*, right lateral view ; *b*, dorsal view. (After Kofoid & Christenson.)

Dimensions.—Length 50–68 μ, breadth 30–38 μ.

Remarks.—Dogiel (1927) recorded this species from domestic cattle in the U.S.S.R., and the measurements given by him are intermediate between those of *D. monacanthum* from the gaur and of *D. ceylonicum* from the Indian ox.

The species is distinguished from *D. ceylonicum* by the shorter length of the body and relatively larger ventral spine, as also by the possession of the longitudinal cuticular groove.

Habitat.—Stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

210. **Diplodinium diacanthum** (Dogiel). (Pl. X, fig. 5.)

Anoplodinium denticulatum forma *diacanthum*, Dogiel, 1927, pp. 80–1, fig. 41, *a*, *b*.
Diplodinium diacanthum, Kofoid & MacLennan, 1932, p. 80.
†*Diplodinium diacanthum*, Kofoid & Christenson, 1934, pp. 356–9, pl. xxvi, fig. 10; fig. C, 3, 4.

Morphologically similar to *D. monacanthum* in all respects except spination. Two caudal spines present, a ventral one of the same size and position as in *D. monacanthum* and a second smaller spine on the right latero-ventral portion of the posterior end or less frequently on the dorsal side. Body relatively short and stout, 1·26–1·49 dorso-ventral diameters in length, laterally compressed. Dorsal and ventral surfaces are both convex, but the dorsal convexity is greater. Both surfaces taper posteriorly to give the characteristic appearance of the *anacanthum* group. A distinct longitudinal cuticular groove along the right dorso-lateral surface as in *D. monacanthum*.

Dimensions.—Length 50–70 μ, breadth 33–42 μ.

Remarks.—Dogiel (1927) recorded somewhat larger specimens (70–83 μ) from cattle from the U.S.S.R.

Habitat.—In small numbers in stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

211. **Diplodinium triacanthum** (Dogiel). (Pl. X, fig. 6.)

Anoplodinium denticulatum forma *triacanthum*, Dogiel, 1927, p. 81, fig. 42, *a*, *b*.
Diplodinium triacanthum, Kofoid & MacLennan, 1932, p. 80.
†*Diplodinium triacanthum*, Kofoid & Christenson, 1934, pp. 359–60, pl. xxvi, fig. 11; fig. C, 5, 6.

Morphologically similar to *D. diacanthum* in all respects except spination. Three caudal spines present; a relatively large ventral spine corresponding to the single spine in *D. monacanthum*, a second smaller spine on the latero-ventral edge of the right side, and a third small spine on the dorsal edge.

Dimensions.—Length 64 μ, breadth 38 μ.

Remarks.—Dogiel (1927) recorded somewhat larger specimens (70–85 μ) from domestic cattle from the U.S.S.R.

Habitat.—Only a single specimen was found in *Bos gaurus* H. Smith : Mulehole, Mysore.

212. **Diplodinium tetracanthum** (Dogiel). (Pl. X, fig. 7.)

Anoplodinium denticulatum forma *tetracanthum*, Dogiel, 1927, p. 82, fig. 42 *c*.
Diplodinium tetracanthum, Kofoid & MacLennan, 1932, p. 80.
†*Diplodinium tetracanthum*, Kofoid & Christenson, 1934, p. 360, pl. xxvi, fig. 12 ; fig. C, 7, 8.

Morphologically similar to *D. diacanthum* in all respects except spination. Four caudal spines are present, three of which are as in *D. triacanthum*. The fourth spine is added on the latero-dorsal edge of the right side.

Dimensions.—Length 53–56 μ, breadth 32–33 μ.

Remarks.—Dogiel (1927) recorded considerably larger (72–83 μ) specimens from domestic cattle from the U.S.S.R.

Habitat.—Two specimens were found in the stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

213. **Diplodinium pentacanthum** (Dogiel). (Pl. X, fig. 8.)

Anoplodinium denticulatum forma *pentacanthum*, Dogiel, 1927, p. 82, fig. 42 *d*.
Diplodinium pentacanthum, Kofoid & MacLennan, 1932, p. 81.
†*Diplodinium pentacanthum*, Kofoid & Christenson, 1934, p. 361, pl. xxvi, fig. 13 ; fig. C, 9, 10.

Morphologically similar to *D. diacanthum* in all respects except spination. There are five caudal spines—four as in *D. tetracanthum* and an additional spine added on the left side.

Dimensions.—Length 50–54 μ, breadth 32–34 μ.

Remarks.—Dogiel (1927) recorded considerably larger specimens (67–84 μ) from domestic cattle from the U.S.S.R.

Habitat.—Two specimens were found in the stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

214. **Diplodinium anisacanthum** da Cunha. (Pl. X, fig. 9.)

Diplodinium anisacanthum, da Cunha, 1914, p. 64, fig. 3; Buisson, 1923 *b*, p. 123, fig. 44.
Metadinium anisacanthum, Crawley, 1923, p. 401; Fantham, 1926, p. 568.
Anoplodinium denticulatum forma *anisacanthum*, Dogiel, 1927, p. 83, fig. 42 *e*.
Diplodinium anisacanthum, Becker & Talbot, 1927, p. 356; Kofoid & MacLennan, 1932, p. 81.
†*Diplodinium anisacanthum*, Kofoid & Christenson, 1934, pp. 361–2, pl. xxvi, fig. 14 ; fig. C, 11, 12 ; Das-Gupta, 1935, p. 166.

Morphologically similar to *D. diacanthum* except spination.

There are six caudal spines—one ventral, one dorsal, and two on each side. The spines are as in *D. pentacanthum*, with a sixth spine added on the left lateral surface.

Dimensions.—Length 46–67 μ, breadth 28–37 μ.

Remarks.—Dogiel (1927) recorded considerably larger specimens (77–86 μ) from domestic cattle from the U.S.S.R.

Habitat.—In very limited numbers in the stomach of *Bos gaurus* H. Smith : Mulehole, Mysore ; in small numbers in the rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

215. **Diplodinium psittaceum** (Dogiel). (Pl. V, fig. 1.)

Anoplodinium psittaceum, Dogiel, 1927, pp. 93–4, fig. 48.
†*Diplodinium psittaceum*, Kofoid & MacLennan, 1932, pp. 81–2, pl. iv, fig. 1 ; fig. C, 1, 2.

Body heavy, rounded, length 1·34–1·61 times the dorso-ventral diameter, compressed laterally. Oral area relatively small in diameter, inclined ventrally and to the left. Adoral region large, with lips of moderate size. Operculum short but relatively broad and conspicuous. Dorsal disk also large and conspicuous. Surfaces of the body convex, with the greatest curvature in the middle and posterior parts of the body. A low narrow rib arises on the posterior half of the ventral mid-line and ends at the anus in a short acute spine. A flange arises in the posterior quarter of the dorsal mid-line and disappears near the anus. Endoplasmic sack extends posteriorly, closely following the contours of the body ; boundary layer distinct. Rectum short, dorso-ventrally flattened cylinder, opening by an elliptical anus. Contractile vacuoles large, lentoidal, anterior on a level with the macronucleus, posterior in the posterior third of the body. Macronucleus a stout rod-like body, from three to six times as long as its largest diameter, with its anterior third bent ventrally, lying under the middle of the right surface of the body. Micronucleus ellipsoidal, in a small depression on the dorsal surface of the anterior third of the macronucleus.

Dimensions.—Length 95–150 μ.

Feeds on large pieces of plant material.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor ; CEYLON, Colombo.

"BUBALIDIS" GROUP.—In this group the organisms have a small longitudinal cuticular groove extending a short distance anteriorly from the right border of the anus, and the endoplasmic sack reaches anteriorly into the operculum. Sometimes a long thin ventral spine with a narrow base may be present. The following species is doubtfully referred to this group.

Remarks.—Dogiel (1927) recorded somewhat larger specimens (70–85 μ) from domestic cattle from the U.S.S.R.

Habitat.—Only a single specimen was found in *Bos gaurus* H. Smith : Mulehole, Mysore.

212. **Diplodinium tetracanthum** (Dogiel). (Pl. X, fig. 7.)

Anoplodinium denticulatum forma *tetracanthum*, Dogiel, 1927, p. 82, fig. 42 *c*.
Diplodinium tetracanthum, Kofoid & MacLennan, 1932, p. 80.
†*Diplodinium tetracanthum*, Kofoid & Christenson, 1934, p. 360, pl. xxvi, fig. 12 ; fig. C, 7, 8.

Morphologically similar to *D. diacanthum* in all respects except spination. Four caudal spines are present, three of which are as in *D. triacanthum*. The fourth spine is added on the latero-dorsal edge of the right side.

Dimensions.—Length 53–56 μ, breadth 32–33 μ.

Remarks.—Dogiel (1927) recorded considerably larger (72–83 μ) specimens from domestic cattle from the U.S.S.R.

Habitat.—Two specimens were found in the stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

213. **Diplodinium pentacanthum** (Dogiel). (Pl. X, fig. 8.)

Anoplodinium denticulatum forma *pentacanthum*, Dogiel, 1927, p. 82, fig. 42 *d*.
Diplodinium pentacanthum, Kofoid & MacLennan, 1932, p. 81.
†*Diplodinium pentacanthum*, Kofoid & Christenson, 1934, p. 361, pl. xxvi, fig. 13 ; fig. C, 9, 10.

Morphologically similar to *D. diacanthum* in all respects except spination. There are five caudal spines—four as in *D. tetracanthum* and an additional spine added on the left side.

Dimensions.—Length 50–54 μ, breadth 32–34 μ.

Remarks.—Dogiel (1927) recorded considerably larger specimens (67–84 μ) from domestic cattle from the U.S.S.R.

Habitat.—Two specimens were found in the stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

214. **Diplodinium anisacanthum** da Cunha. (Pl. X, fig. 9.)

Diplodinium anisacanthum, da Cunha, 1914, p. 64, fig. 3; Buisson, 1923 *b*, p. 123, fig. 44.
Metadinium anisacanthum, Crawley, 1923, p. 401 ; Fantham, 1926, p. 568.
Anoplodinium denticulatum forma *anisacanthum*, Dogiel, 1927, p. 83, fig. 42 *e*.
Diplodinium anisacanthum, Becker & Talbot, 1927, p. 356 ; Kofoid & MacLennan, 1932, p. 81.
†*Diplodinium anisacanthum*, Kofoid & Christenson, 1934, pp. 361–2, pl. xxvi, fig. 14 ; fig. C, 11, 12 ; Das-Gupta, 1935, p. 166.

Morphologically similar to *D. diacanthum* except spination.

There are six caudal spines—one ventral, one dorsal, and two on each side. The spines are as in *D. pentacanthum*, with a sixth spine added on the left lateral surface.

Dimensions.—Length 46–67 μ, breadth 28–37 μ.

Remarks.—Dogiel (1927) recorded considerably larger specimens (77–86 μ) from domestic cattle from the U.S.S.R.

Habitat.—In very limited numbers in the stomach of *Bos gaurus* H. Smith : Mulehole, Mysore ; in small numbers in the rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

215. **Diplodinium psittaceum** (Dogiel). (Pl. V, fig. 1.)

Anoplodinium psittaceum, Dogiel, 1927, pp. 93–4, fig. 48.
†*Diplodinium psittaceum*, Kofoid & MacLennan, 1932, pp. 81–2, pl. iv, fig. 1 ; fig. C, 1, 2.

Body heavy, rounded, length 1·34–1·61 times the dorso-ventral diameter, compressed laterally. Oral area relatively small in diameter, inclined ventrally and to the left. Adoral region large, with lips of moderate size. Operculum short but relatively broad and conspicuous. Dorsal disk also large and conspicuous. Surfaces of the body convex, with the greatest curvature in the middle and posterior parts of the body. A low narrow rib arises on the posterior half of the ventral mid-line and ends at the anus in a short acute spine. A flange arises in the posterior quarter of the dorsal mid-line and disappears near the anus. Endoplasmic sack extends posteriorly, closely following the contours of the body ; boundary layer distinct. Rectum short, dorso-ventrally flattened cylinder, opening by an elliptical anus. Contractile vacuoles large, lentoidal, anterior on a level with the macronucleus, posterior in the posterior third of the body. Macronucleus a stout rod-like body, from three to six times as long as its largest diameter, with its anterior third bent ventrally, lying under the middle of the right surface of the body. Micronucleus ellipsoidal, in a small depression on the dorsal surface of the anterior third of the macronucleus.

Dimensions.—Length 95–150 μ.

Feeds on large pieces of plant material.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor ; CEYLON, Colombo.

"BUBALIDIS" GROUP.—In this group the organisms have a small longitudinal cuticular groove extending a short distance anteriorly from the right border of the anus, and the endoplasmic sack reaches anteriorly into the operculum. Sometimes a long thin ventral spine with a narrow base may be present. The following species is doubtfully referred to this group.

216. **Diplodinium consors** (Dogiel). (Fig. 160.)

Diplodinium bubalidis forma *consors*, Dogiel, 1925 *a*, pp. 124–6, fig. 3; Fantham, 1926, p. 567.
Anoplodinium bubalidis forma *consors*, Dogiel, 1927, pp. 98–9, fig. 52.
Diplodinium consors, Kofoid & MacLennan, 1932, p. 84.
†*Diplodinium consors*, Das-Gupta, 1935, p. 166.

Body oval, dorsal and ventral surfaces strongly convex. Posterior end of the body is provided with a pre-anal sickle-shaped spine, which is movably jointed with the body. Endoplasmic sack is simple and does not extend anteriorly into the operculum. Contractile vacuole lies dorsal to the middle of the macronucleus. Macronucleus relatively short and broad and its long axis not parallel with the long axis of the body,

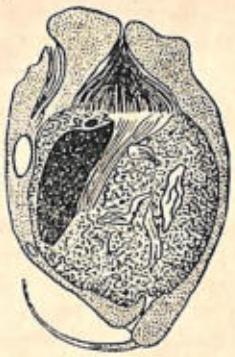


Fig. 160.—*Diplodinium consors* (Dogiel). (After Dogiel.)

but inclined ventralwards. The anterior end of the macronucleus shows a curved point, and the small elongated micronucleus lies in the depression.

Dimensions.—Length 65–108 μ, breadth 35–46 μ; ratio of length to breadth 1·87.

Feeds on vegetable particles.

Remarks.—The species is distinguished from *D. bubalidis* by the form of the macronucleus and by the absence of the apical diverticulum of the endoplasmic sack. Kofoid and MacLennan (1932) consider it questionable if *D. consors* is nearly related to *D. bubalidis*.

Habitat.—Found (in one case only) in the rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

"RANGIFERI" GROUP.—This group includes species marked by a distinct longitudinal cuticular line running along the length of the dorsal edge of the right lateral surface. The rectum is relatively large and heavy. The spines included in this group are relatively short.

217. **Diplodinium costatum** Dogiel. (Fig. 161.)

Diplodinium costatum forma *major*, Dogiel, 1925 *a*, pp. 121–3, fig. 2, E.
Anoplodinium costatum forma *major*, Dogiel, 1927, pp. 102–3, fig. 55.
Diplodinium costatum, Kofoid & MacLennan, 1932, p. 85.
†*Diplodinium costatum*, Das-Gupta, 1935, p. 167.

Body broadly oval, length 1·4 times the dorso-ventral diameter; truncated anteriorly, triangular posteriorly. A narrow longitudinal thickening of the cuticle extends along the right dorsal surface from the anterior end to the anus. Endoplasmic sack has an anterior diverticulum extending into the operculum. Rectum and anus small. Contractile vacuoles

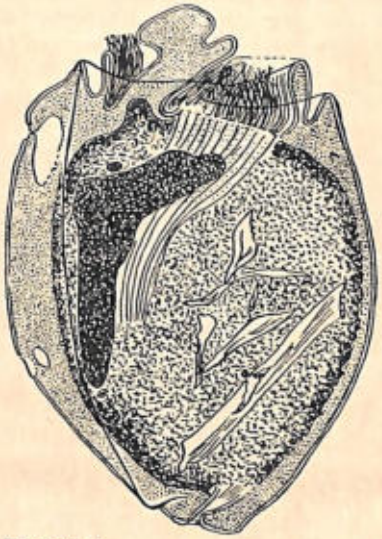


Fig. 161.—*Diplodinium costatum* Dogiel. (After Dogiel.)

two, subequal, lying along the dorsal border, the anterior one somewhat anterior to the macronucleus and the posterior one on a level with its posterior end. Macronucleus in the form of a hook, the horizontal limb of which is directed ventralwards. Micronucleus lies in a depression on the anterior side of the horizontal limb of the macronucleus.

Dimensions.—Length 80–180 μ, breadth 55–110 μ.

Remarks.—Dogiel described *D. costatum major* and *D. costatum minor*. Kofoid and MacLennan (1932), who regard these forms as distinct species, have restricted the name *D. costatum* to the form described as *D. costatum major* by Dogiel.

Habitat.—In two cases in the rumen of *Capra hircus* Linn.: Bengal, Calcutta.

218. **Diplodinium minor** (Dogiel). (Pl. X, fig. 4.)

Diplodinium costatum forma *minor*, Dogiel, 1925 *a*, p. 121–3, fig. 2 F.
Anoplodinium costatum forma *minor*, Dogiel, 1927, pp. 103–4, fig. 56.
Diplodinium minor, Kofoid & MacLennan, 1932, p. 85.
†*Diplodinium minor*, Kofoid & Christenson, 1934, pp. 352–5, pl. 25, fig. 8; fig. B, 3, 4.

Body oval, truncated anteriorly, relatively stout, length 1·22–1·6 times the dorso-ventral diameter, strongly compressed laterally, and somewhat triangular in lateral view in the posterior third of the body. Dorsal zone of membranelles lies at the same transverse level of the body as the adoral zone. A narrow, longitudinal, cuticular line extends along the right dorsal surface from the base of outer dorsal furrow to dorsal edge of the anal opening. Oral region of moderate size, tilted ventrally and to the left. Operculum shallow, projecting a short distance anteriorly. Œsophagus inconspicuous, weakly marked by several curved, longitudinal fibrils. Endoplasmic sack does not form an anterior diverticulum extending into the operculum. Rectum a dorso-ventrally depressed canal opening to exterior through an inconspicuous slit-like anus situated at the posterior end of the body. Macronucleus relatively stout, somewhat hatchet-shaped, lying under the right surface of the body, slightly dorsal to the lateral mid-line. Micronucleus small, ovoid, lying in a slight concavity on the antero-dorsal surface of the macronucleus. Contractile vacuoles two, usually subequal, lying along the dorsal mid-line of the body, the anterior larger at the level of the micronucleus, and the posterior nearly on a level with the posterior end of the macronucleus.

Dimensions.—Length 53–80 μ; dorso-ventral diameter 40–53 μ; ratio of length to dorso-ventral diameter 1·22–1·51 (Kofoid & Christenson); length 60–90 μ, dorso-ventral diameter 45–51 μ; ratio of length to dorso-ventral diameter 1·6 (Dogiel).

Remarks.—The species differs from *D. costatum* in being smaller in size, and in the endoplasmic sack not extending anteriorly into the operculum. Along with *D. rangiferi* Dogiel, 1925, and *D. dogieli* Kof. & MacL., 1932, the four species constitute the natural *rangiferi* group.

Habitat.—Stomach of *Bos gaurus* H. Smith: Mulehole, Mysore.

"Crista-galli" Group.—This group includes species with a roughly triangular lateral outline, truncate anteriorly and tapering posteriorly. Rectum relatively long and circular in cross-section.

219. **Diplodinium crista-galli** Dogiel. (Fig. 162.)

Diplodinium crista-galli, Dogiel, 1927, p. 9.
Anoplodinium crista-galli forma *crista-galli*, Dogiel, 1927, pp. 91–3, fig. 47 *a*, *c–f*.
Diplodinium crista-galli, Kofoid & MacLennan, 1932, p. 86.
†*Diplodinium crista-galli*, Das-Gupta, 1935, p. 167.

Body triangular in lateral view; the left side extends posteriorly, forming a prominent fan with two to seven spines. Endoplasmic sack is full of cellulose particles and chlorophyll granules etc. Anal tube is clear and is directed obliquely backwards and dorsalwards. Contractile vacuoles, two in number, lie dorsal to the macronucleus, and are dorso-ventrally compressed. Macronucleus hatchet-shaped, its anterior limb



Fig. 162.—*Diplodinium crista-galli* Dogiel. (After Dogiel.)

not strongly developed, and directed obliquely forwards and ventralwards. Micronucleus lies in a depression on the dorsal side of the macronucleus.

Dimensions.—Length 77–100 μ, breadth 52–70 μ; ratio of length to breadth 1·45.

Habitat.—In small numbers in the rumen of *Capra hircus* Linn.: Bengal, Calcutta.

220. **Diplodinium flabellum** Kofoid & MacLennan. (Pl. V, fig. 6.)

†*Diplodinium flabellum*, Kofoid & MacLennan, 1932, pp. 86–7, pl. iv, fig. 6; fig. D, 3–8.

Body relatively short, length 1·29–1·56 times the dorso-ventral diameter, laterally compressed, roughly triangular in lateral view, tapering rapidly from the mid-region to the

rounded posterior end. Right side extends posteriorly, forming a prominent fan with five to seven spines which may be simple, bifurcate, or even trifurcate; two small spines arise on the posterior dorsal surface, one on each side of the mid-line, left simple, right bifurcate. Oral area of moderate size, inclined ventrally and to the left. Dorsal membranelle zone short, with a heavy inner lip which hides the small dorsal disk. Operculum relatively small. Endoplasmic sack closely follows the outer contour of the body to the posterior end; boundary layer strongly developed. Rectum narrow, tubular, opening at the posterior end by a circular anus, which lies in the mid-line to the left of the caudal fan. Only one relatively large contractile vacuole observed, located under the mid-dorsal surface near to the dorsal zone, second vacuole may be present. Macronucleus a heavy rod-like body, with its anterior end usually two to three times the diameter of the posterior end and slightly bent ventrally, lying under the right surface. Micronucleus ellipsoidal, in a small depression on the dorsal surface of the anterior third of the macronucleus.

Dimensions.—Length 82–118 μ.

Feeds on small particles of plant material.

Remarks.—The species is similar to *D. crista-galli* Dogiel in the general shape of the body, shape of the rectum, and in the unique caudal fan of spines, which, however, is formed by an extension of the left side of the body in that species.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor.

Genus **EREMOPLASTRON** Kofoid & MacLennan, 1932.

Eudiplodinium, part, Dogiel, 1927, pp. 104–19, figs. 57–66.
Eremoplastron, Kofoid & MacLennan, 1932, pp. 88–103.

Ophryoscolecidæ with two membranelle zones, viz., an adoral, and a dorsal zone lying at the anterior end of the body. A single, narrow skeletal plate beneath the right surface. Contractile vacuoles two. Macronucleus triangular or rod-like, with the anterior end often bent ventrally.

Key to Indian Species.

1 (2).	Posterior end smoothly rounded, with no ventral lobe or caudal spines	[MacL., p. 328. *E. rotundum* Kof. &
2 (1).	Posterior end with one or more lobes or spines	3.
3 (4).	Posterior end with a small ventral lobe only	[p. 325. *E. bovis* (Dogiel),
4 (3).	Posterior end with one or two spines ...	5.
5 (6).	With thick dorsal flange and large ventral caudal spine.....	[tini), p. 327. *E. rostratum* (Fioren-
6 (5).	With two caudal spines	7.

7 (8). Body ellipsoidal in side view, with two short caudal spines ..... *E. brevispinum* Kof. & [MacL., p. 325.

8 (7). Body rectangular in side view, with two large caudal spines ..... *E. magnodentatum* Kof. [& MacL., p. 326.

221. **Eremoplastron bovis** (Dogiel). (Pl. VI, fig. 10.)

Eudiplodinium neglectum forma *bovis*, Dogiel, 1927, p. 108, fig. 58.
Anoplodinium neglectum forma *bovis*, Dogiel, 1927, p. 244.
Diplodinium clevelandi, Becker & Talbot, 1927, pp. 356–7, pl. ii, fig. 20.
†*Eremoplastron bovis*, Kofoid & MacLennan, 1932, pp. 95–7, pl. v, fig. 10; fig. F, 5, 6.

Body ellipsoidal, length 1·44–1·89 times the dorso-ventral diameter, compressed laterally. Ventral surface somewhat flattened except in the posterior quarter, dorsal more strongly convex. A small, smoothly rounded ventral lobe projects from the ventral half of the posterior end. Cytostome relatively small, inclined ventrally and to the left. Dorsal membranelle zone small. Operculum well developed and conspicuous. Narrow skeletal plate extends diagonally under the right surface from the edge of the oral region to the middle of the right side. Endoplasmic sack occupies the greater part of the body; boundary layer easily seen. Rectum extends from the posterior end of the boundary layer and opens in the middle of the posterior end of the body at the base of the ventral lobe. Two contractile vacuoles beneath the surface along the mid-dorsal line, anterior a short distance behind the dorsal membranelle zone and the posterior at the level of the posterior end of the macronucleus. Macronucleus elongate, beneath the middle of the right surface, its ventral edge parallel and close to the skeletal plate and its dorsal side convex with a conspicuous indentation in the middle, in which the small ovoidal micronucleus lies.

Dimensions.—Length 52–100 μ.

Feeds on small bits of plant débris.

Remarks.—*E. bovis* shows closest resemblance to *E. neglectum*, which is relatively simple in structure and, like this species, possesses a single ventral lobe. The operculum in *E. bovis* is a great deal smaller than in *E. neglectum*.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

222. **Eremoplastron brevispinum** Kofoid & MacLennan. (Pl. VI, fig. 8.)

Eremoplastron brevispinum, Kofoid & MacLennan, 1932, pp. 97–8, pl. v, fig. 8; fig. F, 9, 10.
†*Eremoplastron brevispinum*, Das-Gupta, 1935, p. 168.

Body ellipsoidal, length 1·54–1·84 times the dorso-ventral

diameter, compressed laterally. Dorsal surface convex, ventral surface flat or slightly concave in anterior half, convex in posterior half; lateral surfaces convex. Two short broad caudal spines, one dorsal to the anus the other ventral to it and merely a slight prolongation of the ventral lobe. Cytostome small, inclined ventrally and to the left. Dorsal membranelle zone relatively small. Operculum conspicuous. Skeletal plate narrow, extending diagonally beneath the right surface from the edge of the oral zone to the middle of the body; anterior end of the plate three or four times wider than the posterior. Endoplasmic sack occupies the greater part of the body and posteriorly extends beyond the anterior end of the rectum. Rectum wide, slit-like, opening by a narrow elliptical anus lying between the dorsal and ventral spines. Two contractile vacuoles lie beneath the dorsal mid-line, anterior at the level of the anterior end of the macronucleus and the posterior just behind the level of the posterior end of the macronucleus. Macronucleus beneath the right surface just dorsal to the skeletal plate, its ventral side flat or slightly concave, dorsal surface convex, with a large indentation in its middle, in which a spherical or slightly ellipsoidal micronucleus lies.

Dimensions.—Length 72–92 μ.

Feeds on small bits of plant débris.

Remarks.—The shape, proportions and structure relate the species closely to *E. bovis*, but the presence of two spines shows a small advance in complexity over the single conical lobe of *E. bovis*.

Habitat.—Stomach of *Bos indicus* Linn.: CEYLON, Colombo; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

223. **Eremoplastron magnodentatum** Kofoid & MacLennan. (Pl. VI, fig. 9.)

†*Eremoplastron magnodentatum*, Kofoid & MacLennan, 1932, pp. 100–2, pl. v, fig. 9; fig. F, 11, 12.

Body rectangular in side view, length 1·50–1·93 times the dorso-ventral diameter, compressed laterally and ovoidal in dorsal view, with the largest diameter anterior. Dorsal surface flat, ventral slightly convex. Two large laterally compressed caudal spines give a remarkable pincer-like appearance to the posterior end of the body. Oral region inclined ventrally but not inclined toward either side. Adoral zone well developed, but the operculum is relatively small. Skeletal plate lies beneath the right surface and extends diagonally from the edge of the oral region toward the middle of the body, with its anterior part wider than the posterior. Endo-

plasmic sack extends to the posterior end of the body ; a part bulges into the base of the dorsal spine and extends beyond the rectum. Rectum slit-like, opening by an elliptical anus in the base of the ventral spine. Two contractile vacuoles lie beneath the dorsal mid-line, anterior near the level of the micronucleus, posterior near the level of the posterior end of the macronucleus. Macronucleus beneath the right surface close against the dorsal edge of the skeletal plate ; its ventral surface slightly concave, dorsal surface strongly convex, with a small relatively deep depression in which the ellipsoidal micronucleus lies.

Dimensions.—Length 58–82 μ.

Feeds on small bits of plant débris.

Remarks.—This species shows a close resemblance to *E. dilobum* Dogiel, but differs in the possession of large conspicuous caudal spines instead of true caudal lobes as in that species.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

224. **Eremoplastron rostratum** (Fiorentini). (Pl. VI, fig. 7 ; Pl. XI, fig. 12.)

Diplodinium rostratum, Fiorentini, 1889 *a*, pp. 16, 24, fig. 3 ; Eberlein, 1895, pp. 262–3, pl. xviii, fig. 18 ; da Cunha, 1914, pp. 62–4.

Eudiplodinium rostratum, Dogiel, 1927, pp. 118–19, fig. 66.

Diplodinium helseri, Becker & Talbot, 1927, pp. 357–8, pl. ii, fig. 11.

†*Eremoplastron rostratum*, Kofoid & MacLennan, 1932, pp. 91–3, pl. v, fig. 7 ; fig. F, 1, 2 ; Kofoid & Christenson, 1934, pp. 367–8, pl. xxviii, fig. 19 ; fig. E, 1–12 ; Das-Gupta, 1935, pp. 167–8.

Body small but relatively long, length 1·50–2·00 times the dorso-ventral diameter, compressed laterally. Dorsal surface convex, ventral surface nearly flat. A long caudal spine extends posteriorly from the region between the anus and the ventral surface. Posterior third of the dorsal side of the body thin and forms a flange-like projection. Oral region relatively large, tipped ventrally and to the left at an angle. Dorsal membranelle zone small. Operculum relatively small, overhangs and obscures the dorsal membranelle zone. Narrow skeletal plate under the right surface, extending from the edge of the oral zone to the middle of the body ; anterior end of the plate four to five times as broad as the posterior end. Ectoplasm relatively thick, boundary layer thin, endoplasmic sack oval. Rectum short, cylindrical, extending dorsalwards from the posterior end of the endoplasmic sack. Two contractile vacuoles beneath the dorsal surface, along the mid-line, anterior at the level of the micronucleus, posterior in the

anterior part of the dorsal flange. Macronucleus beneath the right surface of the body, parallel and dorsal to the skeletal plate; an elongate body, its ventral side nearly straight and its dorsal surface convex, with a large median indentation in which the small ellipsoidal micronucleus lies.

Dimensions.—Length 40–52 μ (according to other observers up to 80 μ).

Feeds on small bits of plant débris.

Remarks.—*E. rostratum* is marked off from the other species of the genus by its small size and the presence of the dorsal flange. Specimens from *Bos gaurus* were relatively shorter and stouter than those from *B. indicus*.

Habitat.—Stomach of *Bos indicus* Linn.: CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

225. **Eremoplastron rotundum** Kofoid & MacLennan. (Pl. VI, fig. 11.)

†*Eremoplastron rotundum*, Kofoid & MacLennan, 1932, pp. 93–4, pl. v, fig. 11; fig. F, 7, 8.

Body relatively short and broadly ovoidal in side view, length 1·33–1·66 times the dorso-ventral diameter, with the largest diameter posterior, compressed laterally; posterior end smoothly rounded, with neither lobe nor spines. Oral area of medium size, inclined ventrally and to the left. Dorsal zone short but lips well developed. Operculum small and relatively inconspicuous. Skeletal plate extends diagonally beneath the right surface from the edge of the oral region to the middle of the body, broader anteriorly, narrow posteriorly. Endoplasmic sack occupies most of the body and follows the surface contours closely; boundary layer distinct. Rectum wide and slit-like. Anus a narrow slit located in the middle of the posterior end. Two contractile vacuoles under the dorsal mid-line at about the levels of the ends of the macronucleus. Macronucleus in the middle half of the body adjacent to the dorsal edge of the skeletal plate, its ventral side flat or slightly concave, dorsal side strongly convex, with a shallow median depression. Micronucleus small, ovoidal, lying in the depression of the macronucleus.

Dimensions.—Length 70–95 μ.

Feeds on small bits of plant débris.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

Genus **DIPLOPLASTRON** Kofoid & MacLennan, 1932.

Eudiplodinium, part, Dogiel, 1927, pp. 123–4.
Diploplastron, Kofoid & MacLennan, 1932, pp. 107–8.

Ophryoscolecidæ with dorsal and adoral membranelle zones at the anterior end of the body. Two skeletal plates beneath the right surface of the body. Contractile vacuoles two, below dorsal surface, separated from the macronucleus. Macronucleus narrow, rod-like.

Remarks.—Though possessing two skeletal plates the genus is more closely related to *Eremoplastron* than to *Metadinium*. It differs from the former in possessing two skeletal plates and from the latter in the shape of the macronucleus and in possessing thin cuticle and ectoplasm and small rectum and anus.

226. **Diploplastron affine** (Dogiel & Fedorowa). (Fig. 163.)

Diplodinium affine, Dogiel & Fedorowa, 1925, p. 100.
Eudiplodinium affine, Dogiel, 1927, pp. 123–4, fig. 68.
Diploplastron affine, Kofoid & MacLennan, 1932, p. 108, fig. H, 2.
†*Diplodinium affine*, Das-Gupta, 1935, p. 168.

Body small and oval, 1·7 dorso-ventral diameters in length. Two skeletal plates lie beneath the right surface of the body,

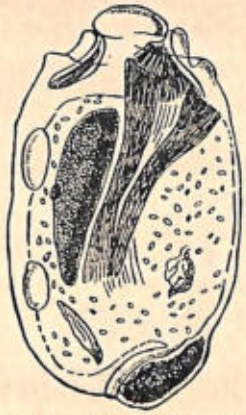


Fig. 163.—*Diploplastron affine* (Dogiel & Fedorowa). (After Dogiel.)

extending from the edge of the oral area past the middle of the body. The anterior ends of the plates are separated, while the posterior parts of the plates come close together but do not fuse. Each plate is made up of from five to six rows of prisms. Operculum is small. Endoplasmic sack extends posteriorly beyond the anterior end of the rectum. Rectum

narrow, tubular, with thin walls. Anus small and circular. Contractile vacuoles two, situated along the dorsal border of the body, apart from the macronucleus, the anterior one in front of the level of the middle of the macronucleus and the posterior behind the level of the posterior end of the macronucleus. Macronucleus narrow, sausage-shaped to club-shaped. Micronucleus lies in a small depression in the middle of the dorsal margin of the macronucleus.

Dimensions.—Length 88–120 μ, breadth 47–65 μ; ratio of length to breadth 1·7.

Habitat.—Rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

Genus **EUDIPLODINIUM** Dogiel, 1927, emend. Kofoid & MacLennan, 1932.

Eudiplodinium, part. Dogiel, 1927, pp. 119–22, fig. 67, *a*, *b*; Kofoid & MacLennan, 1932, pp. 103–7.

Ophryoscolecidæ with two membranelle zones, viz., an adoral zone, and a dorsal zone lying at the anterior end of the body. A single, narrow, skeletal plate beneath the right surface. Cuticle and ectoplasm thick. Two contractile vacuoles with heavy membranes and prominent pores. Macronucleus rod-like, with anterior end enlarged to form a hook opening dorsally.

227. **Eudiplodinium maggii** (Fiorentini). (Pl. VI, fig. 12; Pl. XI, fig. 13.)

Diplodinium maggii, Fiorentini, 1889, p. 13, pl. i, figs. 3, 4; Eberlein, 1895, pp. 252–6, figs. 8, 9; Buisson, 1923 *b*, pp. 103–5, fig. 36.
Diplodinium bursa, Schulze, 1924, pp. 657, 661, fig. 5.
†*Diplodinium maggii*, Jameson, 1925, pp. 408–9.
Diplodinium maggii, Dogiel & Fedorowa, 1925, pp. 98, 100, 106, fig. 1; Becker & Talbott, 1927, p. 353.
Diplodinium bursa, Becker & Talbott, 1927, p. 354, pl. ii, fig. 21.
Eudiplodinium maggii, Dogiel, 1927, pp. 119–22, fig. 67, *a*, *b*.
†*Eudiplodinium maggii*, Kofoid & MacLennan, 1932, pp. 105–7, pl. v, fig. 12; fig. F, 3, 4; Kofoid & Christenson, 1934, pp. 368–70, pl. xxviii, fig. 20; fig. F, 1, 2; Das-Gupta, 1935, p. 168.

Body roughly triangular in side view, length 1·33–1·67 times the dorso-ventral diameter, sharply truncated anteriorly and tapering to a smoothly rounded posterior end; flattened laterally, giving a rather narrow elliptical outline in dorsal view. Dorsal surface convex; anterior half of ventral surface flat or concave, posterior half convex. Oral region relatively small, and inclined ventrally and to the left. Dorsal membranelle zone relatively large, operculum relatively small and inconspicuous. Skeletal plate lies beneath the right surface

and extends from the oral region dorsally across the middle of the body; its anterior end broad, tapering posteriorly. Cuticle forms a distinct layer; ectoplasm thick; boundary layer distinct, clearly marking out the endoplasmic sack. Rectum heavy, slit-like; anus opens on the right side of the posterior end. Usually two contractile vacuoles lie beneath the dorsal surface near the mid-line, anterior at the level of the micronucleus, posterior at the level of the posterior end of the macronucleus; but the number may be increased to six. Macronucleus elongate, rod-like, with the anterior end hooked dorsally, situated beneath the middle of the right surface adjacent to the dorsal border of the skeletal plate. Micronucleus ovoidal, lying in the concavity of the hook.

Dimensions.—Length 104–255 μ.

Feeds on relatively large particles of plant material and some of the smaller Ciliates occurring in the same host.

Remarks.—There has been considerable confusion between *E. maggii* and *Diplodinium bursa* owing to the somewhat incomplete descriptions of Fiorentini. However, as pointed out by Kofoid and MacLennan, it is clear from his drawings that there is a deep anal groove marking off dorsal and ventral caudal lobes in his *D. bursa*, while his *D. maggii* has a rather pointed posterior end with no lobes at all.

This species was present but not abundant in the material from Ceylon. All the specimens were large and were distinguished by the number of contractile vacuoles, six being a common number. Macronucleus was very prominent, and while conforming to the general pistol-shape characteristic of the species the handle-like portion at the anterior end was strongly developed and usually bent into a nearly closed loop.

The specimens from *Bos gaurus* were smaller and relatively stouter than those from *B. indicus*, measuring 102 (80–117) μ, or 1·42 dorso-ventral diameters in length.

Habitat.—Stomach of *Tragulus meminna* Milne-Edwards (mouse-deer): Ceylon; stomach of *Bos indicus* Linn.: Madras, Coonoor; Ceylon, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore; rumen of *Capra hircus* Linn.: Bengal, Calcutta.

Genus **METADINIUM** Awerinzew & Mutafowa, 1914.

Metadinium, Awerinzew & Mutafowa, 1914, pp. 115–18, figs. 7–10.
Metadinium, part, Crawley, 1923, pp. 395, 400, pl. xxviii, fig. C, 1 ; Wenyon, 1926, p. 1215.
Eudiplodinium, part, Dogiel, 1927, pp. 124–130, figs. 69–72.
Diplodinium, part, Becker & Talbot, 1927, p. 354, fig. 24.
Metadinium, Kofoid & MacLennan, 1932, pp. 111–16 ; Calkins, 1933, p. 515 ; Kofoid & Christenson, 1934, pp. 370–2.

Ophryoscolecidæ with dorsal and adoral membranelle zones at the anterior end of the body. Two skeletal plates beneath right surface, occasionally fused at posterior end. Cuticle and ectoplasm heavy. Conspicuous œsophageal fibrils beneath dorsal and right lateral surfaces. Two contractile vacuoles lying close to the macronucleus. Large macronucleus with two or three prominent dorsal lobes.

Key to Indian Species.

1 (2). Body large, heavy ; skeletal plates not fused at their posterior end ; three dorsal lobes on the macronucleus ... [Mut., p. 332. *M. medium* Awer. &

2 (1). Body relatively short ; skeletal plates fused at their posterior end ; macronucleus with a large lateral lobe on its left edge ..... [Christ., p. 333. *M. rotundatum* Kof. &

228. **Metadinium medium** Awerinzew & Mutafowa. (Pl. VII, fig. 16.)

Metadinium medium, Awerinzew & Mutafowa, 1914, pp. 115–18, figs. 7–10.
Diplodinium medium, Buisson, 1923 *b*, pp. 123–4, fig. 45 ; Dogiel & Fedorowa, 1925, pp. 100, 107, fig. 2 ; Becker & Talbot, 1927, pp. 353–4, fig. 24.
Metadinium medium, Wenyon, 1926, p. 1215, fig. 521 A.
Eudiplodinium medium forma *medium*, Dogiel, 1927, pp. 124–6, fig. 69.
†*Metadinium medium*, Kofoid & MacLennan, 1932, pp. 113–15, pl. vi, fig. 16 ; fig. G, 3, 4 ; Kofoid & Christenson, 1934, p. 370, pl. xxix, fig. 25 ; fig. F, 3, 4 ; Das-Gupta, 1935, p. 169.

Body large and heavy, length 1·35–1·78 times the dorso-ventral diameter, flattened laterally ; anterior end blunt, posterior end truncated or slightly rounded. Dorsal and ventral surfaces vary from nearly flat to distinctly convex ; lateral surfaces slightly convex and ends of body smoothly rounded in dorsal view. Oral area relatively large, inclined ventrally, but not inclined to the left. Dorsal membranelle zone also large. Operculum relatively very small. Two skeletal plates extend from the border of the oral area beneath the right

surface towards the middle of the body, anterior end of each plate broader than the posterior; the dorsal plate longer and broader than the ventral plate. Cuticle very heavy and covered with short, fine wrinkles arranged longitudinally, but no regular striations as in other genera. Ectoplasm also very thick. Endoplasmic sack relatively small, usually with two distinct projections on the dorsal and ventral sides. Rectum a large cylinder, anus a large opening in the right posterior end of the body. Two large contractile vacuoles in the hollows between the lobes of the macronucleus, somewhat to the right of the dorsal mid-line. Macronucleus elongate, adjacent to the dorsal edge of the dorsal skeletal plate, with three large dorsal lobes, one at each end and one in its middle. Micronucleus small, ovoid, lying in a slight depression along the anterior border of the middle lobe of the macronucleus.

Dimensions.—Length 108–224 μ (Kof. & MacL.), 150–272 μ (other authors).

Feeds on relatively large bits of plant débris.

Remarks.—The specimens from *Bos gaurus* were significantly smaller than those from *B. indicus*, measuring 130–201 μ, and possessed a relatively wider mouth.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

229. **Metadinium rotundatum** Kofoid & Christenson. (Pl. XI, fig. 11.)

†*Metadinium rotundatum*, Kofoid & Christenson, 1934, pp. 370–2, pl. xxvii, fig. 18; fig. D, 1–2.

Body relatively short, length 1·43–1·55 times the dorsoventral diameter, ovoid, and slightly compressed laterally. Dorsal surface regularly convex throughout its entire length; ventral surface most strongly convex in its posterior third. Right surface more strongly convex than the left. Posterior end extremely smoothly rounded. Operculum shallow, somewhat flattened on the left. Faint longitudinal striations cover the cuticle, which is relatively thick. Mouth well defined, with conspicuous lips and furrows, tilted ventrally and to the left. Dorsal membranelle zone at about the same level as adoral zone. Skeletal complex of two plates underneath the right surface, separate in their anterior halves, fusing about the middle and continuing as one, terminating near the posterior end of the macronucleus. Œsophageal fibrils prominent, extending to posterior end of endoplasm. Rectum conspicu-

ous, with faint longitudinal fibrils. Anus ellipsoidal, in the middle of the smoothly rounded posterior end. Contractile vacuoles two, to the left of the macronucleus along the dorsal mid-line; anterior usually much larger and slightly anterior to the level of the micronucleus, posterior in the posterior concavity of the macronucleus. Macronucleus elongate, with two shallow concavities on the left margin, one on each side of a large lateral lobe. Micronucleus small, subspherical, lying in the anterior lateral concavity of the macronucleus.

Dimensions.—Length 52–73 μ breadth 34–45 μ.

Feeds on plant débris.

Remarks.—This species is most closely related to *M. ypsilon* (Dogiel, 1925). It resembles that species in having a skeletal complex of two plates fused posteriorly, a macronucleus of similar general shape, a similar position of the micronucleus and the contractile vacuoles, and a relatively thick cuticle. It is, however, significantly smaller, has skeletal plates which are concave in their median unfused portions instead of being parallel, and has a macronucleus with a rounded anterior end instead of an anterior end perpendicular to its long axis.

Habitat.—Stomach of *Bos gaurus* H. Smith: Mulehole, Mysore.

Genus **ELYTROPLASTRON** Kofoid & MacLennan, 1932.

Polyplastron, part, Dogiel, 1928, pp. 332–4, figs. 4, *a*, *b*.
Elytroplastron, Kofoid & MacLennan, 1932, pp. 119–22; Calkins, 1933, p. 515.

Ophryoscolecidæ with dorsal and adoral membranelle zones at the anterior end of the body. Two skeletal plates beneath right surface, a small plate beneath ventral surface, and a long plate beneath the left surface. Cuticle and ectoplasm relatively heavy; conspicuous fibrils beneath dorsal and right lateral surfaces.

230. **Elytroplastron bubali** (Dogiel). (Pl. VII, figs. 13, 14.)

Diplodinium (*Polyplastron*) *bubali*, Dogiel, 1928 *b*, pp. 332–4, fig. 4.
†*Elytroplastron bubali*, Kofoid & MacLennan, 1932, pp. 121–2, pl. vi, figs. 13, 14; fig. G, 5, 6.
†*Elytroplastron bubali*, Das-Gupta, 1935, p. 169.

Body ellipsoidal, length 1·43–1·82 times the dorso-ventral diameter, compressed laterally, posterior end smoothly rounded with no suggestion of lobes or spines. Oral area relatively large, inclined ventrally, but not inclined either to left or right. Dorsal membranelle zone relatively short. Operculum broad but does not project anteriorly beyond the adoral zone. Four skeletal plates; two, as in *Metadinium*,

extending diagonally from the edge of the adoral membranelle zone across the middle of the body, gradually fading in that region; one very short triangular plate on the left ventral side just behind the adoral zone; a fourth plate lies beneath the left surface, extending posteriorly and dorsally from the base of the operculum. Endoplasmic sack narrow anteriorly and swollen in the middle. Rectum heavy, tubular, beneath the right side of the body, and terminating by a narrow slit-like anus extending from the middle of the posterior end to the right side. Four contractile vacuoles along the dorsal mid-line, one near the anterior end of the macronucleus, second at the level of the micronucleus, third further back, and the fourth near the posterior tip of the macronucleus. Macronucleus elongate, slightly to the right of the mid-line, with a deep indentation in its left dorsal side, in which the small ellipsoidal micronucleus lies.

Dimensions.—Length 110–160 μ.

Feeds on small pieces of plant débris and occasionally small Ciliates.

Remarks.—In the specimens from *Capra hircus* there are usually only two contractile vacuoles, and never more than three, and the ventral skeletal plate is slightly longer than in specimens from *B. indicus*.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo; rumen of *Capra hircus* Linn.: Calcutta.

Genus **OSTRACODINIUM** Dogiel, 1927, emend. Kofoid & MacLennan, 1932.

Diplodinium, part, Fiorentini, 1889, p. 14, pl. ii, fig. 3; part, Buisson, 1923 *b*, pp. 120–1, figs. 35, 43.
Metadinium, part, Crawley, 1923, p. 400, pl. xxviii, fig. C_3.
Diplodinium, part, Fantham, 1926, pp. 567–8, fig. 7; Becker & Talbot, 1927, pp. 356, 357, figs. 14, 17.
Ostracodinium, part, Dogiel, 1927, pp. 134–52, figs. 76–86; Reichenow, 1929, p. 1199; Kofoid & MacLennan, 1932, pp. 122–40; Calkins, 1933, p. 515; Kofoid & Christenson, 1934, pp. 372–77.

Ophryoscolecidæ with dorsal and adoral membranelle zones at anterior end of body. Broad skeletal plate beneath right side of body. A row of from two to six contractile vacuoles beneath dorsal surface. Œsophageal fibrils heavy and extending to the posterior end of body.

Key to Indian Species.

1 (7). With no caudal lobe or spine ..... 2.
2 (5). Posterior end smoothly rounded..... 3.
3 (4). Macronucleus with two dorsal lobes; two contractile vacuoles ..... *O. gracile* (Dogiel), [p. 337.

4 (3).	Macronucleus with a small, shallow depression in the middle of the left side; three contractile vacuoles ..	[& MacL., p. 341. *O. trivesiculatum* Kof.
5 (2).	Posterior end bluntly pointed	6.
6.	Macronucleus with a small shallow depression in the middle of the dorsal surface, four contractile vacuoles.	[Kof. & MacL., p. 340. *O. quadrivesiculatum*
7 (1).	With one or more caudal lobes	8.
8 (16).	With one caudal lobe	9.
9 (14).	Ventral lobe small	10.
10 (11).	Macronucleus rod-like; two contractile vacuoles	[Christ., p. 339. *O. mysorei* Kof. &
11 (10).	Macronucleus with two dorsal lobes; contractile vacuoles two or three..	12. [MacL., p. 342.
12 (13).	With two contractile vacuoles	*O venustum* Kof. &
13 (12).	With three contractile vacuoles	*O. clipeolum* Kof. &
14 (9).	Ventral lobe wide	15. [MacL., p. 336.
15.	Large inturned skeletal plate; macronucleus with a depression in the middle of the left dorsal side; three contractile vacuoles	[& MacL., p. 340. *O. rugoloricatum* Kof.
16 (8).	With two caudal lobes, one dorsal and one ventral	17.
17 (18).	Macronucleus elongated, with a large shallow depresssion in the middle of the left side; three contractile vacuoles	[liet), p. 338. *O. mammosum* (Rail-
18 (17).	Macronucleus elongated, rod-like; two contractile vacuoles	[p. 337. *O. gauri* Kof. & Christ.,

231. **Ostracodinium clipeolum** Kofoid & MacLennan. (Pl. VII, fig. 15.)

†*Ostracodinium clipeolum* Kofoid & MacLennan, 1932, pp. 135–7, pl. vi, fig. 15; fig. J, 9, 10.

Body ellipsoidal, length 1·64–2·14 times the dorso-ventral diameter, compressed laterally. Dorsal surface convex in anterior half, nearly plane in posterior half; lateral surfaces convex. A small, laterally flattened, shield-shaped lobe on the postero-ventral end of the body to the left of the middle line. Oral area inclined ventrally and to the left. Dorsal membranelle zone relatively inconspicuous. Operculum small. Broad skeletal plate extends laterally beneath the right surface from the macronucleus to the ventral side and posteriorly up to the posterior end of the body. Œsophageal fibres extend to the posterior end of the body. Small, cylindrical rectum in the middle line of the postero-ventral side of the body, and opening by a small elliptical anus. Three contractile vacuoles along the dorsal side of the macronucleus, two between the anterior and posterior lobes, the third just behind the posterior lobe of the macronucleus. Macro-

nucleus an elongate body beneath the right dorsal surface, with two flat lobes dorsally, one on its anterior and the other on its posterior half. Micronucleus ellipsoidal, in a depression on the dorsal side of the macronucleus.

Dimensions.—Length 92–128 μ.

Feeds on large bits of plant débris.

Remarks.—This species resembles *O. dogieli* Kof. & MacL. in proportions, size and the shape of the caudal lobe. The caudal lobe is often reduced, and may be little more than a semicircular flap.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

232. **Ostracodinium gauri** Kofoid & Christenson. (Pl. XI, fig. 14.)

†*Ostracodinium gauri*, Kofoid & Christenson, 1934, pp. 375–6, pl. xxviii, fig. 21 ; fig. G, 7, 8.

Morphologically identical with *O. mysorei* in all respects except caudal armature ; two caudal lobes of subequal size present, one ventral, the other dorsal. Anal opening lies at the base of the dorsal surface of the ventral lobe.

Dimensions.—Length 44–70 μ, breadth 23–40 μ.

Remarks.—This species is related to *O. mysorei* in size and shape of the body, shape of macronucleus, shape of skeletal plate, posterior diverticulum of endoplasmic sack, and the number of vacuoles, but differs in possessing two caudal lobes. It differs from *O. dilobum* Dogiel (1927), in being of smaller size, in having two vacuoles instead of five, and in possessing a posterior diverticulum of the endoplasmic sack.

Habitat.—Stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

233. **Ostracodinium gracile** (Dogiel). (Pl. VIII, fig. 18.)

Diplodinium gracile forma *gracile*, Dogiel, 1925 *a*, pp. 130, 133, 141, fig. 5 ; 1925 *b*, pp. 297–301, figs. B, E–L, E_1–M_1, E_2–G_2.
Ostracodinium gracile forma *gracile*, Dogiel, 1927, pp. 144–6, fig. 81, *d*.
†*Ostracodinium gracile*, Kofoid & MacLennan, 1932, pp. 27–9, pl. vii, fig. 18; fig. J, 1, 2; Kofoid & Christenson, 1934, p. 376, pl. xxviii, fig. 22; fig. G, 1, 2.

Body roughly triangular, length 1·75–2·16 times the dorso-ventral diameter. Ventral and left surfaces plane, right and dorsal surfaces convex ; posterior end smoothly rounded. Oral area prominent, inclined ventrally, but not inclined to the right or the left. Dorsal membranelle zone and the

operculum relatively prominent. A broad skeletal plate beneath the right surface, extending laterally from the macronucleus to the ventral surface. Œsophageal fibrils extending to the posterior end of body. Two contractile vacuoles, close against the dorsal edge of the macronucleus, one vacuole in the depression behind each lobe of the macronucleus. Macronucleus elongate, lying along the right dorsal surface, with two dorsal lobes, one at its anterior end and one in the middle. Micronucleus small, ellipsoidal, lying between the two lobes of the macronucleus.

Dimensions.—Length 90–133 μ.

Feeds on relatively large pieces of plant débris.

Remarks.—This species is closely allied to *O. trivesiculatum* Kof. & MacL. and *O. tenue* (Dog.) in its triangular shape, size, proportions of the body, and in the lack of spines. It is also closely related in shape and proportions to two spined species, *O. nanum* (Dog.) and *O. gladiator* (Dog.). The conjugation of *O. gracile* has been described by Dogiel (1925 *c*).

Specimens of *O. gracile* from *Bos gaurus* were smaller and relatively shorter than individuals from *B. indicus*. They measure 60–85 μ, and the length is 1·58–1·85 times the dorso-ventral diameter.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore.

234. **Ostracodinium mammosum** (Railliet). (Pl. VIII, fig. 17.)

Diplodinium dentatum, Fiorentini, 1889, pp. 14, 24, pl. ii, fig. 3.
Diplodinium mammosum, Railliet, 1890, pp. 318–19; 1895, p. 181.
Diplodinium dentatum, da Cunha, 1914, pp. 63, 64; Sharp, 1914, p. 60; Buisson, 1923 *b*, pp. 120–1, fig. 35; Becker & Talbot, 1927, pp. 353, 356, pl. ii, fig. 14.
Diplodinium fiorentinii, Awerinzew & Mutafowa, 1914, pp. 110–11, figs. 1, 2; Buisson, 1923 *b*, p. 120, fig. 43.
Metadinium dentatum, Crawley, 1923, p. 400.
Ostracodinium dentatum, Dogiel, 1927, pp. 139–42, fig. 79, *a*, *b*.
†*Ostracodinium mammosum*, Kofoid & MacLennan, 1932, pp. 125–6, pl. vii, fig. 17; fig. G, 1, 2.

Body relatively short, length 1·55–1·92 times the dorso-ventral diameter. Ventral surface convex in anterior half, then flat or slightly concave, and convex again in the posterior region; dorsal surface convex; lateral surfaces convex. One dorsal caudal lobe; the ventral lobe hollow on its dorsal side. Oral area inclined ventrally and to the left. Adoral membranelle zone relatively well developed. Operculum large. Skeletal plate broad, anteriorly extending beneath the right surface from the anterior end of the macronucleus to the ventral side,

narrowing posteriorly and extending to the bases of the caudal lobes. Œsophagus and endoplasmic sack marked by heavy fibrils. Rectum a dorso-ventrally flattened tube; elliptical anus in the concave side of the ventral lobe. Three contractile vacuoles beneath the dorsal surface of the body, anterior near the anterior end of the macronucleus and the posterior near the level of the posterior end of the macronucleus. Macronucleus long, rod-like, lying beneath the right dorsal surface, with a large shallow depression in its left side, near which lies the median contractile vacuole. Micronucleus small, ellipsoidal, in a small depression near the middle of the dorsal surface of the macronucleus.

Dimensions.—Length 41–110 μ.

Feeds on small bits of plant débris.

Remarks.—This species resembles *O. dilobum* Dogiel in the general form of the body and in possessing two caudal lobes, but it is smaller, has fewer vacuoles, and the caudal lobes are relatively larger. The ventral lobe is not scoop-shaped in *O. dilobum*.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

235. **Ostracodinium mysorei** Kofoid & Christenson. (Pl. XI, fig. 15.)

†*Ostracodinium mysorei*, Kofoid & Christenson, 1934, pp. 372–5, pl. xxviii, fig. 23; fig. G, 5, 6, 9–12.

Body short and relatively stout, length 1·16–1·60 times the dorso-ventral diameter, strongly compressed laterally. Ventral and left surfaces slightly convex, right and dorsal surfaces more strongly convex. Dorsal membranelle zone at nearly the same transverse level as the adoral zone, and separated from it by the rounded operculum. One ventral caudal lobe of variable size, usually small. Posterior end of the body dorsal to the anus, smoothly rounded. A broad skeletal plate, consisting of about 20 to 30 longitudinal rows of polygonal prisms, lies underneath the right surface of the body, is wider in its anterior third, and extends backwards to the posterior end of the macronucleus. Mouth tilted ventrally and to the left. Œsophagus conspicuously fibrillated, the fibrils terminating at the posterior end of the endoplasmic sack. The endoplasmic sack forms a conspicuous diverticulum extending to the postero-dorsal surface of the body. Rectum conspicuous but undifferentiated, opening by a broad slit anus on the dorsal side of the base of the caudal lobe. Contractile vacuoles two, subequal, along the left edge of the macronucleus, one slightly anterior and the other slightly posterior to the level

of the macronucleus. Macronucleus is a straight rod-like structure along the dorsal mid-line, gradually widening in anterior third. Micronucleus is small, subspherical, contained in a slight concavity on the left dorsal edge of the middle of the macronucleus.

Dimensions.—Length 42–53 μ ; breadth 26–30 μ.

Feeds on plant débris.

Remarks.—The species is closely related to *O. gauri*, except that it possesses a single ventral lobe.

Habitat.—Stomach of *Bos gaurus* H. Smith: Mulehole, Mysore.

236. **Ostracodinium quadrivesiculatum** Kofoid & MacLennan. (Pl. VIII, fig. 19.)

†*Ostracodinium quadrivesiculatum*, Kofoid & MacLennan, 1932, pl. vii, fig. 19; fig. J, 7, 8.

Body triangular in side view, length 1·96–2·24 times the dorso-ventral diameter, only slightly compressed laterally. Ventral surface flat or slightly convex, dorsal surface strongly convex. Left surface only slightly convex, right surface strongly so. Posterior end smoothly rounded. Oral area relatively large, not inclined ventrally, but inclined to the left. Dorsal membranelle zone relatively large. Operculum prominent and extending anteriorly considerably beyond the adoral lips. Broad skeletal plate extends laterally from the right surface of the macronucleus to the ventral surface, and posteriorly to the posterior quarter of the body. Œsophageal fibrils extending to the posterior end of the body. Rectum narrow, cylindrical, opening by an elliptical anus in the posterior end of the body, near the ventral surface. Four contractile vacuoles along the left dorsal surface of the macronucleus, one pair anterior to the micronucleus, the other near the posterior end of the macronucleus. Macronucleus elongate, rod-like, beneath the right dorsal surface, with a small shallow depression in the middle of its dorsal surface, in which lies the small ellipsoidal micronucleus.

Dimensions.—Length 92–112 μ.

Feeds on large bits of plant débris.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

237. **Ostracodinium rugoloricatum** Kofoid & MacLennan. (Pl. VIII, fig. 20.)

†*Ostracodinium rugoloricatum*, Kofoid & MacLennan, 1932, pp. 137–9, pl. vii, fig. 20; figs. I, 1, J, 11, 12.

Body rectangular in lateral view, length 1·78–2·16 times the

dorso-ventral diameter ; ellipsoidal in dorsal view, with both ends bluntly rounded. Ventral surface flat or slightly concave in the anterior three-quarters, convex in posterior quarter. Dorsal surface flat or slightly concave in the anterior half, strongly convex in the posterior half. Left surface flat, right convex. A wide flattened ventral lobe on the ventral third of the posterior end of the body. Oral area somewhat smaller than in *O. gracile* (Dog.), inclined ventrally and to the left. Dorsal membranelle zone relatively small. Operculum relatively large. Broad skeletal plate extends laterally from the macronucleus to the ventral side of the body, its dorsal edge folds inward near the macronucleus and extends toward the middle of the body. Heavy œsophageal fibrils pass from the anterior end of the endoplasmic sack to its posterior end. Rectum wide, strongly compressed dorso-ventrally, opening to the exterior by the thin slit-like anus. Three contractile vacuoles lie along the left dorsal edge of the macronucleus, one at the level of the anterior edge of the macronucleus, second just behind the micronucleus, and the third near the posterior end of the macronucleus. Macronucleus straight, narrow, rod-like, under the right dorsal edge of the body, with a deep depression in the middle of its left dorsal side, in which the small, ellipsoidal micronucleus lies.

Dimensions.—Length 84–125 μ.

Feeds on small bits of plant débris.

Remarks.—The exceptionally large inturned skeletal plate, the ventral lobe, dorso-ventrally compressed rectum and slit-like anus separate this species from the other species of the genus.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

238. **Ostracodinium trivesiculatum** Kofoid & MacLennan. (Pl. VIII, fig 22.)

†*Ostracodinium trivesiculatum*, Kofoid & MacLennan, 1932, pl. vii, fig. 22, fig. J, 3, 4 ; Kofoid & Christenson, 1934, p. 377, pl. xxviii, fig. 24 ; fig. G, 3, 4.

Body triangular in lateral view, length 1·67–2·34 times the dorso-ventral diameter, slightly compressed laterally. Ventral and left surfaces nearly flat, dorsal and right surfaces strongly convex. Posterior end smoothly rounded. Oral area relatively large, inclined ventrally, but not inclined to the left or right. Dorsal membranelle zone somewhat smaller than in *O. gracile*. Operculum fairly prominent. Broad skeletal plate extends laterally from the macronucleus to the ventral surface. Œsophageal fibrils extend to the posterior end of body. Rectum a narrow cylinder, opening by a small circular

anus in the ventral part of posterior end. Three contractile vacuoles, one just anterior to the micronucleus, one just posterior to it, and one at the level of the posterior end of the macronucleus. Macronucleus long, rod-like, lying along the right dorsal surface, with a small, shallow depression in the middle of the left side and occasionally in the posterior end ; it is curved parallel to the curvature of the right side. Micronucleus small, ellipsoidal, lying in a small depression in the middle of the dorsal surface of the macronucleus.

Dimensions.—Length 78–100 μ.

Feeds on large bits of plant débris.

Remarks.—Specimens from *Bos gaurus* were shorter and relatively stouter than those from *B. indicus*. They measure 72–91 μ and the length is 1·70–2·02 times the dorso-ventral diameter.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo ; stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

239. **Ostracodinium venustum** Kofoid & MacLennan. (Pl. VIII, fig. 21.)

†*Ostracodinium venustum*, Kofoid & MacLennan, 1932, pp. 134–5, pl. vii, fig. 21 ; fig. J, 5, 6.

Body triangular in side view, length 1·76–2·06 times the dorso-ventral diameter, laterally compressed, ellipsoidal in dorsal view. Ventral surface nearly plane, dorsal surface convex, lateral surfaces convex. A small caudal lobe projects from the postero-ventral end of the body to the left of the middle line. Oral area inclined ventrally and to the left. Dorsal membranelle zone well developed. Operculum small. Broad skeletal plate beneath the right surface, extending laterally between the macronucleus and the ventral side, and posteriorly up to the posterior quarter of the body. Œsophageal fibrils extending to and terminating at the posterior end of the endoplasmic sack. Small, tubular rectum lies along the mid-line in the postero-ventral end of the body, and opens by a circular anus just dorsal to the ventral lobe. Two contractile vacuoles lie dorsally and to the left of the macronucleus, one behind each of its dorsal lobes. Macronucleus elongate, beneath the dorsal surface slightly to the right of the middle line, with two dorsal lobes, one at the anterior end and one just behind the middle. Micronucleus on the dorsal side of the macronucleus just in front of the median lobe.

Dimensions.—Length 76–115 μ.

Feeds on large bits of plant débris.

Remarks.—This species is similar to *O. gracile* in shape, size, number of vacuoles, and shape of macronucleus, but differs in possessing a small ventral lobe.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor; CEYLON, Colombo.

Genus **EPIDINIUM** Crawley, 1923.

Epidinium, Crawley, 1923, pp. 394, 401; part, Dogiel, 1927, pp. 156–81, figs. 90–9; Wenyon, 1926, p. 1215; Reichenow, 1929, p. 1200; Kofoid & MacLennan, 1932, p. 61; 1933, pp. 1–17; Calkins, 1933, p. 515; Kofoid & Christenson, 1934, pp. 365–7; Das-Gupta, 1935, pp. 169–70.

Ophryoscolecidæ with body elongate and twisted around the main axis. Dorsal membranelle zone behind the anterior end of the body. Main skeletal complex composed of three plates. Macronucleus a straight, elongate body. Two contractile vacuoles present.

Remarks.—The morphology of this genus is more accurately known than that of the other genera in the family. Fiorentini (1889) described *Diplodinium ecaudatum*, *D. caudatum*, and *D. cattanei*. Eberlein (1895) described another species under the name of *D. caudatum* which was renamed *D. eberleini* by da Cunha (1914). Sharp (1914) redescribed two of Fiorentini's species and three new ones, but considered them all as forms of *D. ecaudatum*. This group is marked off from the rest of the species of *Diplodinium* by the shape of the body, size and position of the membranelle zones, and the number of skeletal plates. In these respects the group shows closer resemblance to *Ophryoscolex* than to *Diplodinium*, and this resemblance led da Cunha (1914), Awerinzew & Mutafowa (1914), and Dogiel (1925 *b*) to place it in the genus *Ophryoscolex*. Crawley (1923) showed that the group belonged to neither of these two genera, and erected a new genus *Epidinium* for it.

Key to Indian Species.

1 (14).	Body elongate	2.	
2 (13).	Body tapering posteriorly	3.	
3 (4).	Smoothly rounded posteriorly, without caudal spine	*E. ecaudatum* (Fior.),	[p. 344.
4 (5).	Single ventral caudal spine	*E. caudatum* (Fior.),	[p. 346.
5 (4).	With more than one caudal spine	6.	
6 (7).	Without lateral spines	7.	
7.	With a large ventral spine and a smaller dorsal spine	*E. bicaudatum* (Sharp),	[p. 347.
8 (6).	With one or more lateral spines	9.	
9 (10).	With a large ventral spine, a dorsal spine, and a right lateral spine	*E. tricaudatum* (Sharp),	[p. 347.
10 (9).	With a large ventral spine, a dorsal spine, and two or more lateral spines	11.	[(Sharp), p. 348.
11 (12).	With two right lateral spines	*E. quadricaudatum*	

12 (11). With two right lateral and one left lateral spines ..... *E. parvicaudatum* (Aw. [& Mut.), p. 349.

13 (2). Body with a relatively blunt posterior end, with blunt caudal lobes, and with an accessory skeletal plate in the single long ventral spine ..... *E. eberleini* (da Cunha), [p. 351.

14 (1). Body relatively short and truncate posteriorly, five long straight caudal spines ..... *E. cattanei* (Fior.), [p. 350.

"ECAUDATUM" GROUP.—The six species constituting this group were first assembled by Sharp (1914) as forms belonging to a single species, *Diplodinium ecaudatum*. These forms are now regarded as distinct species.

The group is characterized by a tapering of the posterior half of the body, which terminates in the small rounded posterior end. Speciation within this series is based upon the spination of this small posterior end. There is a complete series of species ranging from *E. ecaudatum* with no spine to *E. parvicaudatum* with five small conical spines. *E. caudatum* has a single large ventral spine. *E. bicaudatum* has a smaller dorsal spine in addition to the ventral spine. A right lateral spine is added in *E. tricaudatum*. *E. quadricaudatum* has both a right and a left lateral spine in addition to the dorsal and ventral spines. *E. parvicaudatum* has two right lateral spines, making a total of five spines.

240. **Epidinium ecaudatum** (Fiorentini). (Fig. 164.)

Diplodinium ecaudatum, Fiorentini, 1889, pp. 15–16, pl. iii, figs. 1, 2.
Diplodinium caudatum, Eberlein, 1895, pp. 263–4, fig. 19.
Diplodinium ecaudatum forma *ecaudatum*, Sharp, 1914, pp. 62–90, figs. A–D; pls. iii, vi, vii.
Ophryoscolex inermis, da Cunha, 1914, pp. 58, 60–61.
Ophryoscolex labiatus, Awerinzew & Mutafowa, 1914, pp. 114–15, fig. 6.
Epidinium ecaudatum, Crawley, 1923.
†*Diplodinium ecaudatum*, Jameson, 1925, p. 408.
Epidinium ecaudatum forma *ecaudatum*, Dogiel, 1927, pp. 159–61, fig. 90; 1932, p. 97.
†*Epidinium ecaudatum*, Das-Gupta, 1935, p. 170.

Body relatively long, length 2·3–2·9 times the dorso-ventral diameter, tapering and smoothly rounded posteriorly.

Dimensions.—Length 90–152 μ.

Remarks.—In the stomach contents of the mouse-deer from Ceylon, examined by Pringle Jameson, the species was present in five of the forms described by Sharp (1914)—*ecaudatum*, *caudatum*, *bicaudatum*, *tricaudatum*, and *quadricaudatum*. Of these the first three were more abundant. The forms were not quite typical. They were built much more squarely, especially at the posterior end, and the spines, where

present, were much shorter and more acutely pointed, more compressed and more fragile, more thorn-like than spine-like, than are usually found in similar varieties from European Ruminants. The forms included under *E. ecaudatum* are

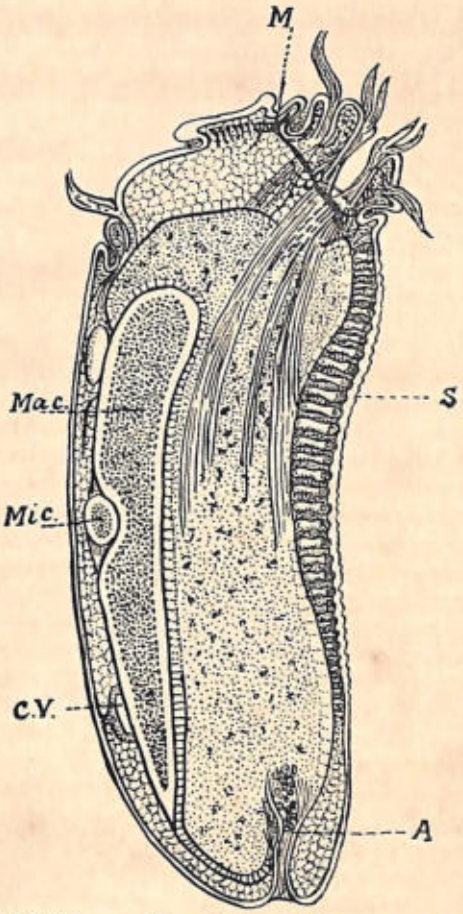


Fig. 164.—*Epidinium ecaudatum* (Fiorentini). *A*, anal canal; *C.V.*, one of the two contractile vacuoles; *M*, motorium with fibre to circumpharyngeal ring; *Mac.*, macronucleus; *Mic.*, micronucleus; *S*, skeletal layer. (After Sharp.)

now regarded as distinct species, and *E. ecaudatum* is the simplest member of the "*Ecaudatum*" group.

Habitat.—Stomach of *Tragulus meminna* Milne-Edwards (mouse-deer): CEYLON; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

241. **Epidinium caudatum** (Fiorentini). (Pl. IX, fig. 1.)

Diplodinium caudatum, Fiorentini, 1889, p. 24, pl. iii, fig. 2.
Diplodinium ecaudatum forma *caudatum*, Sharp, 1914, pp. 90–1, pl. v, fig. 6.
Ophryoscolex inermis var. *caudatus*, da Cunha, 1914, p. 113, fig. 40.
Ophryoscolex intermixtus, Awerinzew & Mutafowa, 1914, pp. 112–13, fig. 3.
Epidinium caudatum, Crawley, 1923, p. 412, pl. xxix, figs. D 4–D 6.
Diplodinium ecaudatum forma *caudatum*, Buisson, 1923 *b*, pp. 113–17, fig. 39.
Ophryoscolex ecaudatus forma *caudatus*, Dogiel, 1925 *a*, pp. 137, 141; 1925 *d*, pp. 57–59; Dogiel & Fedorowa, 1925, p. 102, fig. 6.
†*Diplodinium caudatum*, Jameson, 1925, p. 408.
Diplodinium ecaudatum, Wenyon, 1926, p. 1214, fig. 520.
Epidinium ecaudatum forma *caudatum*, Dogiel, 1927, pp. 161–3, fig. 91 *a–c*; 1932, pp. 97–8.
Diplodinium ecaudatum forma *caudatum*, Becker & Talbot, 1927, pp. 354–5, pl. iii, fig. 25.
Epidinium caudatum, Dogiel, 1927, p. 269.
†*Epidinium caudatum*, Kofoid & MacLennan, 1933, pp. 5–7, pl. i, fig. 1; fig. A, 1, 2; Kofoid & Christenson, 1934, p. 365, pl. xxvii, fig. 15, fig. D, 3, 4; Das-Gupta, 1935, p. 170.

Body elongate, length 2·04–2·86 times the dorso-ventral diameter, tapering towards the posterior end. Ventral and left surfaces flat or slightly concave, dorsal and right surfaces strongly convex. Oral area inclined ventrally and to the left. Single caudal spine arises from the postero-ventral end of the body and curves dorsally and to the right. Cuticle with fine longitudinal striations. Three skeletal plates extend from the operculum and the right side of the oral area posteriorly past the middle of the body. Endoplasmic sack extends from the level of the dorsal membranelle zone to the posterior end of the body. Rectum narrow, lined by fine longitudinal fibrils, with a narrow, elliptical anus. Two contractile vacuoles beneath the dorsal surface to the right of the dorsal middle line. Macronucleus elongate, lying beneath the right dorsal surface adjacent to the edge of the dorsal skeletal plate. Micronucleus a small ellipsoidal body lying in a depression in the macronucleus.

Dimensions.—Length 85–140 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—Specimens from *B. gaurus* are smaller (80–118 μ) than the specimens from *B. indicus* (85–140 μ).

Habitat.—Stomach of *Bos indicus* Linn.: CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore; stomach of *Tragulus meminna* Milne-Edwards: CEYLON; rumen of *Capra hircus* Linn.: BENGAL, Calcutta.

242. **Epidinium bicaudatum** (Sharp). (Pl. IX, fig. 4.)

Diplodinium ecaudatum forma *bicaudatum*, Sharp, 1914, p. 92, pl. v, fig. 7.
Epidinium bicaudatum, Crawley, 1923 p. 412.
†*Diplodinium bicaudatum*, Jameson, 1925, p. 408.
Epidinium ecaudatum forma *bicaudatum*, Dogiel, 1927, pp. 166–7, figs. 94, 95 *c*.
†*Epidinium bicaudatum*, Kofoid & MacLennan, 1933, pp. 7–8, pl. i, fig. 4; fig. A, 3, 4.

Body elongate, length 2·10–2·88 times the dorso-ventral diameter, tapering towards the posterior end. Ventral and left surfaces concave, dorsal and right surfaces strongly convex. Oral area inclined ventrally and to the left. A large ventral caudal spine arises from the postero-ventral end of the body and curves dorsally and to the right, and a small dorsal spine arises from the postero-dorsal end of the body and curves ventrally. Cuticle with fine longitudinal striations. Three skeletal plates extend from the operculum and the right side of the oral area posteriorly past the middle of the body. Endoplasmic sack extends from the level of the dorsal membranelle zone to the posterior end of the body. Rectum narrow, lined by fine longitudinal fibrils, with a narrow elliptical anus. Two contractile vacuoles beneath the dorsal surface slightly to the right of the middle line. Macronucleus elongate, lying beneath the right dorsal surface adjacent to the edge of the dorsal skeletal plate, somewhat longer and narrower than in the preceding species. Micronucleus a small ellipsoidal body lying in a depression in the macronucleus.

Dimensions.—Length 82–144 μ.

Feeds on Bacteria and small Flagellates.

Habitat.—Stomach of *Bos indicus* Linn. : Ceylon, Colombo ; stomach of *Tragulus meminna* Milne-Edwards : Ceylon.

243. **Epidinium tricaudatum** (Sharp). (Pl. IX, fig. 2.)

Diplodinium ecaudatum forma *tricaudatum*, Sharp, 1914, p. 92, pl. v, fig. 8 ; Buisson, 1923 *b*, p. 117, fig. 29 ; Becker & Talbot, 1927, p. 355, fig. 25 *a*.
Epidinium tricaudatum, Crawley, 1923, p. 412.
†*Diplodinium tricaudatum*, Jameson, 1925, p. 408.
Ophryoscolex ecaudatus forma *tricaudatus*, Dogiel, 1926 *a*, p. 253.
Epidinium ecaudatum forma *tricaudatum*, Dogiel, 1927, pp. 167–8, fig. 95, *a*, *b*.
†*Epidinium tricaudatum*, Kofoid & MacLennan, 1933, pp. 8–10, pl. i, fig. 2 ; fig. B, 1, 2.

Body elongate, length 2·02–2·50 times the dorso-ventral diameter, tapering towards the posterior end. Ventral and left surfaces flat or slightly concave, dorsal and right surfaces

convex. Oral area inclined ventrally and to the left. There are three spines; the largest of the three is ventral, arises from the postero-ventral end of the body, and curves dorsally and to the right; there is a small dorsal spine and a small right lateral spine. The dorsal and lateral spines vary from small points to large spines only slightly smaller than the ventral spine. Cuticle with fine longitudinal striations. Three skeletal plates extend from the edge of the oral area posteriorly to the level of the posterior end of the macronucleus. Endoplasmic sack extends from the level of the dorsal membranelle zone to the posterior end of the body. Rectum narrow, lined with fine longitudinal fibrils, with a narrow elliptical anus. Two contractile vacuoles beneath the dorsal surface at the right of the mid-line. Macronucleus elongate, lying beneath the right dorsal surface adjacent to the edge of the dorsal skeletal plate. Micronucleus a small ellipsoidal body lying in a shallow depression in the macronucleus.

Dimensions.—Length 85–131 μ.

Feeds on Bacteria and small Flagellates.

Habitat.—Stomach of *Bos indicus* Linn.: CEYLON, Colombo; stomach of *Tragulus meminna* Milne-Edwards: CEYLON.

244. **Epidinium quadricaudatum** (Sharp). (Pl. IX, fig. 3.)

Diplodinium ecaudatum forma *quadricaudatum*, Sharp, 1914, pp. 93–4, pl. v, fig. 9; Buisson, 1923 *b*, p. 117, fig. 39.
Epidinium quadricaudatum, Crawley, 1923, p. 412.
†*Diplodinium quadricaudatum*, Jameson, 1925, p. 408.
Ophryoscolex ecaudatus forma *quadricaudatus*, Dogiel, 1926 *a*, p. 254.
Epidinium ecaudatum forma *quadricaudatum*, Dogiel, 1927, pp. 168–9, fig. 96 *a*, *b*.
†*Epidinium quadricaudatum*, Kofoid & MacLennan, 1933, pp. 10–11, pl. i, fig. 3; fig. B, 3, 4; Kofoid & Christenson, 1934, p. 365, pl. xxvii, fig. 16; fig. D, 5, 6.

Body elongate, length 2·27–2·32 times the dorso-ventral diameter, tapering posteriorly. Ventral and left surfaces strongly concave, dorsal and right surfaces convex. Oral area inclined ventrally and to the left. There are four spines; the ventral spine is the longest, arises from the postero-ventral end of the body, and curves dorsally and to the right; there are two right lateral spines in place of the single lateral in the preceding species, and a small dorsal spine. The two lateral spines are shortest and nearly equal, and the dorsal spine is slightly larger than the lateral spines. Cuticle with fine longitudinal striations. The three skeletal plates lie beneath the right and ventral sides, and extend from the edge of the oral area posteriorly to the level of the posterior end of the macronucleus. Endoplasmic sack extends from the level of the dorsal membranelle zone to the posterior end of the body.

Rectum narrow, with fine longitudinal fibrils, with the anus lying between the bases of the ventral and lateral spines. Two contractile vacuoles beneath the dorsal surface at the right of the middle line. Macronucleus elongate, lying beneath the right dorsal surface, adjacent to the dorsal skeletal plate. Micronucleus a small ellipsoidal body in a shallow depression in the macronucleus.

Dimensions.—Length 110–119 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—The single specimen from *Bos gaurus* was distinctly smaller (88 μ in length) than specimens from *B. indicus*.

Habitat.—Stomach of *Bos indicus* Linn.: CEYLON, Colombo; stomach of *Bos gaurus* H. Smith: Mulehole, Mysore; stomach of *Tragulus meminna* Milne-Edwards: CEYLON.

245. **Epidinium parvicaudatum** (Awerinzew & Mutafowa). (Pl. XI, fig. 10.)

Diplodinium ecaudatum forma *cattanei*, Sharp, 1914, pp. 94–5, pl. iii, figs. 4, 5.
Ophryoscolex fasciculus var. *parvicaudata*, Awerinzew & Mutafowa, 1914, pp. 113–14, pl. iv, fig. 5.
Epidinium ecaudatum forma *cattenoi*, Dogiel, 1927, pp. 169–71, fig. 97.
Diplodinium ecaudatum forma *catteneoi*, Becker & Talbot, 1927, p. 355.
Epidinium ecaudatum forma *cattenoi*, Dogiel, 1932, p. 97.
Epidinium parvicaudatum, Kofoid & MacLennan, 1933, p. 11.
†*Epidinium parvicaudatum*, Kofoid & Christenson, 1934, pp. 365–7, pl. xxvii, fig. 17; fig. D, 7, 8.

Body relatively long, 2·4–2·8 dorso-ventral diameters in length, almost circular in cross-section, tapering posteriorly. Ventral and left surfaces nearly plane or only slightly convex; dorsal and right surfaces show greater convexity. Five caudal spines present—one large ventral with its extremity curved dorsally, one dorsal, one on the left side, and two on the right side. Fine longitudinal striations over the cuticle. Three skeletal plates lie underneath the right surface of the body and extend up to the posterior fourth of the body. Oral apparatus moderate sized, tilted ventrally and to the left. Operculum wide, smoothly rounded, separating adoral from the dorsal membranelle zones. The dorsal zone is set back on the dorsal surface about one-fifth of the body-length from the anterior end. Contractile vacuoles two, on the dorsal surface to the left of the macronucleus. Macronucleus elongated, rod-like, lies next to the right dorsal surface, adjacent to the dorsal edge of the skeletal complex. Micronucelus small, ellipsoidal, in a slight concavity in the mid-dorsal edge of the macronucleus.

Dimensions.—Length 70–120 μ ; breadth 37–47 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—Sharp (1914) identified his five-spined species as *Diplodinium cattanei* Fiorentini, 1889, but at the same time pointed out serious discrepancies between his description and that of Fiorentini. Awerinzew and Mutafowa (1914) and Dogiel (1927) have separated them. Awerinzew and Mutafowa gave the short-spined type the forma name *parvicaudata*, so the name *E. cattanei* (Fiorentini) clearly belongs to the long-spined species.

Habitat.—Stomach of *Bos gaurus* H. Smith : Mulehole, Mysore.

Unallocated Species.—Three species of *Epidinium*—*E. gigas*, *E. cattanei*, and *E. eberleini*—do not fit in with the *E. ecaudatum* group or the *E. hamatum* group (not known from India so far). *E. gigas* has so far not been met with in Indian material. *E. cattanei* is recognizable by the truncated posterior end and by very long peculiarly shaped spines, and *E. eberleini* by the presence of an accessory skeletal plate in the main caudal spine and by the presence of two lateral lobes.

246. **Epidinium cattanei** (Fiorentini). (Pl. IX, fig. 7.)

Diplodinium cattanei, Fiorentini, 1889, pp. 16–17, pl. iii, figs. 4, 5.
Ophryoscolex cattanei, Railliet, 1890.
Ophryoscolex cattaneoi, da Cunha, 1914 pp. 62, 63.
Ophryoscolex fasciculus, part, Awerinzew & Mutafowa, 1914, pp. 112–14, fig. 4.
Diplodinium ecaudatum var. *cattanei*, Buisson, 1923 *b*, pp. 118–19, fig. 42.
Diplodinium ecaudatum forma *cattanei*, part, Becker & Talbot, 1927, p. 355.
Epidinium cattanei, Crawley, 1923, p. 412.
Ophryoscolex ecaudatus cattaneoi, Dogiel, 1926 *a*, p. 254.
Epidinium ecaudatum forma *fasciculus*, Dogiel, 1927, pp. 171–3, fig. 98.
Epidinium caudatum forma *fasciculus*, Dogiel, 1927, p. 171.
†*Epidinium cattanei*, Kofoid & MacLennan, 1933, pp. 13–15, pl. i, fig. 7; fig. C, 1, 2.
†*Epidinium cattenoi*, Das-Gupta, 1935, p. 170.

Body relatively short and heavy, length 1·63–2·38 times the dorso-ventral diameter, truncated posteriorly. Ventral surface slightly concave ; left and dorsal surfaces concave between the dorsal membranelle zone and the base of the left spine ; the right surface is convex. Oral area is inclined ventrally and to the left. There are five long, straight, caudal spines, which are the largest and most prominent spines found in any of the Ophryoscolecidæ. Each spine arises from a

relatively broad base, but tapers rapidly in the proximal third, so that the distal two-thirds are relatively thin. The largest spine projects from the ventral side of the posterior end of the body, two spines from the dorsal side, and one from each side between the ventral and dorsal spines. Cuticle with fine longitudinal striations. The three skeletal plates extend around the oral area from the operculum to the ventral sides, gradually narrowing posteriorly. The dorsal plate is usually shorter than the other two and often ends near the level of the anterior contractile vacuole, the middle and ventral plates terminating posteriorly a short distance behind the middle of the body. Endoplasmic sack extends from the level of the dorsal membranelle zone to the posterior end of the body. Rectum small, narrow, with a narrow elliptical anus near the dorsal side of the base of the ventral spine. Two contractile vacuoles beneath the dorsal surface, the large anterior located at the right of the middle line, the smaller posterior located very near it. Macronucleus elongate, lying beneath the right dorsal surface adjacent to the edge of the dorsal skeletal plate. Micronucleus a small ellipsoidal body lying in a shallow depression of the macronucleus.

Dimensions.—Length 78–120 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—The relatively short truncated body and the peculiar shape of the very long spines separate this species from the other species of the genus.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo ; rumen of *Capra hircus* Linn. : BENGAL, Calcutta.

247. **Epidinium eberleini** (da Cunha). (Pl. IX, fig. 5.)

Diplodinium caudatum, Eberlein, 1895, pp. 260–1, fig. 16.
Diplodinium eberleini, da Cunha, 1914, p. 62 ; Sharp, 1914, pp. 51, 61 ; Buisson, 1923 *b*, pp. 118–20, fig. 36.
Diplodinium longispinum, Schulze, 1924, p. 656.
Diplodinium eberleini, Dogiel, 1927, p. 156, fig. 89 ; Becker & Talbot, 1927, p. 355.
Epidinium lobatum, Dogiel, 1928 *b*, pp. 334–7, fig. 5, *a*, *b*.
†*Epidinium eberleini*, Kofoid & MacLennan, 1933, pp. 16–17, pl. i, fig. 15 ; fig. D, 1, 2.

Body elongate, length 1·82–2·32 times the dorso-ventral diameter, with a relatively blunt posterior end. Ventral and left surfaces nearly plane, right surface strongly convex, anterior half of dorsal surface convex, posterior half concave or plane. Oral area inclined ventrally and to the left. Right side of the body continued posteriorly as a broad laterally flattened lobe ; a narrower heavier lobe projecting from the posterior end of the left surface. A large curved spine arises

from the posterior end and a long, thin, accessory skeletal plate extends from the middle of the ventral surface to the tip of the large spine. Endoplasmic sack extends from the level of the dorsal membranelle zone to the posterior end of the body. Rectum narrow, with the anus opening at the base of the ventral spine between the two lateral lobes. Two contractile vacuoles lie beneath the dorsal surface, the anterior at the right of the mid-line, the posterior on the mid-line. Macronucleus elongated, lying adjacent to the dorsal edge of the main skeletal complex. Micronucleus a small ellipsoid body lying in a shallow depression of the macronucleus.

Dimensions.—Length 85–118 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—This species is marked off from other species of the genus by the appearance of its caudal lobes and by the presence of the accessory skeletal plate in the ventral spine.

Habitat.—Stomach of *Bos indicus* Linn. : MADRAS, Coonoor ; CEYLON, Colombo.

Genus **OPHRYOSCOLEX** Stein, 1858.

Ophryoscolex, Stein, 1858, p. 69 ; 1859 *a*, pp. 57–8.
Diplodinium, part, Fiorentini, 1889, pp. 11–12, pl. i, figs. 1–2.
Ophryoscolex, Eberlein, 1895, pp. 239–51, pl. xvi, figs. 1–7 ; Buisson, 1923 *a*, p. 237.
Ophryoscolex, part, Dogiel, 1925 *a*, pp. 134–5 ; 1927, pp. 183–211, figs. 103–17.
Ophryoscolex, Wenyon, 1926, p. 1217 ; Becker & Talbot, 1927, pp. 358–9, pl. iii, figs. 26, 27 ; Reichenow, 1929, p. 1201 ; Kofoid & MacLennan, 1932, p. 61 ; 1933, pp. 19–26.

Ophryoscolecidæ with dorsal membranelle zone situated about one-third the length of the body from the anterior pole, forming a girdle extending three-fourths the distance around the body and open only on right ventral side. Skeletal complex formed of three plates extending the length of the right ventral side. Nine to fifteen vacuoles ranged around the body in two transverse rows.

Remarks.—*Ophryoscolex* was first described by Stein (1858) as the type-genus of a new family. He gave a very good description, and described *O. purkynjei*, a common species with a complex array of caudal spines, and *O. inermis*, a rare species with a smooth posterior end. Fiorentini (1889) redescribed *O. purkynjei* as *Diplodinium vortex*. Eberlein (1895) described *O. caudatus*. Dogiel (1927) described four new forms, which are considered as distinct species by Kofoid and MacLennan (1933). One new species, *O. spinosus*, has been described by the latter from *Bos indicus*, thus bringing the total number of species in the genus to nine.

The size and position of the membranelle zones are most important characteristics of the genus. The adoral zone is relatively small and inclined ventrally and to the left. The dorsal membranelle zone is elongated and shifted posteriorly, so that it forms a median girdle around three-quarters of the circumference of the body. The main skeletal complex is composed of three long skeletal plates lying beneath the right ventral side of the body. The three plates are shaped anteriorly as in *Epidinium*, and partly surround and support the oral region. The dorsal plate terminates in the middle of the body, as in that genus, but the right and the ventral plates continue posteriorly to the end of the body and even extend into the main caudal spine. The secondary spines also contain accessory plates. The detailed structure of the caudal complex is used in specific classification. The main spine may be long and slender or short and stumpy, the secondary spines may be simple or complexly furcate, and there may be one to four circlets of these. The number of contractile vacuoles varies from nine to fifteen, depending on the species.

Key to Indian Species.

1 (2). Body relatively slender; main caudal spine short and stumpy, two rows of accessory caudal spines; middle skeletal plate extends to the tip of the main caudal spine; contractile vacuoles ten, in two rows ..... [MacL., p. 353. *O. spinosus* Kof. &

2 (1). Body relatively stout; main caudal spine long and slender, three circlets of accessory caudal spines; middle skeletal plate does not extend to the tip of the main caudal spine; contractile vacuoles nine, in two rows ..... [p. 354. *O. tricoronatus* (Dogiel).

248. **Ophryoscolex spinosus** Kofoid & MacLennan. (Pl. IX, fig. 6.)

†*Ophryoscolex spinosus*, Kofoid & MacLennan, 1933, pp. 23–5, pl. i, fig. 6; fig. C, 3, 4.

Body relatively slender, length 1·59–2·14 times the dorso-ventral diameter. All surfaces are strongly convex except the middle of the ventral side, which is slightly concave, and the anterior two-thirds of the left ventral side, which is nearly plane. Body divided into seven sectors by shallow longitudinal grooves, two of them being designated as the skeletal sector and the macronuclear sector owing to the organelles contained within them. Oral area inclined ventrally and to the left. The dorsal zone arises near the dorsal skeletal plate at the level of the anterior end of the macronucleus, extends to the left and posteriorly, terminating near the ventral skeletal

plate at the level of the micronucleus. There are two caudal circlets of spines, anterior composed of simple or occasionally bifurcate spines, posterior composed of bifurcate or trifurcate spines. Main caudal spine short, with two small accessory spines on its dorsal side and one on its ventral side. Cuticle with fine longitudinal striations. The main skeletal complex composed of three adjacent plates, as in *Epidinium*, the anterior end surrounding the oral area except on the left dorsal side. The dorsal plate extends from the operculum to the level of the micronucleus; median plate from the right side of the oral area to the tip of the main caudal spine; ventral plate from the ventral side of the oral area to the base of the main caudal spine. Small triangular accessory skeletal plates occur in most of the caudal spines. Endoplasmic sack extends from a level just behind the oral area to the posterior end of the body. Rectum narrow, with the anus lying within the anterior circlet of spines near the base of the main caudal spine. Ten contractile vacuoles, arranged in pairs in each sector of the body except the skeletal and macronuclear sectors. Macronucleus elongate, adjacent to the dorsal edge of the main skeletal complex. Micronucleus a small ellipsoid body lying in a shallow depression of the macronucleus.

Dimensions.—Length 122–160 μ.

Feeds on Bacteria and small Flagellates.

Remarks.—*O. spinosus* is similar to *O. purkynjei*, but with two rows of spines instead of three as in that species.

Habitat.—Stomach of *Bos indicus* Linn.: MADRAS, Coonoor.

249. **Ophryoscolex tricoronatus** (Dogiel). (Fig. 165).

Ophryoscolex caudatus, Eberlein, 1895, pp. 247–50, pl. xvi, fig. 4; Guenther, 1900*b*, pp. 641–8, figs. 1–6; Buisson, 1923*b*, pp. 129–fig. 48; Fantham, 1926, p. 568; Becker & Talbot, 1927, p. 258, fig. 26.

Ophryoscolex caudatus tricinctus, Dogiel, 1927, p. 185.

Ophryoscolex caudatus forma *tricoronatus*, Dogiel, 1927, pp. 199–202, figs. 110, 111; Hsiung, 1931, p. 38.

Ophryoscolex caudatus, Kofoid & MacLennan, 1933, p. 26.

†*Ophryoscolex tricoronatus*, Das-Gupta, 1935, p. 172.

Body relatively stout, length 1·65–1·70 times the dorso-ventral diameter, posterior end with a long, slender, main caudal spine and three circlets of secondary spines. The anterior circlet is composed of six usually trifurcate spines, middle circlet of three to five, and the posterior circlet of three to seven spines. Adoral zone relatively small and inclined ventrally and to the left. Dorsal membranelle zone elongated and shifted posteriorly, forming a girdle extending three-fourths the distance round the middle of the body, and incomplete

only on the right ventral side. Main skeletal complex of three plates, the dorsal one terminating in the middle of the body, the right and the ventral plates continuing to the posterior end of the body and even extending for a distance into the main caudal spine. There are nine contractile vacuoles arranged in two transverse bands round the body, one band of four vacuoles, just posterior to the median girdle of dorsal membranelles, and the other of five vacuoles at the base of the anterior circlet of secondary caudal spines. Macronucleus oval,

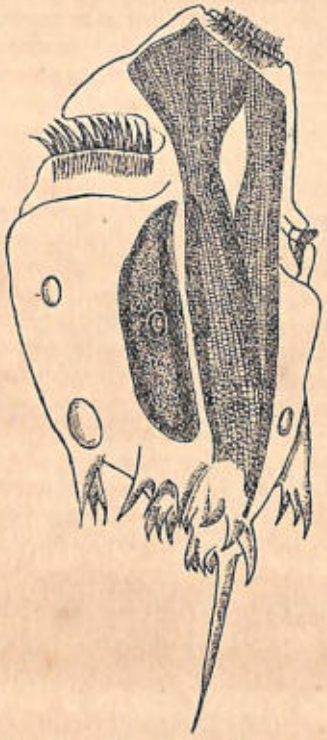


Fig. 165.—*Ophryoscolex tricoronatus* (Dogiel). (After Dogiel.)

pointed at either end, lying dorsal to the skeletal plates on the right side. Micronucleus lies in the middle of the outer side of the macronucleus.

Dimensions.—Length 137–162 μ, breadth 80–98 μ; ratio of length to breadth 1·65.

Remarks.—This is the commonest species of the genus, and by virtue of possessing three circlets of secondary spines stands between *O. bicoronatus* and *O. quadricoronatus*.

Habitat.—Rumen of *Capra hircus* Linn.: Bengal, Calcutta.

General Remarks on Distribution of Ciliates in Ruminants.

Extensive studies by Dogiel (1931–32) and cross-faunation experiments by Becker, Schulz, and Emmerson (1930) have shown that there is very little specificity in the relationship between these Ciliates and their hosts, though there is a certain amount of geographical segregation. Dobell (1910) stated that the stomach contents of the mouse-deer, *Tragulus memmina*, from Ceylon, contained many Ciliates belonging to the Ophryoscolecidæ. Jameson (1925), who studied Dobell's material, described one new species, *Entodinium ovalis*, and noted the presence of several other species which he considered to be identical with the species from European cattle, although the forms examined showed striking differences from the European forms in such characters as spination, shape of the body, and number of vacuoles. According to Kofoid and MacLennan (1933) the majority of Ciliates from *Bos indicus* are found in other parts of the world, but a few are apparently found only in Asia. The *Diplodinium crista-galli* group (*D. læve*, *D. crista-galli*, and *D. flabellum*) have been found only in Persia and in India and Ceylon. *Elytroplastron bubali* is found in three different hosts (*Buffelus bubalus*, *Bos indicus*, and domestic sheep) all from Asia. *Entodinium bimastus*, on the other hand, has been found in three hosts (domestic cattle, *Buffelus bubalus*, and *Bos indicus*) from Asia and European U.S.S.R.

The striking differences found between the Ciliate fauna of *Bos indicus* from India and of the same host from Ceylon were that six species of *Epidinium* were found in the latter while only two were noted in the former; the single species of *Ophryoscolex*, on the other hand, was only found in two hosts from India.

2. Subfamily POLYDINIINÆ Kofoid, 1935.

Numerous accessory membranelle zones, extending over the considerably elongated body. These zones, instead of being dorsal, are divided bilaterally into two groups which still fall into a descending right spiral both individually and in pairs. Contractile vacuoles numerous, arranged in zones parallel to the membranelle zones. One to three skeletal plates present.

The two genera included in this subfamily exhibit a secondary bilateral symmetry superposed upon the primitive spiral one, and an extension of metamerism by the added membranelle zones throughout the elongated body of these Ciliates.

Key to Indian Genera.

1 (2). Body very large, initially with five additional membranelle zones; three equal club-shaped skeletal plates, extending nearly the whole length of the body; macronucleus stout, club-shaped. [p. 357. POLYDINIUM Kofoid.

2 (1). Body very large, initially with six additional membranelle zones; skeletal plate single, sigmoid, confined to the anterior half of the body; macronucleus Z-shaped, with enlarged ends. [Kofoid, p. 359. ELEPHANTOPHILUS

Genus **POLYDINIUM** Kofoid, 1935.

Polydinium, Kofoid, 1935, pp. 502–4.

Body oval, very large in size, with a relatively feebly developed adoral zone and five additional membranelle zones in the young state. Posterior caudal lobe with accessory cilia. Three equal, club-shaped, skeletal plates extending nearly the whole length of the body. Contractile vacuoles twenty to thirty, distributed in irregular rows. Macronucleus stout, club-shaped, on the left side of the skeletal plates near the middle of the body.

250. **Polydinium mysoreum** Kofoid. (Fig. 166.)

†*Polydinium mysoreum*, Kofoid, 1935, pp. 502–4, figs. 1–3.

Body oval, very large in size, anterior end truncated and broader than the posterior end. Caudal lobe with an accessory group of cilia on its dorsal face and containing an irregular mass of stored material in a vacuole in the ectoplasm. Adoral spiral of membranelles makes a single turn and is relatively feebly developed; it leads directly into the well-developed but narrow œsophagus, which is laterally compressed and continues posteriorly for two-thirds of the length of the body, opening there in the endoplasm. Rectum short and wide, opening by a large oval anal opening situated in front of the posterior lobe. In addition to the adoral zone there are, to begin with, five additional membranelle zones, which increase to seven during early stages of growth, and ultimately to ten, prior to binary fission. These zones are divided bilaterally into two groups and run in a descending right spiral both individually and in pairs. There are three equal club-shaped, double-layered, skeletal plates running nearly the whole length of the body surrounding the œsophagus. These plates are crowned by the œsophageal neuromotor ring with deeply staining enlargements at the nodes (fig. 166, *c*). Contractile vacuoles twenty to thirty, distributed in irregular

rows posterior to each of the pairs of accessory membranelle zones. Macronucleus stout, club-shaped, lying on the left side of the skeletal plates near the middle of the body, with a micronucleus embedded in its ventral side.

Dimensions.—Length 200–250 μ.

Feeds on plant débris, Bacteria, and Flagellates.

Habitat.—In the cæcum and colon of the Indian elephant, *Elephas indicus* Cuvier : MADRAS, Nilgiri Mountains.

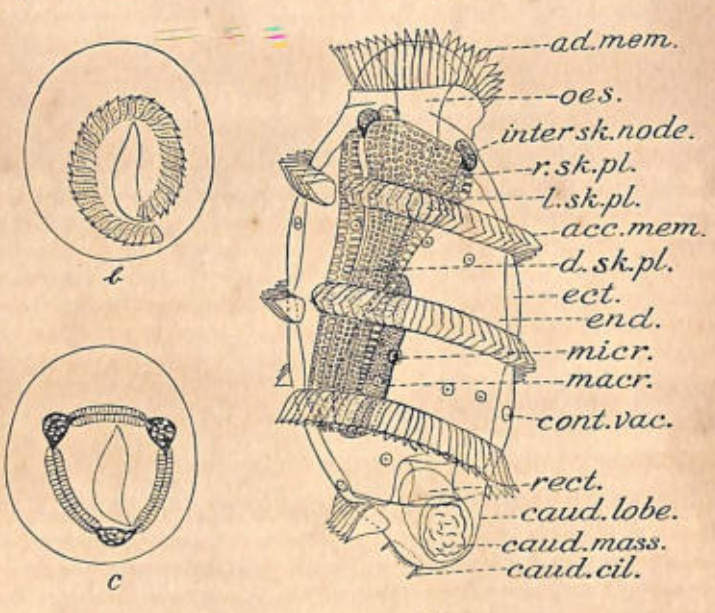


Fig. 166.—*Polydinium mysoreum* Kofoid. *a*, right view ; *b*, cross-section, showing œsophagus and adoral membranelle zone ; *c*, oblique section through anterior ends of the skeletal plates, showing their bilaminate structure, circumœsophageal neural ring, and two dorsal and one ventral interskeletal nodes. *acc.mem.*, accessory membranelle zone ; *ad.mem.*, adoral membranelles ; *caud.cil.*, caudal cilia ; *caud.lobe*, caudal lobe ; *caud.mass*, caudal mass ; *cont.vac.*, contractile vacuole ; *d.sk.pl.*, dorsal skeletal plate ; *ect.*, ectoplasm ; *end.*, endoplasm ; *intersk. node*, interskeletal node of œsophageal neural ring ; *l.sk.pl.*, left skeletal plate ; *macr.*, macronucleus ; *micr.*, micronucleus ; *oes.*, œsophagus ; *r.sk.pl.*, right skeletal plate ; *rect.*, rectum. (After Kofoid.)

Genus **ELEPHANTOPHILUS** Kofoid, 1935.

Elephantophilus, Kofoid, 1935, p. 504.

Body oval, very large in size, with an adoral zone and six additional membranelle zones in the young state. Posterior caudal lobe with accessory cilia. Skeletal plate single, sigmoid, confined to the anterior half of the body. Contractile vacuoles numerous, distributed in irregular rows. Macronucleus Z-shaped, with enlarged ends.

251. **Elephantophilus zeta** Kofoid. (Fig. 167.)

†*Elephantophilus zeta*, Kofoid, 1935, p. 504, figs. 4, 5.

Body oval, very large in size, anterior end broadly truncated, posterior end narrower and smoothly rounded. Caudal lobe

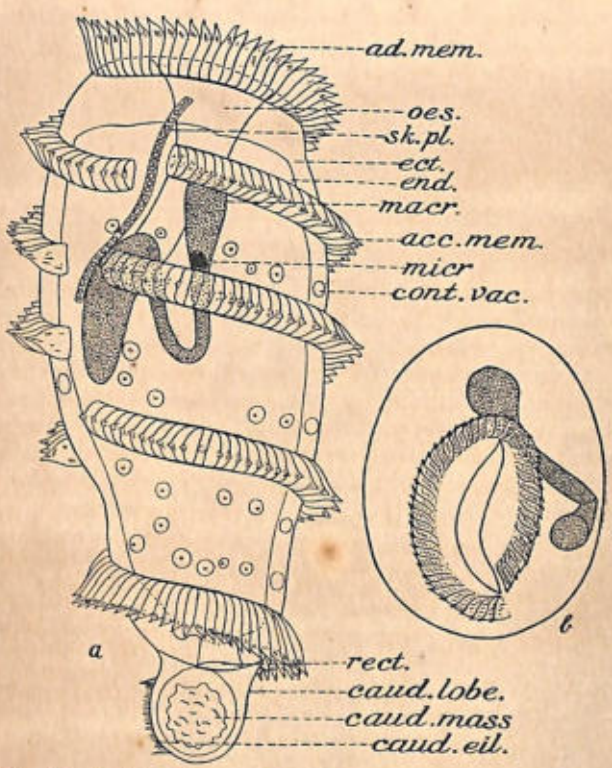


Fig. 167.—*Elephantophilus zeta* Kofoid. *a*, right view; *b*, cross-section, showing œsophagus with optical projection of adoral membranelle zone and macronucleus. Lettering as in the previous figure. (After Kofoid.)

with an accessory group of cilia on its dorsal face and containing an irregular mass of stored material in a vacuole in the ectoplasm. Adoral membranelle zone relatively feebly developed. Œsophagus much wider and shorter than in *Polydinium* and lacking the skeletal support. In addition to the adoral zone there are six seriated accessory membranelle zones in the young stage, increasing to twelve prior to binary fission. These are arranged in bilateral pairs in a descending right spiral, and impart a secondary bilateral symmetry. Skeletal plates are reduced to a single one, composed of one linear row of prismatic chambers forming a sigmoid line on the right dorsal side in the anterior half of the body. Contractile vacuoles numerous, distributed in irregular rows posterior to the accessory membranelle zones. The macronucleus, viewed laterally, has the form of a flattened letter Z, with enlarged ends, and has the micronucleus embedded in the anterior lobe on the right face; viewed dorsally it presents a slightly flattened spiral form.

Dimensions.—Length 250–290 μ.

IV. Suborder *CTENOSTOMIDA* Lauterborn (=Ctenostomata Kahl.)

Small laterally flattened Ciliates with elongated cilia confined to a few rows or groups, especially at the posterior end. Both the frontal and the posterior end of the body are provided with teeth-like processes. Near the anterior end is situated a transversely running frontal band, thickly provided with cilia arranged in five rows. Mouth with a peculiar comb-like structure, the teeth of which are cirri-like structures. The adoral zone is limited to eight membranelles, which are situated in a groove opening ventralwards. Pellicle is strengthened with armour-plates. Almost exclusively sapropelic in foul muddy water.

Identification Table of Families.

1. Posteriorly the coat of mail is open. Ciliation relatively strong. Right lateral surface with at least two, left lateral surface with four posterior and one frontal row.. **Epalcidæ** * Wetzel.
2. Posteriorly the coat of mail is slightly open or wholly closed. Ciliation weak. Generally the left lateral surface only provided posteriorly with one or two short rows of cirri-like fused longer cilia. Frontal band limited to the narrow ventral side..... **Mylestomidæ** * Kahl.

3. Posteriorly the coat of mail is closed. Ciliation weak. Frontal band extends to a strong swelling on both lateral surfaces, on the left as a wide unbroken stretch; right lateral surface with a stronger posterior spine directed ventralwards ... **Discomorphidæ** * Kahl.

Up to the present time no animals belonging to any of the families in this suborder have been discovered in India.

Remarks.—As CTENOSTOMATA is preoccupied as a name for a suborder of Polyzoa, the name of the suborder should be CTENOSTOMIDA.

V. Suborder *HYPOTRICHA* Stein.

The suborder HYPOTRICHA includes some of the most highly differentiated forms among the Protozoa. They are generally flattened dorso-ventrally, and the motile organs are confined to the ventral surface. In the less differentiated forms (family Peritromidæ) there are numerous cilia of uniform size arranged in rows on the ventral surface. In others the cilia are reduced in number and there are groups of cirri which are believed to be formed by fusion of adjacent cilia. The cirri are located in regional groups known as frontals, ventrals, anals, marginals and caudals. Among the Urostylinæ, frontal and anal cirri are differentiated and the rest of the ventral surface is covered with uniform cilia. In the Pleurotrichinæ and Psilotrichinæ the cirri are increased and ventral cilia further reduced or even absent. In Euplotidæ and Aspidiscidæ the ventral cilia are entirely replaced by cirri, and marginal cirri are greatly reduced or absent. On the dorsal surface the cilia are changed into stiff tactile bristles, which are arranged in rows and recognizable with difficulty. Peristome lies ventrally at the anterior end of the body. The adoral zone of membranelles, after going round the anterior end of the body, runs along the left margin of the triangular peristomial field. Along the right margin of the peristomial field and in the peristomial field itself there are one or more undulating membranes or ciliary rows named as preoral, adoral, paroral, etc., according to their position in relation to the mouth (see fig. 168).

There are usually two macronuclei and two micronuclei. Conjugation and encystment occur in all forms. Cysts are frequently ornamented by numerous spines.

The great majority of the HYPOTRICHA live in fresh water and are bottom feeders, showing a great variety of swimming,

creeping or springing movements. Many of them (e. g., *Stylonychia*) walk or run on the tips of their frontal and ventral cirri; others (e. g., *Aspidisca*) swim with a peculiar jerky movement; while still others (e. g., *Uronychia*, *Euplotes*) combine swimming due to the adoral zone with sudden springs

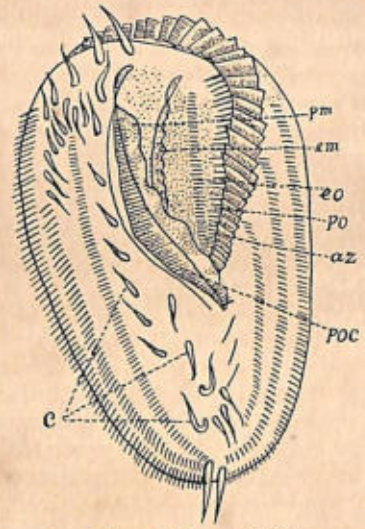


Fig. 168.—Diagram of a Hypotrichous Ciliate. *az*, adoral zone of membranelles; *c*, ventral and anal cirri; *em*, endoral membrane; *eo*, endoral cilia; *pm*, paroral membrane; *po*, preoral cilia; *poc*, paroral cilia. (After Calkins.)

or jumps due to the anal or caudal cirri. A few of them (e. g., *Stichotricha*) dwell in tubes; and one genus (*Kerona*) is found as an ectoparasite on *Hydra*.

Identification Table of Families.

1 (2). Ventral surface bearing cilia only, no cirri ..... **Peritromidæ** St., p. 363.

2 (1). At least anal cirri on ventral surface .. 3.

3 (4). Ciliation on the ventral surface thick and tolerably uniform, or, when reduced, limited to a few longitudinal rows. Two uninterrupted marginal rows always present ..... [p. 365. **Oxytrichidæ** Ehrbg.,

a. At least two uninterrupted rows of ventral cilia present; no ventral cirri posterior to mouth except anals.... Urostylinæ, p. 365.

b. Ventral rows interrupted, of their cilia only some changed into cirri; five to eight frontal cirri ..... [p. 371. Pleurotrichinæ,

c. One or two ventral rows of bristle-shaped cirri, in part irregularly situated; no ventral cilia ..... Psilotrichinæ, p. 382.

4 (3). Ventral cilia entirely replaced by cirri; marginal cilia greatly reduced or absent ..... 5.

5 (6). A few marginal cirri present on the sides of the body or at the posterior end; frontal, ventral and anal cirri present. [p. 384. **Euplotidæ** Ehrbg.,

6 (5). Marginal rows completely absent; variable frontals, ventrals and anals .... [p. 388. **Aspidiscidæ** Ehrbg.,

1. Family PERITROMIDÆ Stein, 1867.

Flattened forms with uniform coating of undifferentiated cilia on the ventral surface. The adoral zone of membranelles surrounds the anterior end of the body and runs along the left margin of the peristome.

Kahl (1930–5) has transferred this family to HETEROTRICHA, and restricted HYPOTRICHA to include only those forms in which some of the ventral cilia are modified into cirri. In my opinion, in the structure of the adoral zone and in the possession of a double macronucleus the family shows undoubted resemblance to the other HYPOTRICHA, and should not be separated from them.

Genus **PERITROMOIDES,** gen. nov.

Animalcules free-swimming, large, ovate; depressed. Peristomial field extends backwards to the middle of the ventral surface and possesses a fringe of large, powerful adoral membranelles surrounding the anterior end of the body and extending along the left border of the peristome, and an undulating membrane extending along the right border of the peristome. Peristome followed by a narrow cytopharynx. No ventral or anal styles or setæ; the ventral surface bearing interrupted but parallel rows of fine vibratile cilia. Macronucleus double. Inhabiting fresh water.

252. **Peritromoides simplex,** sp. nov. (Fig. 169.)

Body ovate, widest in the posterior half, about one and a half times as long as broad, with a small triangular tail-like projection at the posterior end of the body. Peristomial field wide, gradually narrowing posteriorly, with a fringe of stout and powerful adoral membranelles along its left border and around the anterior margin of the body and an undulating membrane along the right margin of the peristome. From the posterior end of the peristome a narrow and tapering

cytopharynx extends to middle line of the body. Ventral surface provided with obliquely running, parallel rows of cilia, four rows in the anterior half and only three in the posterior half, with bunches of similar cilia in slight indentations of the margins of the body; short marginal cilia also present except at the anterior extremity of the body. Contractile vacuoles two, one slightly to the left of the posterior end of the peristomial groove, the other situated to the right of the groove in the anterior half of the body. Macronucleus double, the two halves widely separated.

Dimensions.—Length 136 μ.

Remarks.—This form was met with in water from a pond in Lahore. It measured 136 μ in length, and its greatest width was 90 μ. The form was flattened and showed a certain degree of resemblance with Oxytrichinæ in possessing an

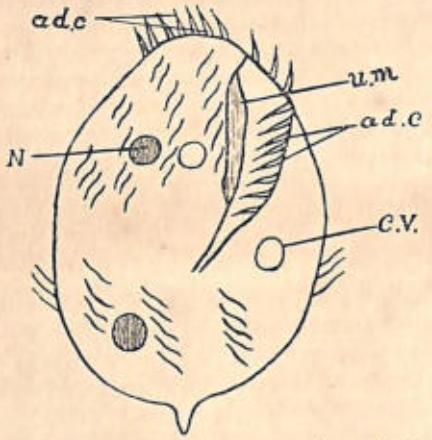


Fig. 169.—*Peritromoides simplex*, sp. nov. *ad.c*, adoral zone of membranelles; *C.V.*, contractile vacuole; *N*, nucleus; *u.m*, undulating membrane.

edentulate cytopharynx, an excavate peristomial field, and a fringe of adoral membranelles. It differed from the latter, however, in the complete absence of any ventral or anal styles or setæ and in possessing rows of ordinary cilia on the ventral surface. It differs from *Peritromus* in that the cilia of the ventral surface are not uniformly and densely arranged, but occur in oblique and interrupted rows. Other points of difference that may be mentioned are the existence of an undulating membrane along the right peristomial border and the occurrence of two contractile vacuoles. The body of the organism was remarkably clear and transparent, there being only a few green corpuscles and other food vacuoles present.

While *Peritromus* shows close-set rows of ventral cilia of uniform size, *Peritromoides* shows an even nearer approach to the Oxytrichidæ by the reduction of both marginal and ventral cilia and the possession of an undulating membrane along the right peristomial border. Both are flattened and possess an adoral zone of membranelles and the double macronucleus.

Habitat.—Fresh water : PUNJAB, Lahore.

2. Family OXYTRICHIDÆ Ehrenberg, 1838.

Flattened forms with thick and tolerably uniform ciliation on the ventral surface, or, when this is reduced, cilia are limited to a few longitudinal rows. With the reduction in the ventral cilia there is a corresponding increase in the number and complexity of the cirri. Anal cirri at least are always developed. Two uninterrupted marginal rows are always present. Adoral zone of membranelles is well developed. Dorsal bristles are present.

The family is divided into three subfamilies—Urostylinæ, Pleurotrichinæ, and Psilotrichinæ.

1. Subfamily UROSTYLINÆ Bütschli, 1889.

At least two uninterrupted rows of ventral cilia present. Frontal and anal cirri generally distinct. Apart from these ventral cilia are not changed into cirri.

Key to Indian Genera.

1 (4).	Distinct anal cirri present	2.
2 (3).	Two rows of marginal; five to seven rows of ventral cilia	[p. 366. UROSTYLA Ehrbg., [em. Entz, p. 367.
3 (2).	Two rows of marginal; two to three rows of ventral cilia	HOLOSTICHA Wrzes.
4 (1).	Without distinct anal cirri	5.
5 (6).	Posterior end not drawn out into a tail. Ventral ciliary rows oblique; without frontal or anal cirri. Body anteriorly drawn out into a neck. Peristome long. Often tube-dwelling	[p. 368. STICHOTRICHA Perty.
6 (5).	Posterior end distinctly drawn out into a tail. Two rows of ventral cilia; three frontal cirri; no anal cirri; no long caudal cilia or bristles	[em. St., p. 369. UROLEPTUS Ehrbg.

Genus **UROSTYLA** Ehrenberg, 1830.

Urostyla, Ehrenberg, 1830, p. 43; 1838, p. 369; Stein, 1859 *d*, p. 191; 1867, p. 63; Claparède & Lachmann, 1858–61, p. 168; Kent, 1880–2, p. 764; Bütschli, 1887–9, p. 1741; Roux, 1901, p. 95; Lepsi, 1926*a*, p. 81; Schoenichen, 1927, p. 228; Reichenow, 1929, p. 1206; Kahl, 1930–5, p. 564; Calkins, 1933, p. 519.

Body egg-shaped, elongated, very flexible, often coloured yellow or brown. Peristome more or less elongated, not extending beyond the middle of the body, breadth very variable. Mouth provided with two undulating membranes and three ciliary rows. Marginal, frontal (three or more) and anal (5 to 12) cirri well developed. Numerous rows of ventral cilia or setæ arranged in longitudinal rows. Caudal setæ absent. Contractile vacuole to the left, near the posterior angle of the peristome. Macronucleus single or multiple. Often with zoochlorellæ. Locomotion moderately brisk.

253. **Urostyla weissii** Stein. (Fig. 170.)

Oxytricha urostyla (?), Claparède & Lachmann, 1858, pp. 141–2, pl. v, fig. 2.
Oxytricha multipes (?), Claparède & Lachmann, 1858–61, pp. 143–4, pl. v, fig. 1.
Urostyla weissii, Stein, 1859 *d*, pp. 192–4, pl. xiii, figs. 1–4; Kent, 1880–2, pp. 764–5.
†*Urostyla weissii*, Gulati, 1925, p. 752, fig. 22.
Urostyla weissii, Lepsi, 1926 *a*, p. 84, fig. 430; Schoenichen, 1927, pp. 228–9, pl. xiii, fig. 4.
Urostyla weissei, Reichenow, 1929, p. 1206, fig. 1188 A; Kahl, 1930–5, p. 568, fig. 97, *4*.

Body elongate-elliptical, about three and a half times as long as broad, widest centrally, gradually tapering towards the two extremities, anterior end the narrower. Peristomial field forming an acute triangle, extending to a little beyond the anterior third of the body, its reflected border ciliate, nearly straight. Three to five frontal styles, supplemented by five even median rows of short ventral setæ; marginal setæ forming a continuous projecting row; anal styles seven to eight. Contractile vacuole single, subcentral. Macronucleus ovate, double. Micronucleus not distinguished. Body yellowish or brownish.

Dimensions.—Length 280–297 μ.

Remarks.—Gulati mentions that in the form examined by him the macronucleus was broken up into many small oval bodies.

Habitat.—Pond water: PUNJAB, Lahore.

Fig. 170. Fig. 171.

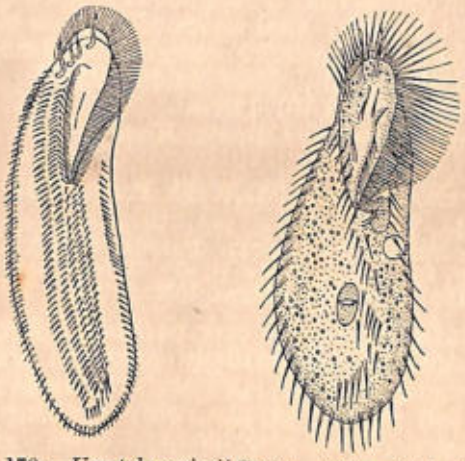


Fig. 170.—*Urostyla weissii* Stein. (After Stein.)
Fig. 171.—*Holosticha mystacea* (Stein). (After Stein.)

Genus **HOLOSTICHA** Wrzesniowski, 1877, emend. Entz, 1884.

Holosticha, Wrzesniowski, 1877, p. 278; Kent, 1880–2, p. 769; Entz, 1884, pp. 360–7; Bütschli, 1887–9, p. 1744; Kahl, 1930–5, p. 578; Calkins, 1933, p. 519.

Body free-swimming, more or less elastic, and changeable in form, oval or elongate, not drawn out into a neck or tail. Frontal cirri absent, two or three uninterrupted rows of short ventral setæ which extend over frontal area also; five or more anal styles and a continuous projecting border of marginal setæ. Contractile vacuole single, spherical, usually occupying a median position close to the left margin. Macronucleus double. Inhabiting salt and fresh water.

254. **Holosticha mystacea** (Stein). (Fig. 171.)

Oxytricha mystacea, Stein, 1859 *d*, pp. 188–9, pl. xii, figs. 7–11.
Holosticha mystacea, Kent, 1880–2, p. 769, pl. xliii, fig. 11.
†*Oxytricha mystacea*, Daday, 1898, p. 8.
Gastrostyla mystacea, Lepsi, 1926 *a*, p. 85, fig. 455; Schoenichen, 1927, p. 234.
Holosticha mystacea, Kahl, 1930–5, p. 585, fig. 106, *25*.

Body ovate, flattened, nearly three times as long as broad, rounded and widest posteriorly; right side convex, left concave. Peristomial field extending backwards nearly to the centre of the body, its reflected border arcuate, distinctly ciliate. Ventral setæ forming two irregular, curved, central

rows, supplemented anteriorly with a few additional styles; marginal setæ constituting a continuous projecting border, the posterior ones longest; anal styles of medium size, not projecting beyond the posterior margin. Contractile vacuole single, spherical, median. Macronucleus double.

Dimensions.—Length 131–173 μ.

Habitat.—Pond water: CEYLON, Kandy.

Genus **STICHOTRICHA** Perty, 1849.

Stichotricha, Perty, 1849, p. 169; Stein, 1859 *d*, p. 174; 1867, p. 149; Kent, 1880–2, p. 775; Bütschli, 1887–9, p. 1743; Roux, 1901, p. 96; Lepsi, 1926 *a*, p. 81; Schoenichen, 1927, p. 230; Kahl, 1930–5, p. 556; Calkins, 1933, p. 517.

Body spindle-shaped but very variable in form, colourless or green. Anterior end strongly narrowed and flattened, forming a more or less elongated and contractile neck. Peristome long and narrow, slit-like, with very long adoral cilia that are constantly surging up and down, extending to the middle of the body. Marginal cilia well developed, commencing on the left margin behind the peristome and on the right margin near the summit of the narrow part. Varying number of rows of ventral cirri. Without frontal or anal cirri. The narrow anterior end carries on either side a row of larger dorsal bristles. Macronucleus in the form of two oval bodies. Locomotion irregular.

255. **Stichotricha** sp. (Fig. 172.)

†*Stichotricha* sp., Chaudhuri, 1929, p. 54, pl. ii, fig. 21.

Remarks.—The form figured by Chaudhuri resembles in all essential respects *S. aculeata* Wrzesn., except that the two rows of ventral cirri are not shown.



Fig. 172.—*Stichotricha* sp. (After Chaudhuri.)

Habitat.—Soil from CENTRAL INDIA, Indore.

Genus **UROLEPTUS** Ehrenberg, 1831, emend. Stein, 1859.

Uroleptus, Ehrenberg, 1831, p. 116; 1833, p. 277; 1838, p. 358; Stein, 1859 *d*, p. 176; Claparède & Lachmann, 1858–61, p. 151; Engelmann, 1862, p. 386; Kent, 1880–2, p. 779; Bütschli, 1887–9, p. 1745; Roux, 1901, p. 98; Lepsi, 1926 *a*, p. 81; Schoenichen, 1927, p. 231; Sandon, 1927, p. 192; Kahl, 1930–5, p. 547; Calkins, 1933, p. 517.

Body elongated, posteriorly with a tail-like prolongation, variable or constant in form; colourless, red, or violet. In addition to the well developed marginal cilia there are two rows of ventral cilia, lying close to one another. Three frontal cirri present, anal cirri and caudal setæ absent. Peristome of varying length and breadth. Contractile vacuole to the left of the middle. All species live in stagnant water. Locomotion rapid, incessant, frequently changing in direction.

Feed on detritus, Algæ, Diatoms, etc.

Key to India Species.

1. Body not pear-shaped, but narrow, elongated, spindle-shaped ..... 2.
2 (3). Marginal cilia longer posteriorly. Body anteriorly widened. Length up to 140 μ ..... *U. piscis* (Müll.) [Ehrbg., p. 370.
3 (2). Marginal cilia uniform. Body not widened anteriorly. Length 350–400 μ ..... *U. mobilis* Engelm., [p. 369.

256. **Uroleptus mobilis** Engelmann. (Fig. 173.)

Uroleptus mobilis, Engelmann, 1862, p. 386, pl. xxxi, figs. 11, 12; Kent, 1880–2, p. 781, pl. xliii, figs. 9, 10; Roux, 1901, p. 99, pl. vi, fig. 2; Lepsi, 1926 *a*, p. 84, fig. 439; Schoenichen, 1927, p. 232, pl. xiii, fig. 9.

†*Uroleptus mobilis* (?), Sandon, 1927, p. 193.

†*Uroleptus mobilis*, Chaudhuri, 1929, p. 54, pl. ii, fig. 26.

Uroleptus mobilis, Kahl, 1930–5, p. 548, fig. 101, *2*; Calkins, 1933, pp. 27, 28, 58, 63, 84, 219, 220, 245, 251, 254, 267, 313, 334, figs. 1, 27, 32, 109, 127, 128, 129, 131, 137, 159, 160, 166.

Very narrow, about twelve times as long as broad, posterior end tapering to a blunt point; body cylindrical and contractile. Peristome very narrow, exceedingly small, extending to about one-ninth of the length of the body, its inner border with an undulating membrane. Frontal styles uncinate, three in number; some scattered ventral cirri; marginal setæ relatively long and widely spaced. Contractile vacuole near the left margin, in front of the middle of the body. Macronucleus consisting of six ovoid masses arranged in a longitudinal row.

Dimensions.—Length 350–400 μ, breadth about 40 μ.

Fresh water and in soil.

Habitat.—Doubtfully recorded by Sandon in soil from MADRAS, Coimbatore, and by Chaudhuri in soils from KASHMIR, Srinagar; PUNJAB, Ghora Gali; DELHI; CENTRAL INDIA, Indore; BENGAL, Chittagong; BURMA, Rangoon.

257. **Uroleptus piscis** (Müller) Ehrenberg. (Fig. 174.)

Trichoda piscis, Müller, 1773, p. 73; 1786, p. 214, pl. xxxi, figs. 1–4.
Uroleptus piscis, Ehrenberg, 1838, p. 358, pl. xl, fig. 1.
Oxytricha caudata, Ehrenberg, 1838, p. 365, pl. xl, fig. 11; Claparède & Lachmann, 1858, p. 146, pl. v, fig. 7.
Uroleptus piscis, Kent, 1880–2, p. 780, pl. xliii, fig. 21.
Uroleptus (*Amphisia*) *piscis*, Bütschli, 1887–9, pl. lxxi, fig. 2.
Uroleptus piscis, Roux, 1901, p. 99, pl. vi, fig. 3; Lepsi, 1926 *a*, p. 84, fig. 435; Schoenichen, 1927, p. 232, pl. xiii, fig. 8.
†*Uroleptus piscis*, Sandon, 1927, p. 193; Chaudhuri, 1929, p. 60.
Uroleptus piscis, Kahl, 1930–5, p. 550, fig. 101, *1*; Calkins, 1933, pp. 151, 518, figs. 81, 209 B.

Body exceedingly elastic and somewhat variable in shape, broadly linear-fusiform or band-like, from six to eight times

Fig. 173. Fig. 174.

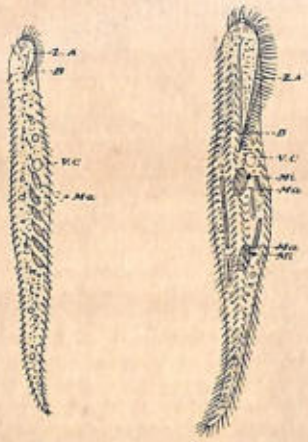


Fig. 173.—*Uroleptus mobilis* Engelmann. *B*, cytostome; *Ma*, macronucleus; *Mi*, micronucleus; *V.C*, contractile vacuole; *Z.A*, adoral zone. (After Roux.)
Fig. 174.—*Uroleptus piscis* (Müller) Ehrenberg. Lettering as in the previous figure. (After Roux.)

as long as broad, anterior end rounded, maximum width about the middle, with a long strap-like tail ending in a blunt point and turning to the right. Peristome extending from one-fourth to one-third of the length of the body; adoral zone well developed along the anterior and left margin, right margin with a narrow undulating membrane and fine preoral cilia. Frontal cirri three, marginal setæ set on ventral

surface but projecting beyond the edge all along the body, rather longer on the tail; ventral setæ in two median rows. Contractile vacuole near the left margin, in front of the middle of the body. Macronucleus consisting of two ovoid masses, situated in the middle part of the body behind the contractile vacuole.

Dimensions.—Length 600–800 μ, maximum breadth 80–110 μ.

Fresh water and in soil.

Habitat.—Soils from KASHMIR, Srinagar; CENTRAL INDIA, Indore; MADRAS, Coimbatore.

258. **Uroleptus** sp.

†*Uroleptus* sp., Chaudhuri, 1929, p. 54, pl. iii, figs. 3, 4.

Habitat.—Soils from N.W.F. PROVINCE, Peshawar; CENTRAL INDIA, Indore.

2. Subfamily PLEUROTRICHINÆ Bütschli, 1889.

Ventral cilia in interrupted rows, some of them being changed into cirri. Frontal cirri distinctly developed, typically eight in number. Anal cirri invariably present. One or two rows of marginal cilia also present.

Key to Indian Genera.

1.	Eight frontal cirri arranged in a typical manner	2.
2 (3).	Peristome narrow, elongated, bent at an angle about the middle of the body; three caudal cirri	[p. 372. GONOSTOMUM Sterki.
3 (2).	Peristome broad or narrow, not bent at an angle in the middle of the body..	4.
4 (7).	Besides the fine, strongly developed ventral cirri there are rows of smaller cirri, or altogether only one or two rows of but slightly differentiated ventral cirri. Peristome broadly triangular	5.
5 (6).	Eight frontal cirri; five differentiated ventral cirri; row of anal cirri broken, two near posterior end; no caudals; marginal row of cilia unbroken posteriorly	[p. 373. PLEUROTRICHA Stein.
6 (5).	Eight frontal cirri, the three anterior being more conspicuously developed; ventral setæ forming an oblique row, occasionally supplemented by a few others; four or five anals well developed; marginal row of cilia unbroken posteriorly	[p. 377. GASTROSTYLA Engelm.

7 (4). Only five ventral cirri. Peristome large, often extending to the middle of the body ..... 8.

8 (9). Eight frontal and five ventral cirri, two of the latter near the peristome, two near the anals, and one median; five well-developed anal cirri; without caudal cirri ..... [em. Sterki, p. 378. OXYTRICHA (Ehrbg.)

9 (8). As above, but marginal cirri interrupted posteriorly; three caudal cirri . [em. Stein, p. 380. STYLONYCHIA (Ehrbg.)

Genus **GONOSTOMUM** Sterki, 1878.

Oxytricha, part, Stein, 1859 *d*, p. 182.
Gonostonum, Sterki, 1878, p. 57.
Plagiotricha, part, Kent, 1880–2, p. 772.
Gonostomum, Maupas, 1883 *a*, pp. 550–6; Bütschli, 1887–9, p. 1748; Lepsi, 1926 *a*, p. 82; Schoenichen, 1927, p. 234; Kahl, 1930–5, p. 597; Calkins, 1933, p. 519.

Body form mostly narrow, narrow and pointed at both extremities. Peristome very narrow, with its posterior extremity bent abruptly inwards, and terminating near the centre of the body. Eight frontal styles, one or more oblique rows of ventral setæ, a projecting fringe of marginal setæ, and four or five anal styles. Generally with three distinct caudal setæ. Contractile vacuole single, near the left lateral border. Macronucleus bipartite.

259. **Gonostomum affine** (Stein). (Fig. 175.)

Oxytricha affinis, Stein, 1859 *d*, pp. 186–7, pl. xii, figs. 1–6.
Plagiotricha (*Gonostomum*) *affinis*, Kent, 1880–2, p. 772, pl. xliii, fig. 25.
Gonostomum affine, Bütschli, 1887–9, pl. lxxi, fig. 8; Lepsi, 1926 *a*, p. 86, fig. 457; Schoenichen, 1927, p. 234, pl. xiii, fig. 13.
†*Gonostomum* (*Plagiotricha*) *affine*, Sandon, 1927, p. 195, pl. vi, fig. 15; pl. i, fig. 25.
†*Gonostomum affine*, Chaudhuri, 1929, p. 60, pl. ii, figs. 29, 30; pl. iv, fig. 17.
Gonostomum (*Oxytricha*) *affine*, Kahl, 1930–5, p. 598, fig. 113, *9*, fig. 115, *1–4*.

Body elongated oval, three and a half to four times as long as broad; ends narrowed and equally rounded, in section almost circular; very flexible. Peristome very narrow, reaching to the middle of the body, running back for the greater part of its length parallel to the axis of the body and making a very characteristic sharp bend inwards near its hind end. Cilia of the adoral zone uniformly elongated. Eight frontal cirri; five or six ventral cirri arranged in an oblique row; marginal cirri uninterrupted at the posterior end, where they are a little longer; anal styles five, short and inconspicuous, not reaching

to the posterior extremity of the body; no caudal setæ. Contractile vacuole near the left margin, about the middle. Macronucelus in two rather elongated ovoid masses. Cyst has a thin smooth wall.

Dimensions.—Length 75–100 μ. Diameter of cyst 33 μ.

In swampy water and a very common soil form.



Fig. 175.—*Gonostomum affine* (Stein). (After Sandon.)

Habitat.—Sandon records it from soil from spice-gardens: SOUTHERN INDIA, Kanara; and doubtfully records it from soils from PUNJAB, Jullundur; MADRAS, Coimbatore. Chaudhuri records it from soils from KASHMIR, Srinagar; PUNJAB, Lahore; DELHI; UNITED PROVINCES, Agra; BOMBAY, Dharwar; CEYLON, Colombo.

260. **Gonostomum** sp.

†*Gonostomum* sp., Chaudhuri, 1929, p. 54, pl. iii, figs. 5, 6.

Remarks.—This form has been imperfectly described and poorly figured. It is doubtful if it is a species of *Gonostomum* at all.

Habitat.—From soils from PUNJAB, Lahore; BENGAL, Dacca; and MADRAS, Madras.

Genus **PLEUROTRICHA** Stein, 1859.

Pleurotricha, Stein, 1859 *a*, p. 4; 1859 *d*, p. 168; Engelmann, 1862, p. 385; Kent, 1880–2, p. 782; Bütschli, 1887–9, p. 1747; Lepsi, 1926 *a*, p. 82; Schoenichen, 1927, p. 233; Reichenow, 1929, p. 1207; Kahl, 1930–5, p. 593.

Free-swimming, medium-sized, persistent in form, elongate or elliptical. Peristome-field broad, triangular, not extending to the median line, with both undulating membranes well developed. Eight frontal cirri, the three anterior of which are usually more conspicuously developed, arranged in a

typical manner. Five large ventral cirri, together with one or more complete rows of smaller ventral setæ. Anal styles five or six, arranged in two groups, of which one, containing the two on the right side, is situated close to the posterior end, whilst the other, consisting of the three on the left side, is situated further forwards on a level with the last of the ventral cirri. Caudal styles absent. Contractile vacuole situated near the posterior angle of the peristome. Macronucleus ovate, sometimes multiple. Locomotion swift, almost springing, changing in direction to left and right. Inhabiting fresh water.

Key to Indian Species.

1 (2). Body broad, egg-shaped. Two or more, usually three, rows of ventral cirri on either side of the median group of ventral uncini. ..... *P. grandis* Stein, p. 374.

2 (1). Body lanceolate. One complete and one incomplete row of ventral cirri on the right side only of the median group of ventral uncini ..... [Stein, p. 376. *P. lanceolata* (Ehrbg.)

261. **Pleurotricha grandis** Stein. (Fig. 176.)

Pleurotricha grandis, Stein, 1859 *a*, p. 4; 1859 *d*, pp. 169–70, pl. x, fig. 1; Kent, 1880–2, p. 782; Bütschli, 1887–9, p. 1248, fig. 6, pl. lxxi, fig. 5.

†*Pleurotricha grandis*, Bhatia, 1920, p. 262; Gulati, 1925, p. 10, fig. 23.

Pleurotricha grandis, Lepsi, 1926 *a*, p. 85, fig. 452; Schoenichen, 1927, p. 233, pl. xii, fig. 11.

†*Pleurotricha grandis* (?), Sandon, 1927, p. 197; Chaudhuri, 1929, p. 54.

Pleurotricha grandis, Reichenow, 1929, p. 1207, fig. 1188 B; Kahl, 1930–5, p. 593, fig. 113, *3*.

Body elliptical, about twice as long as broad, widest a little behind the middle. Peristome not extending to the middle. Eight frontal cirri arranged in a typical manner; five ventral uncini stout and subcentral, supplemented on each side by usually three parallel rows of smaller ventral setæ; anal styles in two subgroups, the two together constituting one group, removed towards the posterior extremity and projecting to a considerable distance beyond its margin. Contractile vacuole close to the posterior angle of the peristome.

Dimensions.—Length 100–420 μ.

Fresh water among aquatic plants.

Remarks.—The size of this species is apparently subject to considerable variation. The form met with at Lahore measured only 100 μ in length and 40 μ in its greatest width. Schoenichen gives the length as 100–200 μ; Kent 208–416 μ; Sandon 210–420 μ. The number of supplementary rows of

small ventral setæ also shows considerable variation. Kent mentions two parallel rows of smaller ventral setæ on each side. Stein, Bütschli, and Schoenichen show three rows on each side. Lepsi states that there are some five rows, of which in his figure three are shown on the right and two on the left. Sandon gives two complete and one partial row on either side of the median group. Gulati mentions one or more rows on each side. In the specimens examined by me at Lahore I found on one occasion five rows on the right side and only three rows on the left, and on another only two rows on each side.

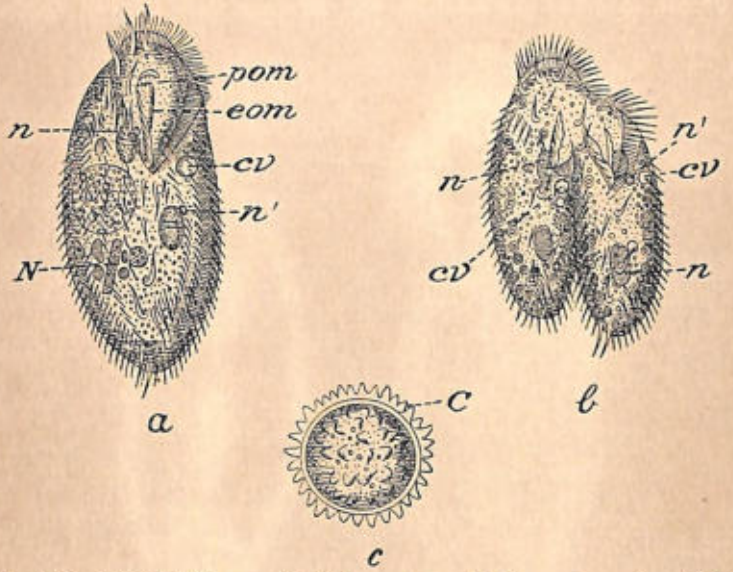


Fig. 176.—*Pleurotricha grandis* Stein. *a*, ventral view; *b*, conjugation; *c*, cyst. *C*, cyst; *cv*, contractile vacuole; *eom*, endoral membrane; *n*, macronucelus; *n'*, micronucleus; *N*, food-particle; *pom*, postoral membrane. (After Bütschli.)

Transverse fission was observed in this form. The anterior part of the body containing the peristome narrowed somewhat, some of the bristles were cast off, another contractile vacuole developed in the anterior portion and a new peristome in the posterior part. The anterior portion then curved round to the side of the rest of the body, and was finally constricted off from it.

Habitat.—Pond water and infusion of dry leaves: PUNJAB, Lahore. Soils from N.W.F. PROVINCE, Peshawar; PUNJAB, Ghora Gali; BOMBAY; UNITED PROVINCES, Agra; CENTRAL INDIA, Indore; BENGAL, Sibpore; ASSAM.

262. **Pleurotricha lanceolata** (Ehrenberg) Stein. (Fig. 177.)

Kerona calvitium, Müller, 1786, p. 245, pl. xxxiv, figs. 11–13.
Stylonichia lanceolata, Ehrenberg, 1838, p. 373, pl. xlii, fig. 5.
Pleurotricha lanceolata, Stein, 1859 *a*, p. 4; 1859 *d*, pp. 170–1, pl. x, figs. 2–4; Kent, 1880–2, p. 783, pl. xliii, figs. 26, 27; Lepsi, 1926 *a*, p. 85, fig. 453; Schoenichen, 1927, p. 233.
†*Pleurotricha lanceolata* (?), Sandon, 1927, p. 196, fig. 12.
Pleurotricha lanceolata, Manwell, 1928 *a*, pp. 417–37, pls. i–xii, figs. 1–54; 1928 *b*, pp. 433–6.
†*Pleurotricha lanceolata*, Chaudhuri, 1929, p. 54.
Pleurotricha lanceolata, Kahl, 1930–5, p. 593, fig. 113, *4*.

Body elongate-lanceolate, two and a half times as long as broad, pointed posteriorly, the anterior end curved slightly

Fig. 177.

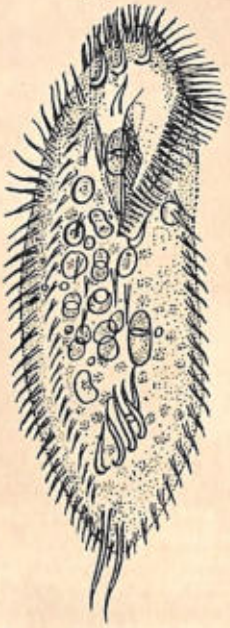


Fig. 178.



Fig. 177.—*Pleurotricha lanceolata* (Ehrenberg). (After Sandon.)
Fig. 178.—*Gastrostyla setifera* (Engelmann). *c.v*, contractile vacuole. (After Gulati.)

towards the left. Peristome, frontal, ventral, anal styles, and other details as in *P. grandis*; one complete and a second incomplete row of supplementary ventral setæ on the right only of the larger ventral uncini. Cyst characteristic, being covered with short, stout, straight spiny processes.

Dimensions.—Length 83–143 μ (Stein), 173–297 μ (Kent), 70–80 μ (Sandon), 100–165 μ (Manwell).

Fresh water, among aquatic plants; fairly common in soil.

Remarks.—Conjugation, division, and encystment in this species have been fully described by Manwell (1928 *a*).

Habitat.—In soils: KASHMIR, Srinagar; N.W.F. PROVINCE, Peshawar; PUNJAB, Ghora Gali, Jullundur (?); DELHI; CENTRAL INDIA, Indore; HYDERABAD; MADRAS, Madras; ASSAM, Cinnamara.

Genus **GASTROSTYLA** Engelmann, 1862.

Gastrostyla, Engelmann, 1862, p. 383; Kent, 1880–2, p. 783; Bütschli, 1887–9, p. 1747; Roux, 1901, p. 100; Lepsi, 1926*a*, p. 82; Schoenichen, 1927, p. 233; Sandon, 1927, p. 194; Kahl, 1930–5, p. 593; Calkins, 1933, p. 519.

Body elliptical, anteriorly narrower, posteriorly rounded, flexible, but little contractile. Peristome occupying about one-third of the body-length. Eight frontal cirri. Ventral cirri in one or two oblique rows, sometimes with a few additional scattered ones. Four or five anal cirri, situated as in *Pleurotricha*, besides the marginal cilia, which form an uninterrupted row at the posterior extremity of the body. No caudal bristles. Single contractile vacuole, situated to the left in the middle part of the body. Macronucleus in two or four ovoid masses. Locomotion swift.

263. **Gastrostyla setifera** (Engelmann). (Fig. 178.)

Pleurotricha setifera, Engelmann, 1862, p. 39, pl. xxx, fig. 10.
Gastrostyla setifera, Kent, 1880–2, p. 784; Bütschli, 1887–9, p. 1248, fig. 7.
†*Gastrostyla setifera*, Gulati, 1925, p. 752, fig. 24.
Gastrostyla setifera, Schoenichen, 1927, p. 234.
Gastrostyla (*Pleurotricha*) *setifera*, Kahl, 1930–5, p. 595, fig. 113, *6*.

Body elongate-lanceolate, constant in form, widest centrally, equally narrowed at the two extremities, about two and a half times as long as broad. Peristome extending backwards, its reflected border bearing a band-like undulating membrane. Frontal styles in the form of five uncini, the three anterior of which are largest, and three or more bristles situated further back; an oblique row of ventral styles as well as a few scattered ones; anal styles five in number, forming two groups of three and two each, only the latter projecting beyond the posterior border; marginal setæ coarse, forming an uninterrupted row; no caudal styles. Contractile vacuole near the middle of the left lateral border. Macronucleus consisting of two ovate masses.

Dimensions.—Length about 270 μ (Schoenichen), 312 μ (Kent).

Remarks.—Engelmann, who originally described this species under the name of *Pleurotricha setifera*, mentions five frontal setæ and four or five additional frontal setæ which are interpreted by Kent as the anterior setæ of the oblique ventral row. Schoenichen gives five uncini and four to six bristle-shaped frontal cirri. Kent relegated the species to the genus *Gastrostyla*, as the latter is distinguished from *Pleurotricha* by the possession of a single oblique row of ventral setæ.

The form described and figured by Gulati differs from the species, as defined above, in possessing eight frontal styles disposed in a typical arrangement, two short rows of ventral setæ, the five anal styles not being arranged in two groups, and in the very much smaller size, 90 μ by 30 μ only. Either it was not correctly observed or it represents a distinct species.

Habitat.—Pond water : PUNJAB, Lahore.

Genus **OXYTRICHA** (Ehrenberg, 1830) Sterki, 1878.

Oxytricha, Ehrenberg, 1830, p. 43 ; 1838, p. 363.
Oxytricha, part, Dujardin, 1841, p. 416.
Oxytricha, Claparède & Lachmann, 1858–61, p. 138 ; Stein, 1859 *d*, p. 182 ; Engelmann, 1862, p. 387 ; Fromentel, 1874, p. 160 ; Sterki, 1878, pp. 56–7 ; Kent, 1880–2, p. 786 ; Bütschli, 1887–9, p. 1749 ; Roux, 1901, p. 100 ; Lepsi, 1926 *a*, p. 82 ; Schoenichen, 1927, p. 234 ; Sandon, 1927, p. 195 ; Reichenow, 1929, p. 1207 ; Kahl, 1930–5, p. 599 ; Calkins, 1933, p. 521.

Body elongate-oval, rounded at both ends ; flexible and contractile. Dorsal surface convex, least so in the middle part of the body ; ventral surface flat. Peristome large, sometimes extending to the neighbourhood of the middle of the body, right peristomial margin anteriorly bent to the left. Adoral zone of cirri well developed anteriorly and along the left margin, more or less strongly curved. Eight frontal cirri ; five ventral cirri, two below the peristome, one in the middle, two above the anal cirri, sometimes with supplementary ones ; and five well developed anal cirri. Marginal row of setæ unbroken at the posterior end. Often with dorsal bristles. Contractile vacuole single. Macronucleus double. Locomotion swift, with frequent changes of direction.

Kahl (1930–5) has divided the genus into seven subgenera, of which *Tachysoma* and *Stylonichia* are represented in India.

264. **Oxytricha pellionella** (O. F. Müller) Ehrenberg. (Fig. 179.)

Trichoda pellionella, O. F. Müller, 1773, p. 80; 1786, p. 222, pl. xxxi, fig. 21.
Oxytricha pellionella, Ehrenberg, 1838, p. 364, pl. xl, fig. 10; Dujardin, 1841, p. 417, pl. xi, fig. 10; Stein, 1859 *d*, pp. 185–6, pl. xi, figs. 13–18; Kent, 1880–2, p. 786, pl. xlv, figs. 3–5.
Tachysoma agilis, Stokes, 1887 *b*, p. 180, pl. iii, fig. 6.
Oxytricha pellionella, Bütschli, 1887–9, pl. lxxi, fig. 9; Roux, 1901, p. 101, pl. vi, fig. 5; Lepsi, 1926 *a*, p. 86, fig. 461; Schoenichen, 1927, p. 236, fig. 751, & pl. xiii, fig. 14.
†*Oxytricha pellionella* (?), Sandon, 1927, p. 196, pl. vi, fig. 14.
†*Oxytricha pellionella*, Chaudhuri, 1929, p. 54.
Tachysoma (*Oxytricha*) *pellionella*, Kahl, 1930–5, p. 606, fig. 113, *31*.

Body elongate-oval, moderately elastic, rather more than four times as long as broad, widest in the middle, lateral margins nearly parallel, uniformly rounded at both extremities. Peristome rather narrow, about one-third the length of the body, not reaching the median line of the body in its maximum



Fig. 179.—*Oxytricha pellionella* (O. F. Müller). (After Sandon.)

width, with well developed adoral zone of membranelles, and a narrow undulating membrane along its right border. Frontal cirri eight, ventral setæ five, anal uncini projecting to a considerable distance beyond the posterior end of the body; marginal setæ stationed at some distance from the periphery, row interrupted posteriorly. Dorsal bristles well developed. Contractile vacuole near the left border about the middle. Macronucleus consisting of two oval masses, with adjacent micronuclei.

Dimensions.—Length 80–100 μ, width 19–24 μ.

In stagnant water and in soil.

Habitat.—Sandon doubtfully records it from soils from PUNJAB, Jullundur; Chaudhuri from soils from PUNJAB, Lahore; CENTRAL INDIA, Indore.

265. **Oxytricha** sp.

Oxytricha sp., Carter, 1856.

Habitat.—Fresh water : Bombay.

266. **Oxytricha** sp.

Oxytricha sp. (?), Sandon, 1927, p. 23.

Habitat.—Sandon doubtfully records it from wet paddy soil from MADRAS, Coimbatore.

267. **Oxytricha** sp.

Oxytricha sp., Chaudhuri, 1929, p. 54.

Chaudhuri mentions *Oxytricha* sp. as a new record, but the locality is not indicated in his Table III.

Genus **STYLONYCHIA** (Ehrenberg, 1830) emend. Stein, 1859.

Stylonychia, Ehrenberg, 1830, p. 120 ; 1838, p. 370 ; Claparède & Lachmann, 1858–61, p. 154 ; Stein, 1859 *d*, p. 146 ; Fromentel, 1874, p. 162 ; Kent, 1880–2, p. 790 ; Bütschli, 1887–9, p. 1749 ; Roux, 1901, p. 103 ; Lepsi, 1926 *a*, p. 82 ; Wenyon, 1926, p. 1221 ; Schoenichen, 1927, p. 236 ; Sandon, 1927, p. 197 ; Reichenow, 1929, p. 1207 ; Kahl, 1930–5, p. 617.

Free-swimming, medium-sized to very large, elongate-oval, persistent in shape ; dorsal surface convex, ventral flat. Peristome half as wide as the body, extending up to the middle, with its right border curved in a S-like manner, not or only slightly bent at its anterior end towards the left. Eight frontal cirri typically situated ; five claw-like ventral styles or uncini arranged in two rows ; and five straight anal styles, as in *Oxytricha*. The marginal setæ form on each side an even and continuous border, but are in most species separated at the posterior extremity by a gap in which are situated three very long bristle-shaped caudal styles, diverging at the end. Macronucleus double, oval or elongate. Contractile vacuole single, spherical, situated near the posterior angle of the peristome. Locomotion quick, swimming and creeping, but not shooting backwards. Inhabiting salt, fresh and stagnant water.

Kahl (1930–5) regards *Stylonychia* as a subgenus of *Oxytricha* Ehrbg.

268. **Stylonychia pustulata** Ehrenberg. (Fig. 180.)

Kerona pustulata (?), Müller, 1786, p. 246, pl. xxxiv, figs. 14, 15.
Kerona silurus (?), Müller, 1786, p. 244, pl. xxxiv, figs. 9, 10.
Kerona pustulata, Ehrenberg, 1830, pp. 53, 63; 1831, p. 119.
Stylonychia pustulata, Ehrenberg, 1835, p. 164; 1838, p. 371, pl. xlii, fig. 1.
Kerona pustulata, Dujardin, 1841, p. 423, pl. vi, fig. 10; pl. xiii, fig. 7.
Stylonychia pustulata, Claparède & Lachmann, 1858–61, p. 161, pl. vi, fig. 2; Stein, 1859 *d*, pp. 161–6, pl. ix, figs. 1–16; Fromentel, 1874, p. 274, pl. xiv, fig. 9; Kent, 1880–2, p. 791, pl. xlv, figs. 15–17.
†*Stylonychia pustulata*, Daday, 1898, p. 8.
Stylonychia pustulata, Roux, 1901, p. 104, pl. vi, fig. 9.
†*Stylonychia pustulata*, Bhatia, 1922, p. 33.
Stylonychia pustulata, Lepsi, 1926 *a*, p. 86, fig. 467; Schoenichen, 1927, p. 237, fig. 753.
†*Stylonychia pustulata*, Bhatia & Mullick, 1930, pp. 401–2.
Stylonychia pustulata, Kahl, 1930–5, p. 619, fig. 121, *21*, *21 a*.

Body elongate-oval, equally wide in front of and behind the median line, the posterior extremity evenly rounded. Frontal cirri eight; ventral cirri five, not arranged in a row; anal styles five, three or four of which project beyond the

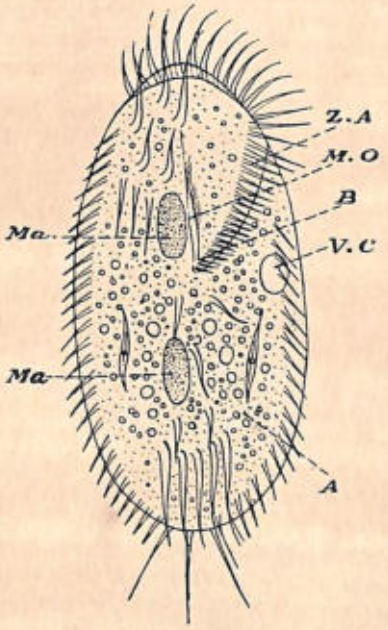


Fig. 180.—*Stylonychia pustulata* Ehrenberg. *A*, anus; *B*, cytostome; *Ma*, macronucleus; *M.O*, undulating membrane; *V.C*, contractile vacuole; *Z.A*, adoral zone. (After Roux.)

posterior border ; three long, diverging caudal styles, interrupting the marginal setæ at the posterior end of the body. Peristome not quite half the length of the body, with a very narrow, indistinct undulating membrane. Contractile vacuole close to the middle of the body. Macronucleus consisting of two oval parts, with a micronucleus lying close to each. Cysts spherical with warty projections.

Dimensions.—Length 150–220 μ.

Occurs in salt, fresh and stagnant water, infusions, and soil. Tolerant of carbon dioxide.

Remarks.—In the specimens found at Lahore the frontal cirri were eight in number and arranged in the characteristic manner ; ventral setæ were present but not distinct, and their number could not be ascertained ; anal styles were five in number, turned back, and projected beyond the posterior end of the body. The marginal cilia were set within the border, and the row was interrupted at the posterior end by the three caudal styles characteristic of the genus, but these were not very long. The macronucleus was central, consisting of two parts, oval in outline, and one part was partly overlying the other, no connecting thread being present.

The Srinagar specimens resembled closely those from Lahore except that they measured 50–60 μ only. The macronuclear portions lay at some distance from one another and the caudal styles were situated close to one another.

Habitat.—Pond water : KASHMIR, Srinagar ; PUNJAB, Lahore ; and CEYLON, Kandy.

269. **Stylonychia** sp.

†*Stylonychia* sp., Chaudhuri, 1929, p. 54.

Habitat.—Soil from UNITED PROVINCES, Agra.

3. Subfamily PSILOTRICHINÆ Bütschli, 1889.

Frontal and ventral cirri much reduced ; ventral cilia, apart from cirri, entirely absent. Anal cirri often present.

Genus **BALLADINOPSIS** Ghosh, 1921.

Balladinopsis, Ghosh, 1921 *b*, p. 248.
Balladynopsis, Kahl, 1930–5, p. 592.

Body rigid, elliptical, somewhat narrower anteriorly, rounded and wide posteriorly. Dorsal surface convex,

ventral slightly convex. Peristome narrow and extending to two-thirds of the length of the body. Ventral cirri three in number and placed near the right peristomial margin in the anterior half of the body ; anal cirri five, long, protruding beyond the posterior margin of the body. Contractile vacuole single, median, near the right margin. Macronuclei two, oval.

The genus is represented by a single species, and resembles *Balladyna kowalewski* in having a rigid body and elongated marginal cirri, in the absence of frontal cirri, in the number and arrangement of anal cirri, in the somewhat elongated membranelles, in the number of macro- and micronuclei, and in having a single contractile vacuole. It differs, however, from that genus in the absence of a single uniform row of ventral cirri and the bristles on the dorsal surface.

Kahl (1930–5) considers it to be very likely a degenerate form.

270. **Balladinopsis nuda** Ghosh. (Fig. 181.)

†*Balladinopsis nuda*, Ghosh, 1921 *b*, p. 248, fig. 1.
Balladynopsis nuda, Kahl, 1930–5, p. 592, fig. 86, *21*.

Body exhibits the characters given above under the genus. Peristome narrow, extending along the entire anterior margin

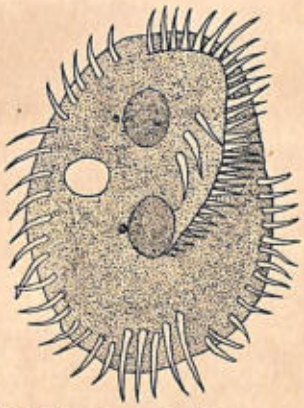


Fig. 181.—*Balladinopsis nuda* Ghosh. (After Ghosh.)

and the anterior third of the left side, whence it curves inwards to nearly the median line, reaching the junction of the anterior two-thirds and posterior one-third of the body-length ; membranelles long and narrow. Anal cirri long, five in number, three on the left side in an oblique and two on the right side

in a transverse row, all projecting beyond the posterior margin of the body. Marginal cirri long, arising from the ventral surface just inside the margin, on the right side extending along the entire margin, on the left from the middle and stopping short of the posterior end. Contractile vacuole placed near the right lateral margin in the middle of the body. Macronucleus consisting of two oval parts, each with a micronucleus, one placed anteriorly and the other just behind the middle of the body.

Dimensions.—Length 63 μ, breadth 20 μ.

Habitat.—In vegetable infusions : BENGAL, Calcutta.

3. Family EUPLOTIDÆ Ehrenberg, 1838.

Body constant in form. Cilia entirely replaced by cirri. Frontal, ventral, and anal cirri present. The anal cirri are characteristically five in number and specially strong, forming springing organs along with the ventrals and caudals. A few marginal cirri present on the sides of the body or at the posterior end. Dorsal bristles present. Peristome harp-shaped or sickle-shaped. Adoral zone of membranelles well developed on the anterior and left borders of the peristome. Contractile vacuole posterior, to the right of the anus. Macronucleus band-shaped, curved.

Genus **EUPLOTES** (Ehrenberg, 1831) emend. Stein, 1859.

Euplotes, Ehrenberg, 1831, p. 118 ; 1838, p. 377.
Ploesconia, Dujardin, 1841, p. 431.
Euplotes, Claparède & Lachmann, 1858–61, p. 168 ; Stein, 1859 *d*, p. 133 ; Fromentel, 1874, p. 164 ; Kent, 1880–2, p. 797 ; Bütschli, 1887–9, p. 1752 ; Roux, 1901, p. 108 ; Lepsi, 1926 *a*, p. 80 ; Wenyon, 1926, p. 1221 ; Schoenichen, 1927, p. 240 ; Sandon, 1927, p. 198 ; Reichenow, 1929, p. 1207 ; Kudo, 1931, pp. 389–90 ; Kahl, 1930–5, p. 628 ; Calkin, 1933, p. 521.

Free-swimming. Body constant in form, shield-shaped, colourless and transparent, or greenish through the presence of zoochlorellæ. Dorsal surface more or less convex, sometimes smooth, but generally with sharp longitudinal ribs. Ventral surface flattened, provided in its middle part with more or less elongated furrows running longitudinally. Peristome harp-shaped or sickle-shaped, well developed, adoral zone of membranelles well developed on the anterior and left borders of the peristome. Fronto-ventral cirri well developed and

variable in number, usually nine or ten. Five strongly developed anal styles arranged in a transverse row. Four flexible marginal cirri, situated along the posterior border. Contractile vacuole single, spherical. Macronucleus band-shaped, curved. Locomotion swift, with frequent changes of surface And direction. Feeding on Algæ, detritus and Flagellates, etc.

Key to Indian Species.

1 (2). Ten fronto-ventral cirri, postero-marginal setæ unbranched. Length 80 μ .... *E. charon* (O. F. Müll.) [Ehrbg., p. 385.

2 (1). Nine fronto-ventral cirri, two postero-marginal setæ branched or fimbriated. Length 100–125 μ ..... *E. patella* Ehrbg., [p. 386.

271. **Euplotes charon** (O. F. Müller) Ehrenberg. (Fig. 182.)

Trichoda charon, O. F. Müller, 1773, p. 83; 1786, p. 229, pl. xxxii, figs. 12–20.
Trichoda cimex, O. F. Müller, 1773, p. 84; 1786, p. 231, pl. xxxii, figs. 21–24.
Euplotes charon, Ehrenberg, 1838, p. 378, pl. xlii, fig. x.
Euplotes appendiculatus, Ehrenberg, 1838, p. 379, pl. xlii, fig. xii.
Plœsconia charon, Dujardin, 1841, p. 439, pl. x, figs. 8, 13.
Plœsconia affinis, Dujardin, 1841, p. 441, pl. vi, fig. 7.
Plœsconia subrotunda, Dujardin, 1841, p. 441, pl. xiii, fig. 5.
Plœsconia radiosa, Dujardin, 1841, p. 442.
Plœsconia longiremis, Dujardin, 1841, p. 442, pl. x, figs. 9, 12.
†*Himantophorus charon*, Carter, 1856 *b*, p. 132, pl. vii, fig. 86.
Euplotes charon, Claparède & Lachmann, 1858–61, p. 173, pl. vii, fig. 10; Stein, 1859 *d*, pp. 137–40, pl. iv, figs. 14–20; Fromentel, 1874, p. 278, pl. xii, fig. 9; Kent, 1880–2, pp. 799–800, pl. xliv, figs. 26–9; Bütschli, 1887–9, pl. lxxii, fig. 29; Roux, 1901, p. 109, pl. vi, fig. 15; Bullington, 1925, p. 272; Lepsi, 1926 *a*, p. 83, fig. 396; Schoenichen, 1927, p. 240, fig. 756; Sandon, 1927, p. 198, pl. vi, fig. 10; Reichenow, 1929, p. 1207; Kudo, 1931, p. 390, fig. 167 *a*; Kahl, 1930–5, p. 633, fig. 123, *13–15*; Calkins, 1933, p. 160, fig. 89 D.

Medium-sized. Shape regular, oval, rounded at the two extremities, slightly narrower in front than behind. Peristome rather narrow. Dorsal furrows not very distinct. Ten fronto-ventral cirri on the anterior half of the ventral surface. Posterior marginal setæ small, not branched. Contractile vacuole posterior. Macronucleus band-shaped, curved.

Dimensions.—Length 80 μ, breadth 38–40 μ.

Salt and fresh water. Very tolerant of deficiency of oxygen.

Habitat.—Fresh water : Bombay.

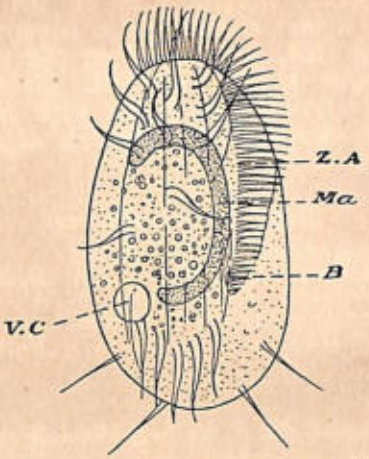


Fig. 182.—*Euplotes charon* (O. F. Müller). *B*, cytostome; *Ma*, macronucleus; *V.C*, contractile vacuole; *Z.A*, adoral zone. (After Roux.)

272. **Euplotes patella** (O. F. Müller) Ehrenberg. (Fig. 183.)

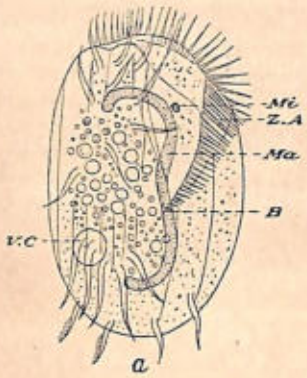
Kerona patella (?), Müller, 1786 p. 238, pl. xxxiii, figs. 14–17.
Euplotes patella, Ehrenberg, 1838, p. 378, pl. xlii, fig. ix.
Euplotes viridis, Ehrenberg, 1840, p. 200.
Plæsconia patella, Dujardin, 1841, p. 435, pl. viii, figs. 1–4.
Euplotes patella, Stein, 1859 *d*, pp. 135–6, pl. iv, figs. 6–11; Claparède & Lachmann, 1858–61, p. 170, pl. vii, figs. 1, 2; Kent, 1880–2, p. 798, pl. xliv, figs. 23–5.
Euplotes paradoxa, Kent, 1880–2, p. 798.
Euplotes patella, Bütschli, 1887–9, pl. lxxii, fig. 2; Roux, 1901, p. 109, pl. vii, fig. 1; Taylor, 1920, pp. 403–70, pls. xxix–xxxiii; Bullington, 1925, pp. 249, 272; Lepsi, 1926 *a*, pp. 82–3, fig. 398; Wenyon, 1926, p. 1221, fig. 527, A, B; Schoenichen, 1927, p. 240, pl. xiii, fig. 18; Sandon, 1927, p. 199.
†*Euplotes patella*, Madhava Rao, 1928, p. 114, pl. *ii*, fig. 2.
Euplotes patella, Kudo, 1931, p. 390, fig. 167 *b*.
Euplotes (*Trichoda*) *patella*, Kahl, 1930–5, p. 639, fig. 124, *1*, *2*.
Euplotes patella, Calkins, 1933, pp. 94, 129–30, 182, figs. 48, 72, 96.

Medium-sized to large. Roughly oval, truncated in front and rounded posteriorly, breadth nearly equal at the two extremities. Peristome well developed, wide anteriorly. Ventral surface with longitudinal ridges in the neighbourhood of anal cirri. Fronto-ventral cirri nine, anal five, marginal four, the two on the right being branched or fimbriated. Contractile vacuole posterior. Macronucleus band-shaped, curved.

Dimensions.—Length 100–125 μ, breadth 60–75 μ.

Food largely Diatoms and other Algæ. Salt and fresh water.

Habitat.—Soil: Mysore.



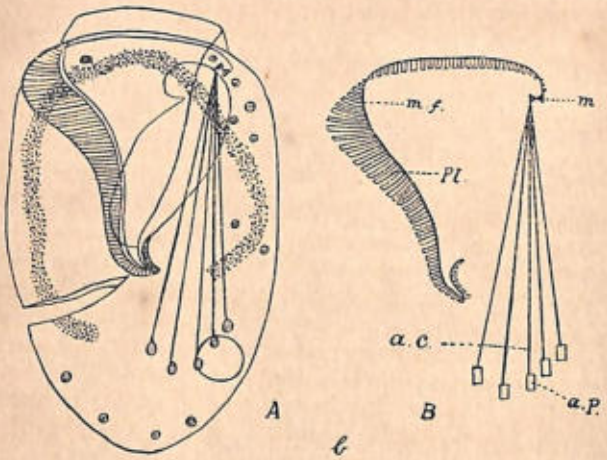


Fig. 183.—*a*. *Euplotes patella* (O. F. Müller). *B*, cytostome; *Ma*, macronucleus; *Mi*, micronucleus; *V.C.*, contractile vacuole; *Z.A*, adoral zone. (After Roux.)

b. Micro-dissection of *Euplotes patella*. A. Individual with lateral cut, showing distribution of the various structures. B. Neuromotor apparatus isolated. *a.c.*, fibres to anal cirri; *a.P.*, basal plates of anal cirri; *m*, motorium; *m.f.*, membranelle fibre; *Pl.*, membranelle plates. (After Taylor.)

4. Family ASPIDISCIDÆ Ehrenberg, 1838.

Cilia are entirely replaced by cirri. Frontal, ventral, and anal cirri present. Marginal cirri completely absent. Peristome very small, shifted to the left margin of the body; it lies covered by a transparent fold extending from the right margin of the body. Adoral zone of membranelles confined to the left and not marking off a frontal field. Dorsal bristles absent. Contractile vacuole posterior. Macronucleus band-shaped, curved.

Key to Indian Genera.

1 (2).	Peristome begins at the anterior end, 7 fronto-ventral and 5 anal cirri	[p. 388. ASPIDISCA Ehrnbg.,
2 (1).	Peristome begins at the left lateral margin, 4 frontal well differentiated from 5 ventral, and 5 anal cirri	[p. 391. ASPIDISCOPSIS Ghosh,

Genus **ASPIDISCA** Ehrenberg, 1830.

Aspidisca, Ehrenberg, 1830, p. 42; 1838, p. 344; Dujardin, 1841, p. 448; Claparède & Lachmann, 1858–61, p. 188; Stein, 1859*d*, p. 121; Fromentel, 1874, p. 164; Kent, 1880–2, p. 792; Bütschli, 1887–9, p. 1754; Roux, 1901, p. 110; Lepsi, 1926*a*, p. 80; Schoenichen, 1927, p. 241; Reichenow, 1929, p. 1207; Kudo, 1931, p. 390; Kahl, 1930–5, p. 643; Calkins, 1933, p. 521.

Free-swimming. Very small or small, encuirassed, orbicular or shield-shaped. Dorsal surface more or less convex. Ventral surface plane, with its right border thickened. Peristome set far back on the left side, with a simple arcuate fringe of adoral cirri; the right border of the peristome spread out into a plate covering the furrow more or less completely, and sometimes projecting beyond the left margin of the body. Cirri strong and long, seven fronto-ventral cirri (in two species nine to fifteen anterior fronto-ventral cirri), and from five to twelve transverse or anal styles. Anal aperture placed far back, a little in advance of the posterior or anal styles. Contractile vacuole single, posterior. Macronucleus curved in a horseshoe-shaped manner. Locomotion irregular. Salt or fresh water.

Key to Indian Species.

1.	Transverse cirri at some distance from the posterior end; 3 right transverse cirri situated in an anterior group apart from the others	2.
2 (3).	Dorsal surface smooth or with 3 feeble longitudinal furrows	[p. 390. *A. lynceus* (O. F. Müll.),
3 (2).	Dorsal surface with 5 or 6 well-marked longitudinal furrows	[Stein, p. 389. *A. costata* (Duj.)

273. **Aspidisca costata** (Dujardin) Stein. (Fig. 184.)

Loxodes plicatus (?), Ehrenberg, 1838, p. 325, pl. xxxiv, fig. 4.
Coccudina costata, Dujardin, 1841, p. 446, pl. x, fig. 1.
Aspidisca cicada, Claparède & Lachmann, 1858–61, p. 190, pl. vii, figs. 13–15.
Aspidisca costata, Stein, 1859 *d*, p. 125, pl. iii, figs. 15–17; Kent, 1880–2, pp. 794–5, pl. xlv, figs. 25–29; Roux, 1901, p. 111, pl. vii, fig. 3.
†*Aspidisca costata*, Bhatia, 1920, p. 262.
Aspidisca costata, Bullington, 1925, p. 272; Lepsi, 1926 *a*, p. 83, fig. 412; Schoenichen, 1927, p. 242, fig. 759.
Aspidisca (*Coccudina*) *costata*, Kahl, 1930–5, p. 645, fig. 125, *3*.

Body nearly ovate, rounded at both extremities, wider in the posterior part of the body. The right border of the peristome forms a wide plate, which extends beyond the left

Fig. 184.

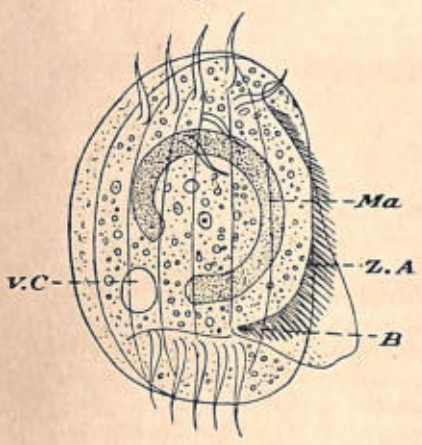


Fig. 185.

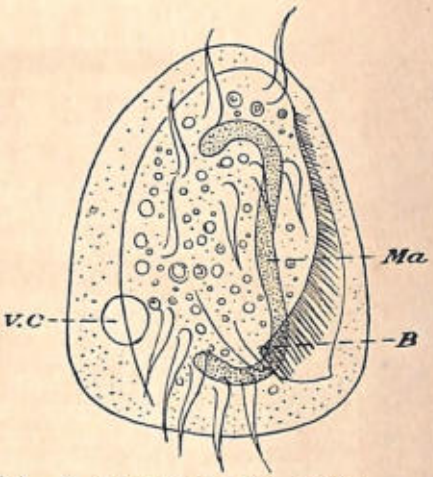


Fig. 184.—*Aspidisca costata* (Dujardin). *B*, cytostome; *Ma*, macronucleus; *V.C.* contractile vacuole; *Z.A*, adoral zone. (After Roux.)
Fig. 185.—*Aspidisca lynceus* (O. F. Müller). Lettering as in the previous figure. (After Roux.)

border of the body and is rounded posteriorly, terminating near the anal cirri. Dorsal surface convex, traversed by five or six well-marked longitudinal furrows. Fronto-ventral styles seven in number, forming two anterior, oblique, parallel rows of three each, the seventh style stationed by itself to the right and rear of the other six; anal styles five.

Dimensions.—Length 30–40 μ, width 22–31 μ.

Remarks.—The form exhibited six deep furrows on the dorsal surface, along which were also seen distinct rows of large

bristles. Specimens belonging to this species were also found in a sample of pond water sent from Lucknow by Dr. G. S. Thapar.

Habitat.—Pond water : PUNJAB, Lahore ; UNITED PROVINCES, Lucknow.

274. **Aspidisca lynceus** (O. F. Müller). (Fig. 185.)

Trichoda lynceus, O. F. Müller, 1773, p. 86; 1786, p. 225, pl. xxxii, figs. 1, 2.
Aspidisca lynceus, Ehrenberg, 1838, p. 344, pl. xxxix, fig. 1.
Coccudina crassa, Dujardin, 1841, p. 446, pl. x, fig. 2.
Aspidisca lynceus, Claparède & Lachmann, 1858–61, p. 191, pl. vii, fig. 16 ; Stein, 1859 *d*, pp. 123–4, pl. iii, figs. 4–10 ; Kent, 1880–2, p. 793 ; Bütschli, 1887–9, pl. lxxii, fig. 5 *c* ; Roux, 1901, p. 110, pl. vii, fig. 2.
†*Aspidisca lynceus*, Bhatia, 1920, p. 263.
Aspidisca lynceus, Lepsi, 1926 *a*, p. 83, fig. 411 ; Schoenichen, 1927, p. 242, pl. xiii, fig. 19 ; Reichenow, 1929, p. 1207, fig. 1188, D ; Kudo, 1931, p. 391, fig. 168 *a* ; Kahl, 1930–5, p. 644, fig. 125, *6*.

Body ovate, widest and somewhat truncate posteriorly ; the marginal border of the carapace entirely even, the left margin less strongly convex than the right. The right border of the peristome does not extend beyond the left margin of the body, but is rather pointed posteriorly. Dorsal surface smooth or marked longitudinally with three feeble furrows. Ventral surface bearing seven fronto-ventral and five anal styles.

Dimensions.—Length 30–50 μ, maximum width 25–32 μ.

Fresh water or salt water.

Remarks.—As observed at Lahore, the animal would swim round and round, now from left to right, now from right to left, sometimes stopping and jumping or creeping forward. The body was rigid and constant in form, the anterior end narrower and with a cleft under its overlap. The peristomial cleft was very small, arising from the left margin of the body, and with a very short zone of adoral cirri. The dorsal surface was smooth, and not furrowed or provided with a backwardly pointing stalk. Five distinct anal styles were present. There were seven other styles situated on the ventral surface of the body, four on the central part and three near the anterior end projecting beyond the anterior extremity. The contractile vacuole was situated on the right side a little in advance of the anal styles. The nucleus was horseshoe-shaped. The specimens were small and measured only 24 μ by 21 μ.

Habitat.—Fresh water : PUNJAB, Lahore.

Genus **ASPIDISCOPSIS** Ghosh, 1921.

Aspidiscopsis, Ghosh, 1921 *b*, p. 249.

Body broadly ovate, narrow and rounded anteriorly and broadly subtruncate behind. Dorsal surface convex, with six or seven longitudinal ribs. Right margin of the body evenly convex, left margin with a shallow notch just behind the anterior end. Peristome obliquely crescentic, occupying the postero-lateral portion of ventral surface, with membranelles. Frontal cirri four, ventral cirri five, anal cirri five. Contractile vacuole posterior. Macronucleus band-shaped, curved like a bow, and placed to the left of the median line. Movements brisk.

275. **Aspidiscopsis bengalensis** Ghosh. (Fig. 186.)

†*Aspidiscopsis bengalensis*, Ghosh, 1921 *b*, pp. 249–250, fig. 2.
Aspidisca (*Aspidiscopsis*) *bengalensis*, Kahl, 1930–5, p. 644, fig. 125, *26*.

Body broadly ovate, narrow and tapering to a rounded end in front, broadly and obliquely subtruncate behind.

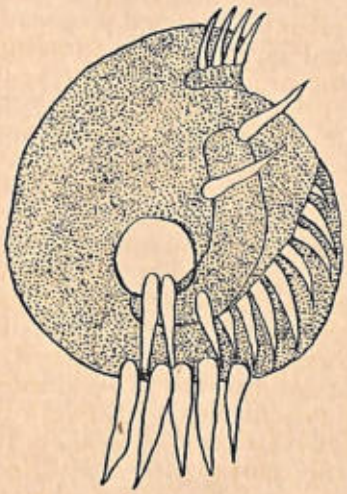


Fig. 186.—*Aspidiscopsis bengalensis* Ghosh. (After Ghosh.)

Dorsal surface convex, with six or seven longitudinal ribs. Right margin evenly convex, left margin with a shallow notch just behind the anterior end, but uniformly convex behind the notch ; notch produced into a groove on the ventral aspect. Peristome obliquely crescentic, occupying the postero-lateral

portion of the ventral surface, from the left margin to halfway across the posterior portion of the body, provided with about eight membranelles. Frontal cirri four, just in front of the notch. Ventral cirri five, one behind the notch, another further behind and more median, the next two stout and lying side by side, and the fifth one behind and to the left of these. Anal cirri five, four on the right are long, stout, and placed side by side, the fifth one somewhat separated, smallest, and on the left. Contractile vacuole posterior. Macronucleus band-like, curved like a bow, and placed obliquely to the left of the median line.

Dimensions.—Length 21·4 μ, breadth 16 μ.

Habitat.—Pond water : BENGAL, Calcutta.

III. Order PERITRICHA Stein.

The majority of the PERITRICHA are typically bell-shaped, attached forms with or without prolongations of the posterior (aboral) end in the form of a stalk. The stalk may or may not contain a myoneme thread, and is consequently either highly contractile or rigid. Generally there are no cilia on the body. The anterior (oral) end of the body forms the peristomial field and bears a projecting peristomial disc which carries the adoral zone of cilia. This consists of two parallel ciliary girdles which run round spirally to the left (contra-clockwise) and are continued down into the vestibule. The outer girdle consists of a single row of cilia fused to form the outer peristomial membrane which projects out radially over the peristomial border, forming a kind of circular shelf. The inner girdle consists of two rows of cilia, which are neither completely free nor completely fused to form membranes. They are fused proximally, but are frayed out into separate cilia at the tips. They are obliquely placed and produce by their movement a whirlpool, bringing particles of food, which is directed towards the vestibule by the outer membrane. Both the girdles run spirally to the bottom of the vestibule. Where the outer membrane descends into the vestibule its base parts company with the bases of the inner membranes and follows the outer wall of the vestibule in its descent into the interior of the cell. This descending portion of the outer membrane is composed of much stronger cilia, which are fused into a typical, definite undulating membrane. The peristomial groove runs between the margin of the bell or the peristomial border and the margin of the ciliary disc, and is continued down as a deep funnel-shaped vestibule, at the bottom of which is situated the cytostome, followed by a delicate, non-ciliated cytopharynx which remains collapsed except when a food-particle passes down it. A single contractile vacuole is situated to one side of the vestibule and communicates with a reservoir which opens into the vestibule. Anus is situated close to the cytostome and also opens into the vestibule (fig. 187). Macronucleus is usually horseshoe-shaped or band-shaped. Micronucleus is minute, situated close to the macronucleus.

Binary fission is apparently longitudinal, but this is due to the special modification of the body, the morphological dorsal and ventral surfaces being represented by the oral and aboral

ends. Conjugation is anisogamous, dimorphic conjugants are formed, and the fusion is complete and permanent.

The majority of the PERITRICHA are sedentary throughout the greater part of their existence. In the primitive forms (*Scyphidia*) the attachment is made by the aboral end, which acts like a sucker. In other cases the body is provided with a

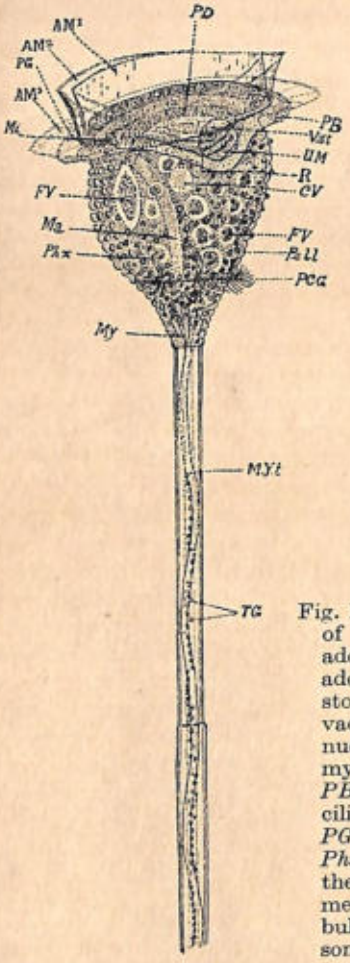


Fig. 187.—Diagram showing the structure of a typical Vorticellid. AM^1, inner adoral row of cilia; AM^2, middle adoral row of cilia; AM^3, outer peristomial membrane; *CV*, contractile vacuole; *FV*, food-vacuole; *Ma*, macronucleus; *Mi*, micronucleus; *My*, myoneme; *My.t*, myoneme thread; *PB*, peristomial border; *PCG*, posterior ciliary girdle; *PD*, peristomial disc; *PG*, peristomial groove; *Pell*, pellicle; *Phx*, cytopharynx; *R*, reservoir; *TG*, thecoplasmic granules; *Um*, undulating membrane in the vestibule; *Vst*, vestibule. (After Noland & Finley: lettering somewhat altered.)

stalk which is rigid (*Epistylis*) or spirally contractile (*Vorticella, Carchesium*). Many of these stalked forms form large branching colonies. Even in the stalked forms the individual may, after developing a posterior girdle of cilia, detach itself from the stalk and swim away as a solitary individual, only to settle again somewhere and develop a new stalk. Apart from this posterior girdle the body cilia are, as a rule, absent

in Vorticellidæ, but may be present in Urceolidæ. Some genera (*Cothurnia*, *Vaginicola*) secrete a tube which is attached to some animal or plant, or a colony of stalked individuals may secrete a common gelatinous covering (*Ophrydium*).

Kahl (1933) has classified the order into two suborders, as follows :—

1 (2). Capable of moving from place to place ; with a posterior ciliary girdle; usually ectocommensal on Metazoa ..... Suborder **Mobilia**, [p. 395.
2 (1). Sessile in the fully developed condition.. Suborder **Sessilia**, [p. 395.

1. Suborder *MOBILIA* Kahl, 1933.

The suborder includes a single family, Urceolariidæ Stein, which is not known from India so far.

2. Suborder *SESSILIA* Kahl, 1933.

The suborder is divided into two tribes :—

1 (2). Without test ..... Tribe **Aloricata**, p. 395.
2 (1). With test ..... Tribe **Loricata**, p. 418.

1. Tribe ALORICATA Kahl, 1933.

Usually bell-shaped, with or without a stalk, which may be spirally contractile or rigid. Ordinarily no cilia on the body. Posterior cilia, when developed, temporary. Oral end of the body shows the peristomial field and bears a projecting disc which carries the adoral zone of cilia. The adoral zone consists of two or three parallel ciliary girdles running spirally to the left (contra-clockwise) and continued down into the vestibule. Peristome is surrounded by a raised, contractile peristomial border, which closes over the disc and the cilia when the organism retracts. Peristomial groove is continued down as the vestibule, at the bottom of which is the cytostome, followed by a short cytopharynx. Contractile vacuole and anus both open into the vestibule. Macronucleus horseshoe-shaped or band-shaped. Micronucleus single. Binary fission apparently longitudinal. Conjugation anisogamous.

It is very interesting to watch a living Vorticellid. It not only springs forwards and backwards by the expansion and contraction of the stalk, but has also the power of opening out or contracting its anterior end. When fully expanded the peristomial border is everted, like the rim of a bell, the disc

is protruded, and the whorls of cilia are seen working beautifully. In some species the disc is protruded far above the peristomial border, in others it scarcely reaches on a level with it. When the organism contracts the disc is withdrawn, the cilia turned in, and it is covered over by the peristomial border folding in, the body thus assuming a pyriform shape.

Identification Table of Families.

1 (2).	Stalkless; with a cup-like organ of attachment at the posterior end (generally attached on bodies of Metazoa)	[p. 396. **Scyphidiidæ** Kahl,
2 (1).	With stalk in the adult state	3. [p. 398.
3 (4).	Stalk with a contractile thread.....	**Vorticellidæ** Stein,
4 (3).	Stalk without a contractile thread	**Epistylidæ** Kahl, p. 413.

1. Family SCYPHIDIIDÆ Kahl, 1933.

The family includes *Vorticella*-like organisms which do not possess a stalk even in the adult condition. The organisms are attached to the body of various animals by a cup-like disc at the posterior end.

Genus **SCYPHIDIA** (Dujardin, 1841) Lachmann, 1856.

Scyphidia, Dujardin, 1841, p. 538; Lachmann, 1856, p. 348 Claparède & Lachmann, 1858–61, p. 115; Fromentel, 1874, p. 144; Kent, 1880–2, p. 658; Bütschli, 1887–9, p. 1761; Roux, 1901, p. 114; Lepsi, 1926*a*, p. 88; Schoenichen, 1927, p. 246; Reichenow, 1929, p. 1209; Calkins, 1933, p. 522; Kahl, 1933, p. 124; 1930–5, p. 669.

Animalcules solitary, medium to large sized, form variable, cylindrical or urn-shaped, highly contractile, adherent posteriorly to foreign bodies by means of a specially developed acetabuliform organ of attachment. Surface of the integument often transversely or obliquely furrowed. Body without cilia. Oral end with a ciliary disc provided with two ciliary girdles, running in a contra-clockwise spiral. Margin of the peristome padded, rarely turned down. Peristomial groove continued as a vestibule, with the cytostome at its end. Position of contractile vacuole variable. Macronucleus of variable form.

Key to Indian Species.

1.	Body elongate, transversely wrinkled. Macronucleus spherical	[p. 397. *S. indica*, sp. n.,
2.	Body cylindrical, slightly wider posteriorly, smooth. Macronucleus a spiral band	[Ghosh, p. 398. *S. purniensis*,

276. **Scyphidia indica,** sp. nov. (Fig. 188.)

†*Scyphidia fromentellii* (?), Bhatia, 1920, p. 263.

Body elongate, urn-shaped, anteriorly truncate, the posterior extremity contracted, stalk-like, not longitudinally plicate, remainder of the body transversely wrinkled. Peristomial margin thickened and eversible. Contractile vacuole single. Macronucleus spherical.

Dimensions.—Length 52 μ.

Fresh water, on *Daphnia*.

Remarks.—The specimens were found in Lahore, and were originally with some hesitation referred to *S. fromentellii* Kent. The body was small, measuring 52 μ by 25 μ, form elongated, posterior end thinner and provided with a rounded sucking-cup. In a specimen detached from the host this posterior end was seen to contract independently, as in sucking. The body surface was transversely wrinkled and the posterior extremity was not longitudinally plicate. The peristomial margin was thickened and eversible. The contractile vacuole



Fig. 188.—*Scyphidia indica*, sp. nov. *C.V.*, contractile vacuole; *N*, nucleus.

was single, placed anteriorly in front of the middle of the body. Kent records having received "specimens of the Entomostracan *Daphnia pulex* extensively infested with a minute sessile Vorticellidan agreeing in all respects, except for the presence of a single and normally located contractile vesicle, with the species now under discussion as figured and described by De Fromentel." The form that came under my observation differs from the type of *S. fromentellii*, as recorded by Kent, not only in possessing a single normally located contractile vacuole, but also in the body surface being transversely wrinkled and the posterior extremity of the body not being longitudinally plicate. In its shape and in being transversely wrinkled it agrees with *S. amœbea* Grenfell, but differs from it in the absence of an irregular shaped plate at the posterior extremity and in the form of the macronucleus. I consider that it is a hitherto undescribed species.

Habitat.—Pond water: PUNJAB, Lahore.

277. **Scyphidia purniensis** Ghosh.

†*Scyphidia purniensis*, Ghosh, 1923, p. 74.

Body cylindrical, slightly wider posteriorly; spheroidal when contracted. Surface smooth. Peristomial margin thin and slightly everted, but not revolute; peristomial groove shallow; ciliary disc not elevate; vestibule prolonged backwards as a narrow straight canal beyond the middle of the body-length. Contractile vacuole beneath the peristome at the side of the vestibule. Macronucleus a spiral band of more than two turns.

Remarks.—Neither a drawing nor dimensions are given by the author of the species. It is said to agree with *S. patella* Cuénot in having the body surface smooth, but to differ from that species in its wider posterior end and from all known species in its spiral band-like macronucleus.

Habitat.—Pond water: Bengal, Purnea.

2. Family VORTICELLIDÆ Stein, 1859.

Body without test. Posterior end of the body provided with a contractile stalk, which may be simple or branching.

Key to Genera.

1 (2).	Stalk not branching	Vorticella Linn., 3. [emend. Ehrbg., [p. 398.
2 (1).	Stalk branching	
3 (4).	Contractile threads in the lateral branches not united with the thread in the main stalk	Carchesium Ehrbg., [p. 409.
4 (3).	Contractile threads from the lateral branches continuous with the thread in the main stalk	Zoothamnium * St.

Genus **VORTICELLA** (Linnæus, 1767) emend. Ehrenberg, 1838.

Vorticella, Linnæus, 1767, p. 1317; O. F. Müller, 1773, p. 96; Ehrenberg, 1838, p. 269; Dujardin, 1841, p. 546; Claparède & Lachmann, 1858–61, p. 94; Stein, 1867, p. 168; Greef, 1870, pp. 353–84; 1871, pp. 185–221; Fromentel, 1874, p. 141; Kent, 1880–2, p. 667; Bütschli, 1887–9, p. 1763; Roux, 1901, p. 116; Penard, 1922, p. 251; Lepsi, 1926*a*, p. 87; Wenyon, 1926, p. 1223; Schoenichen, 1927, p. 248; Sandon, 1927, p. 200; Reichenow, 1929, p. 1210; Noland & Finley, 1931, pp. 81–123, Kudo, 1931, p. 394; Calkins, 1933, p. 522; Kahl, 1933, p. 125; 1930–5, p. 712.

Animalcules small or medium-sized, ovate, sphæroidal, pyriform or campanulate, attached posteriorly by a simple, undivided, more or less elongate and thread-like pedicle

which encloses an elastic, spirally disposed, contractile axial filament; on contraction the pedicle suddenly assumes a much shortened and usually corkscrew-like contour. Adoral zone consists of two or three parallel ciliary girdles running spirally to the left (contra-clockwise), the right limb of which descends into the vestibule and the left limb is obliquely elevated and encircles the ciliary disc. The entire adoral zone is contained within and bounded by a more or less distinctly raised annular peristomial border, between which and the elevated ciliary disc, on the ventral side, the widely excavated oral fossa or vestibule is situated; the vestibule is continued further into a cleft-like cytopharynx. Anal aperture opening into the vestibular fossa. Contractile vacuole single, spherical, usually opening into a reservoir, which in turn opens into the vestibule. Macronucleus almost always elongated, band-shaped, with a micronucleus lying close to it.

The animals possess, in all cases, separate spirally contractile stalks, with which they attach themselves to other objects. Some species are, however, colonial, occurring in little "families," fixed and appearing as white little clouds amongst the roots of *Lemna*, the feathery leaves of *Ceratophyllum* and other plants, on the tentacles and legs of cyclopods, beetles, water-lice, crabs and other animals, as also on the walls of the vessels containing pond water. Often the whole family suddenly contracts together, all zooids acting simultaneously, and then again extend themselves slowly and majestically. Inhabiting salt and fresh water, many species only in clear water, others only in water with decaying matter.

Key to Indian Species.

1 (12).	Cuticular surface smooth	2.
2 (5).	Body conical or elongate	3.
3 (4).	Body elongate, cylindrical, about thrice as long as broad. Length 15 μ (?). Pedicle as long as body..	[p. 407. *V. subcylindrica* Ghosh,
4 (3).	Body somewhat vase-shaped, one and a half times as long as broad, rounded in the middle, with constrictions above and below the middle. Body-length 15 μ (?). Pedicle twice as long as body	[p. 409. *V. subsinuata* Ghosh,
5 (2).	Body not conical or elongate	6.
6 (11).	Body more or less campanulate	7.
7 (10).	Body broadly campanulate	8.
8 (9).	Peristomial margin broad, padded. Sides of the body curved. Body-length 50–157 μ. Pedicle thick ..	[p. 400. *V. campanula* Ehrnbg.,
9 (8).	Peristomial margin broad, not padded. Sides of the body almost straight. Body-length up to 120 μ. Pedicle slender	[p. 402. *V. citrina* O. F. Müll.,

10 (7). Body conical-campanulate, widest at the anterior border and tapering thence in a straight line to its point of junction with the pedicle. Peristomial border thin. Body-length up to 90 μ. Pedicle slender ..... [p. 406.
V. patellina Ehrnbg.,

11 (6). Body spheroidal, posterior end tapering abruptly to a point. Peristomial margin half the greatest diameter of the body. Body-length 25 μ. Pedicle four to five times the body-length ..... [p. 404.
V. globosa Ghosh,

12 (1). Cuticular surface transversely striated. 13.

13. Body conical or elongate. 14.

14. Body somewhat vase-shaped, broadest in the middle, and narrowing anteriorly and posteriorly. 15.

15 (16). Peristome not everted, about half the maximum width of the body. Body-length up to 100 μ. Pedicle very slender ..... [p. 405.
V. microstoma Ehrnbg.,

16 (15). Peristomial margin widely everted and slightly less than the maximum width of the body. Body-length 76 μ. Pedicle stout and less than twice the body-length ..... [Ghosh, p. 407.
V. submicrostoma

17. Body conical-campanulate, widest anteriorly ..... 18.

18 (19). Body scarcely twice as long as broad. Peristomial margin dilated, slightly revolute. Body-length up to 120 μ. Pedicle thick, three to six times the body-length ..... [p. 403.
V. convallaria Linn.,

19 (18). Body curved, one and a half times as long as broad. Peristomial margin placed obliquely and slightly everted. Body-length 15 μ (?). Pedicle slender, four to fivet imes the body-length ..... [p. 408.
V. subprocubens Ghosh

278. **Vorticella campanula** Ehrenberg. (Fig. 189.)

Vorticella campanula, Ehrenberg, 1831, p. 92; 1835, p. 165; 1838, p. 273, pl. xxv, fig. iv.
Vorticella lunaris, Dujardin, 1841, p. 554, pl. xiv, fig. 12.
Vorticella campanula, Claparède & Lachmann, 1858–61, p. 97; Fromentel, 1874, p. 232, pl. v, fig. 2; Kent, 1880–2, p. 678, pl. xxxiv, fig. 36, pl. xlix, fig. 12; Roux, 1901, pp. 116–17, pl. vii, fig. 10.
†*Vorticella campanula*, Bhatia, 1920, p. 263.
Vorticella campanula, Bullington, 1925, p. 269; Lepsi, 1926 *a*, p. 91, fig. 512; Schoenichen, 1927, p. 250, fig. 771, pl. xiii, fig. 266; Sandon, 1927, p. 201; Noland & Finley, 1931, pp. 105–6, figs. 18–25; Kudo, 1931, p. 394, fig. 169 *e*; Kahl, 1930–5, p. 722, fig. 125, *21*, *21 a*.

Body usually broadly campanulate or hemispherical, but soft and very variable in contour; when contracted subspheroidal, with a puckered anterior margin. The frontal

margin widely dilated, often exceeding in width the length of the body; the ciliary wreath apparently forming two or more spiral convolutions. Pedicle thick, varying from three or four to six or seven times the length of the body. Cuticular surface smooth, highly elastic; parenchyma densely granular centrally. Macronucleus worm-like, bent.

Dimensions.—Body-length 50–157 μ.

Pond water. Social.

Remarks.—Found at Lahore in pond water on leaves of *Lemna*. Social, a body-length of 63 μ to 73 μ being common. Noland and Finley give 68 μ as the mode of the body-length and 50–157 μ as limits.

The body was campanulate and slightly narrowed behind the anterior end, which was not much widened out; the length of the body was one and a quarter to one and a half times the



Fig. 189.—*Vorticella campanula* Ehrbg. *B*, cytostome; *Ma*, macronucleus; *Ph*, gullet; *V.C*, contractile vacuole. (After Roux.)

maximum width. The peristome was thickened and was slightly eversible; the ciliary disc projected slightly in a condition of expansion and bore fine long, close-set cilia. The cuticular surface was smooth and the parenchyma densely granular. The stalk was four to five times the length of the body, and the thread in the stalk was uninterrupted.

Noland and Finley mention that the pellicular striæ are faint, requiring close focussing, and that small transparent spherules (about 1 μ), interpreted by Faure-Fremiet (1910) as mitochondria, are visible sometimes in the living animal in the thin peristomial border. The thecoplasmic granules in the stalk are numerous.

Habitat.—Pond water: PUNJAB, Lahore.

279. **Vorticella citrina** O. F. Müller. (Fig. 190.)

Vorticella citrina, O. F. Müller, 1773, p. 123; 1786, p. 306, pl. xliv, figs. 1–7; Ehrenberg, 1830, pp. 41, 81, pl. v, fig. B; 1831, p. 91; 1838, pp. 271–2, pl. xxv, fig. iii; Claparède & Lachmann, 1858–61, p. 96; Kent, 1880–2, pp. 678–9, pl. xxxv, fig. 29, pl. xlix, fig. 13; Roux, 1901, p. 117, pl. vii, fig. 11.

†*Vorticella citrina*, Bhatia, 1920, p. 264.

Vorticella citrina, Bullington, 1925, p. 269; Lepsi, 1926*a*, p. 91, fig. 513; Sandon, 1927, p. 201; Schoenichen, 1927, p. 250, fig. 772; Noland & Finley, 1931, p. 93; Kahl, 1933, p. 128; 1930–5, p. 717, fig. 135, *23 a, b, c*.

Body broadly campanulate, plastic and changeable in form, smooth. Peristomial border broad, crateriform, often considerably exceeding in diameter the entire length of the body, not padded. Sides of the body almost straight; posterior

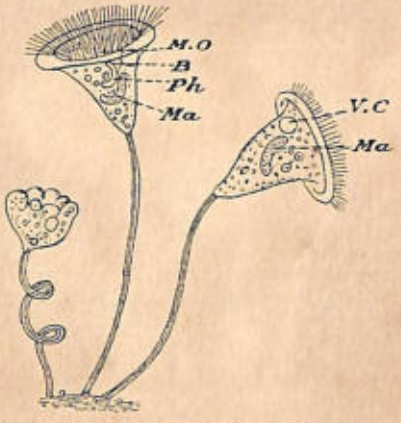


Fig. 190.—*Vorticella citrina* O. F. Müll. *B*, cytostome; *Ma*, macronucleus; *M.O*, adoral zone; *Ph*, gullet; *V.C*, contractile vacuole. (After Roux.)

end drawn out and pointed; depressed and with a puckered anterior border when contracted. Parenchyma transparent, usually pale yellow. Pedicle slender, four or five times the length of the body.

Dimensions.—Body-length up to 120 μ.

Fresh water, on various aquatic plants. Social.

Remarks.—Found very abundantly at Lahore in infusions of dry leaves and in pond water on various aquatic plants. The body was broadly campanulate, not narrowed behind the anterior end. The sides of the body were straight and the posterior end was drawn out into a cone-like process. The length of the body, including the basal cone-like projection, was 26 μ in a contracted and 50 μ in an expanded specimen.

The stalk was about three to five times the length of the body. Spherical cysts of the zooids, measuring 24 μ across, were later found in abundance in the same culture.

Noland and Finley (1931) remark as follows :—" *V. citrina* O. F. Müller, 1773, was distinguished largely on the basis of its greenish-yellow colour. Fauré-Fremiet (1904) regards it as a physiological variant of *V. convallaria*. If it is distinct its identity must be based on other grounds than color alone."

I have, however, followed Roux, Lepsi, and Schoenichen in retaining it as a distinct species. *V. citrina* differs from *V. convallaria* in the body being smooth and broadly companulate in the former and transversely striate and conical-campanulate in the latter ; the sides of the body are straight in the former and curve inwards behind the anterior end in the latter ; the peristomial border is not thickened in the former, and is padded in the latter. These characters are sufficient to show the distinctness of the two species.

Habitat.—Fresh water, on various aquatic plants : PUNJAB, Lahore.

280. **Vorticella convallaria** Linnæus. (Fig. 191.)

Vorticella convallaria, Linnæus, 1767, p. 1319 ; Ehrenberg, 1830, pp. 66, 79, pl. v A ; 1831, p. 92 ; 1838, p. 274, pl. xxvi, fig. iii ; Dujardin, 1841, p. 557 ; Claparède & Lachmann, 1858–61, p. 95.
†*Vorticella convallaria* (?), Carter, 1856*b*, p. 247, pl. vii, fig. 77.
Vorticella convallaria, Kent, 1880–2, pp. 686–7, pl. xlix, fig. 34 ; Roux, 1901, p. 119, pl. vii, fig. 19 ; Lepsi, 1926*a*, p. 90, fig. 531 ; Schoenichen, 1927, p. 249, pl. xiii, fig. 26 *c*, & fig. 764 ; Noland & Finley, 1931, pp. 94, 104–5, figs. 10–17 ; Kahl, 1930–5, p. 722, figs. 136, *34*, 138, *44*.

Body conical-campanulate, scarcely twice as long as broad, anteriorly as wide as in the middle. Peristomial border dilated, slightly revolute. Cuticular surface transversely annulate. Parenchyma clear, transparent, sometimes yellow. Contractile vacuole single. Pedicle rather thick, from three to six times the length of the body. Macronucleus long, worm-like.

Dimensions.—Body-length 110–120 μ, maximum width 61–67 μ.

In stagnant water and infusions. Social.

Remarks.—This species resembles *V. campanula* in size and general appearance, but is easily distinguishable from that species by a number of differences : (1) the animals multiply in bad-smelling infusions, which *V. campanula* does not ; (2) contracted individuals are not puckered anteriorly ; (3) animals are oftener tinted yellow ; (4) bell opening is somewhat narrower ; and (5) the reserve granules, so abundant in *V. campanula*, are here usually absent. The thecoplasmic

granules along the spasmoneme have a distribution similar to that of *V. campanula*, but occasional larger granules occurring at fairly regular intervals among the smaller ones have been noticed by Noland and Finley. The species is often found in

Fig. 191.



Fig. 192.

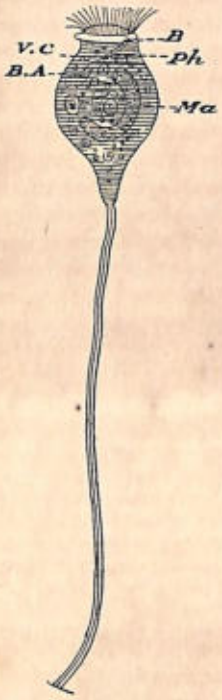


Fig. 191.—*Vorticella convallaria* Linn. *B*, peristomial groove; *B.A*, cytopharynx; *Ma*, macronucelus; *Ph*, vestibule; *V.C*, contractile vacuole. (After Roux.)

Fig. 192.—*Virticella microstoma* Ehrbg. Lettering as in previous figure. (After Roux.)

the upper layers of vegetable infusions along with *V. microstomas*, from which it can be readily distinguished by its thicker stalk and by the body not being narrowed anteriorly.

Habitat.—Fresh water: Bombay.

281. **Vorticella globosa** Ghosh. (Fig. 196.)

†*Vorticella globosa*, Ghosh, 1922 *d*, p. 8, pl. i, fig. iii.
Vorticella globosa, Kahl, 1930–5, p. 723, fig. 137, *30*.

Body spherical, with posterior end tapering abruptly to a point, spheroidal when contracted. Peristomial margin

half the greatest diameter of the body and raised vertically like a collar. Ciliary disc short, discoidal, with a slightly convex upper surface, and about half the peristome in diameter, being attached to one side of the capacious vestibule, which extends towards the aboral pole beyond the middle of the body. Surface smooth. Endoplasm granular. Contractile vacuole placed at the side of the vestibule on the side opposite to the ciliary disc. Macronucleus horseshoe-shaped and placed in the middle of the body. Pedicle four to five times the length of the body.

Dimensions.—Length of body 25 μ.

Remarks.—The length is given as 0·25 mm. in the original paper, which is probably an error for 0·025 mm.

Habitat.—Pond water : BENGAL, Calcutta.

282. **Vorticella microstoma** Ehrenberg. (Fig. 192.)

Vorticella microstoma, Ehrenberg, 1830, p. 66 ; 1831, p. 92 ; 1838, p. 272, pl. xxv, fig. iii ; Dujardin, 1841, p. 560 ; Claparède & Lachmann, 1858–61, p. 97.

†*Vorticella microstoma*, Carter, 1856*b*, pp. 126, 247, pl. vii, figs. 76, 78.

Vorticella microstoma, Fromentel, 1874, p. 236, pl. vii, figs. 18, 19 ; Kent, 1880–2, pp. 683–4, pl. xxxv, figs. 9–24, pl. xlix, fig. 27 ; Roux, 1901, p. 119, pl. vii, fig. 18 ; Brand, 1923, pp. 61, 69, 73 ; Lepsi, 1926*a*, p. 90, fig. 524 ; Schoenichen, 1927, pp. 248–9, pl. xiii, fig. 26 *a*, & fig. 763.

†*Vorticella microstoma*, Sandon, 1927, pp. 200–1, pl. vi, fig. 11 ; Madhava Rao, 1928, p. 114, pl. iv, fig. 1 ; Chaudhuri, 1929, p. 60, pl. iii, fig. 11.

Vorticella microstoma, Noland & Finley, 1931, pp. 98, 108, figs. 33–44 ; Kahl, 1930–5, p. 729, figs. 136, *11* ; 138, *40*, *40 a*.

Body somewhat vase-shaped, broadest in middle and narrowing in the region of the peristome, which is not everted and is about half the maximum width of the body. Cuticle with fine transverse striations, specially prominent when body is contracted. Colour whitish or greyish. Contractile vacuole single. Macronucleus long, slender, or somewhat shortened and horseshoe-shaped. Pedicle very slender, two or three to five or six times the length of the body.

Dimensions.—Body-length 60–100 μ, maximum width 32–54 μ.

Common in soils and sour infusions.

Remarks.—Thecoplasmic granules are not visible along the spasmoneme in the living animals. "The species shows a great tolerance to bacterial action in infusions. In infusions it will sometimes disappear for a few days when bacterial action is at its height, to return again after the decomposition has subsided somewhat" (Noland & Finley). Brand (1923) has studied its encystment.

Habitat.—Fresh water: Bombay; soils from KASHMIR, Srinagar; N.W.F. PROVINCE, Peshawar; PUNJAB, Ghora Gali; CENTRAL INDIA, Indore; MYSORE; MADRAS, Coimbatore.

283. **Vorticella patellina** Ehrenberg. (Fig. 193.)

Vorticella patellina (?), O. F. Müller, 1776, p. 281; 1786, p. 312.
Carchesium fasciculatum, Ehrenberg, 1830, p. 41; 1831, p. 93; 1835, p. 165.
Vorticella patellina, Lamarck, 1836, p. 58; Ehrenberg, 1838, p. 273, pl. xxvi, fig. ii.
†*Vorticella patellina*, Grant, 1842.
Vorticella patellina, Pritchard, 1861, p. 587, pl. xxix, fig. 1; Fromentel, 1874, p. 230, pl. v, figs. 8–9.
Vorticella cratera, Kent, 1880–2, p. 679, pl. xxxv, fig. 26, & pl. xlix, fig. 15.
Vorticella patellina, Lepsi, 1926 *a*, p. 91, fig. 515; Schoenichen, 1927, p. 249, pl. xiii, fig. 26 *d*; Kahl, 1933, p. 128, fig. 22, *8*, *8 a*; 1930–5, p. 733, fig. 135, *32*, *33*.

Body conical-campanulate in extension, widest at the anterior border, and tapering thence in a straight line to its

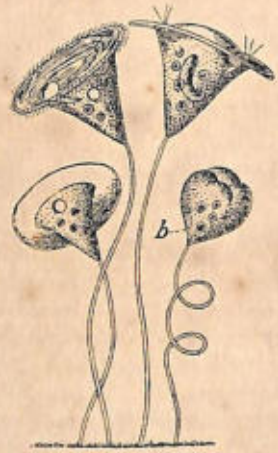


Fig. 193.—*Vorticella patellina* Ehrbg. *b*, contracted individual. (After Ehrenberg.)

point of junction with the pedicle; when contracted pyriform, with a puckered anterior margin; the diameter of the expanded frontal border equalling or but slightly less than the total length of the body. Peristome border thin; ciliary disc but slightly elevated. Cuticular surface smooth, parenchyma transparent. Pedicle slender, three or four times the length of the body, contracting spirally. Social.

Dimensions.—Body-length up to 90 μ.

Remarks.—*Vorticella patellina*, as originally named and figured by O. F. Müller, was a marine form. Ehrenberg and subsequent writers described a freshwater form as the same species. Kent considered the freshwater species to be distinct, and named it *Vorticella cratera*. Noland and Finley also consider the marine species described by O. F. Müller as quite different from *V. patellina* of Ehrenberg and Fromentel. They, however, think that *V. cratera* Kent is not identical with *V. patellina* Ehrbg.

Habitat.—Pond water : BENGAL, Calcutta.

284. **Vorticella submicrostoma** Ghosh. (Fig. 194.)

†*Vorticella submicrostoma*, Ghosh, 1922 *d*, p. 8, pl. i, fig. i.
Vorticella submicrostoma, Kahl, 1930–5, p. 727, fig. 137, *29*.

Body subpyriform, less than twice as long as broad, spherical when contracted ; posterior end tapering and conical ; body constricted behind the peristome. Surface striate transversely. Peristomial margin widely everted and slightly less than the greatest body diameter in the middle. Ciliary disc moderately and obliquely elevated. Vestibule small. Cilia long and stout. Contractile vacuole large and placed at the base of the ciliary disc. Macronucleus horseshoe-shaped, placed in the middle of the body. Pedicle stout and less than twice the body-length, sometimes holding the bell slightly inclined.

Dimensions.—Body-length 76 μ.

Remarks.—The species, as above described, is not sufficiently distinct from *V. microstoma* Ehrbg. The length is given as 0·76 mm. in the original paper, which is probably an error for 0·076 mm. Kahl regards it as only a larger variety of *V. octava* Stokes.

Habitat.—Pond water : BENGAL, Calcutta.

285. **Vorticella subcylindrica** Ghosh. (Fig. 195.)

†*Vorticella subcylindrica*, Ghosh, 1922 *d*, p. 8, pl. i, fig. ii.
Vorticella subcylindrica, Kahl, 1930–5, p. 716, fig. 137, *5*.

Body elongated, cylindrical, about thrice as long as broad and suddenly tapering to a point at the aboral end. Peristomial margin slightly everted and raised. Ciliary disc slightly elevated. Vestibule wide and extending to the middle of the body. Contractile vacuole near the lower end of the vestibule. Macronucleus band-like and placed in the middle of the body. Surface smooth. Pedicle narrow and about as long as the body.

Dimensions.—Body-length, as given by Ghosh, 150 μ (probably an error for 15 μ).

Habitat.—Pond water : BENGAL, Calcutta.

Fig. 194.



Fig. 196.



Fig. 195.



Fig. 197.

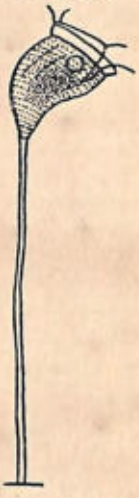


Fig. 198.



Fig. 194.—*Vorticella submicrostoma* Ghosh. (After Ghosh.)
Fig. 195.—*Vorticella subcylindrica* Ghosh. (After Ghosh.)
Fig. 196.—*Vorticella globosa* Ghosh. (After Ghosh.)
Fig. 197.—*Vorticella subprocubens* Ghosh. (After Ghosh.)
Fig. 198.—*Vorticella subsinuata* Ghosh. (After Ghosh.)

286. **Vorticella subprocubens** Ghosh. (Fig. 197.)

†*Vorticella subprocubens*, Ghosh, 1922 *d*, p. 9, pl. i, fig. iv.
Vorticella subprocumbens, Kahl, 1930–5, p. 727, fig. 137, *23*.

Body curved, obliquely conical-campanulate, widest anteriorly, one and a half times as long as wide. Peristomial margin placed obliquely and slightly everted. Ciliary disc

slightly elevated. Vestibule small. Surface striate transversely. Pedicle four to five times the body-length.

Dimensions.—Body-length, as given by Ghosh, 150 μ (probably an error for 15 μ).

Remarks.—Kahl regards it as a doubtful species.

Habitat.—Pond water : BENGAL, Calcutta.

287. **Vorticella subsinuata** Ghosh. (Fig. 198.)

†*Vorticella subsinuata*, Ghosh, 1922 *d*, p. 9, pl. i, fig. v.
Vorticella subsinuata, Kahl, 1930–5, p. 720, fig. 137, 7.

Body somewhat vase-shaped, widest anteriorly, one and a half times as long as broad, somewhat rounded in the middle, with constrictions above and below which separate the middle region from the peristomial margin, and a smaller rounded aboral end respectively. Surface smooth. Peristomial margin slightly everted. Ciliary disc obliquely elevated. Vestibule short and wide. Pedicle about twice the body in length.

Dimensions.—Body-length, as given by Ghosh, 150 μ (probably an error for 15 μ).

Habitat.—Pond water : BENGAL, Calcutta.

288. **Vorticella** sp.

†*Vorticella* sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

289. **Vorticella** sp.

†*Vorticella* sp., Carter, 1856 *b*, pp. 235–7, pl. vii, fig. 75.

Habitat.—Fresh water : BOMBAY.

290. **Vorticella** sp.

†*Vorticella* sp., Chaudhuri, 1929, p. 60.

Habitat.—Soils from PUNJAB, Ghora Gali ; CENTRAL INDIA, Indore.

Genus **CARCHESIUM** Ehrenberg, 1830.

Carchesium, Ehrenberg, 1830, p. 41 ; 1831, p. 93 ; 1838, p. 278, Claparède & Lachmann, 1858–61, p. 97 ; Engelmann, 1862, p. 389 ; Stein, 1867, p. 168 ; Fromentel, 1874, p. 142 ; Kent, 1880–2, p. 690 ; Bütschli, 1887–9, p. 1764 ; Roux, 1901, p. 120 Lepsi, 1926 *a*, p. 87 ; Schoenichen, 1927, p. 251 ; Reichenow, 1929, p. 1210 ; Kudo, 1931, pp. 394–5 ; Calkins, 1933, p. 522 ; Kahl, 1933, p. 131 ; 1930–5, p. 736.

Animalcules ovate or pyriform, small to medium-sized, in shape and size resembling those of *Vorticella*, but united in social clusters and forming tree-like colonies through repeated

longitudinal fission, accompanied by a regular or irregular branching of their flexible primary pedicle; the contractile thread within the compound pedicle not continuous throughout, but interrupted at each bifurcation, so as to permit of the independent extension and contraction of the individual zooids. Colonies are sometimes more than a millimetre in height. Mostly inhabiting clear stagnant water, fixed to débris, leaves, and aquatic plants or animals.

Key to Indian Species.

1 (2). Stalk distinctly articulated; body smooth ..... *C. epistylis*, Cl. & L., [p. 410.
2 (1). Stalk not articulated; body smooth .. *C. polypinum* (Linn.), [p. 412.

291. **Carchesium epistylis** Claparède & Lachmann. (Fig. 199.)

Carchesium epistylis, Claparède & Lachmann, 1858–61, pp. 99–100, pl. i, fig. 1.
Carchesium epistylidis, Kent, 1880–2, p. 692–3, pl. xxxvi, figs. 12–14.
Carchesium epistylis, Roux, 1901, p. 121, pl. vii, fig. 22.
†*Carchesium epistylidis*, Bhatia, 1920, p. 264.
Carchesium epistylidis, Lepsi, 1926 *a*, p. 91.
Carchesium epistylis, Schoenichen, 1927, p. 253, fig. 776; Kahl, 1930–5, p. 738, fig. 139, *17*, *18*.

Body campanulate or elongate-conical, very small or small, abruptly narrowed near the point of junction with the pedicle. Peristomial border well dilated but not eversible, body not plicate when contracted. Cuticular surface smooth or feebly striated transversely. Zoodendrium branching subdichotomously, more or less distinctly articulate, such articulations usually occurring immediately beneath each bifurcation. Ciliary disc moderately elevated. Contractile vacuole single, close to the vestibule. Macronucleus band-like, curved, short, transversely disposed, with a small rounded micronucleus placed close to it.

Dimensions.—Length of the zooids up to 60 μ.

Remarks.—Numerous colonies were found on the gills, legs and tail-bristles of ephemerid larvæ in pond water at Lahore, each colony consisting of a few (two to four) individuals only. The individual zooids were separately contractile, the thread in the stalk being interrupted at each bifurcation. The main pedicle was 168 μ in length, stalks supporting individual zooids were three to four times the length of the body, smooth, and during contraction the portion near the body of the zooids was thrown into a spiral. Some stalks terminated in two zooids, the stalk just bifurcating near the tip, one portion containing the thread and the other not.

Individual zooids were very small, measuring 32 μ by 26 μ, with the anterior end slightly less wide than the middle of the body. The vestibule extended to about the middle of the body and the peristomial margin was thickened and slightly eversible. The contractile vacuole was situated about the middle of the body, and the macronucleus was only slightly

Fig. 199.

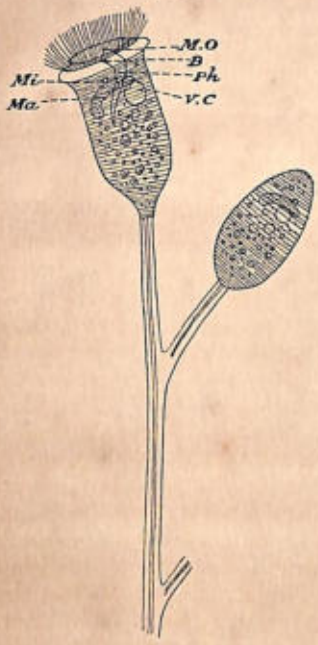


Fig. 200.

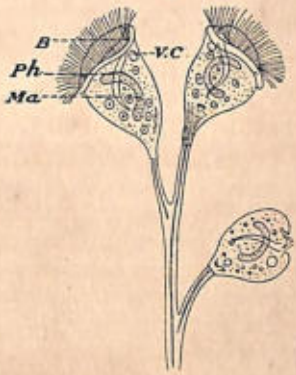


Fig. 199.—*Carchesium epistylis* Cl. & L. *B*, peristomial groove; *Ma*, macronucleus; *Mi*, micronucleus; *M.O*, adoral zone; *Ph*, vestibule; *V.C*, contractile vacuole. (After Roux.)

Fig. 200.—*Carchesium polypinum* (Linn.). Lettering as in previous figure. (After Roux.)

curved and somewhat kidney-shaped. The contracted zooids were pyriform in shape and the cuticle was smooth.

The form encountered differed, however, from the type in lacking the articulate character of the stalk.

Habitat.—Pond water, attached to ephemerid larvæ: PUNJAB, Lahore.

292. **Carchesium polypinum** (Linnæus) Ehrenberg. (Fig. 200.)

Vorticella polypina, Linnæus, 1767, p. 1317.
Carchesium polypinum, Ehrenberg, 1830, p. 41; 1831, p. 94; 1838, p. 278, pl. xxvi, fig. v.
Vorticella ramosissima, Dujardin, 1841, p. 551, pl. xiv, fig. 11.
Carchesium polypinum, Claparède & Lachmann, 1858–61, p. 98; Fromentel, 1874, p. 238, pl. vi, fig. 1; pl. iv, figs. 17–20; Kent, 1880–2, pp. 690–1, pl. xxxv, figs. 30, 31, 51; pl. xxxvi, figs. 1–8; Bütschli, 1887–9, pl. lxxiv, fig. 1, *a–b*; Roux, 1901, p. 122, pl. vii, fig. 24.
†*Carchesium polypinum*, Annandale, 1907, pp. 37–38.
Carchesium polypinum, Enriques, 1908, pp. 270–2.
Carchesium corymbosum, Penard, 1922, pp. 260–2, figs. 246, 247.
Carchesium polypinum, Bullington, 1925, p. 270; Lepsi, 1926 *a*, p. 91, fig. 540; Wenyon, 1926, fig. 528; Schoenichen, 1927, p. 253, pl. xiii, fig. 27.
†*Carchesium polypinum*, Madhava Rao, 1928, p. 114.
Carchesium polypinum, Reichenow, 1929, p. 1210, fig. 1191; Kudo, 1931, p. 395, fig. 169, *k*; Calkins, 1933, p. 38, fig. 102; Kahl, 1930–5, pp. 738–9, fig. 139, *19*, *20*.

Body campanulate, or more or less conical, broadly expanded in front. Peristomial border everted and recurved. Cuticular surface smooth. Contractile vacuole single, close to the vestibule. Macronucleus curved, forming an arc in the longitudinal plane. Compound pedicle branching, non-articulate and smooth. Colonies composed sometimes of an immense number of individuals, frequently attaining a height of 2 to 3 millimetres.

Dimensions.—Length of individuals 60–65 μ, width anteriorly 42–44 μ.

Habitat.—Brackish and freshwater ponds: BENGAL, Port Canning. Soil: MYSORE.

293. **Carchesium** sp., Simmons.

Carchesium sp., Simmons, 1891, p. 4.

Habitat.—Pond water: BENGAL, Calcutta.

3. Family EPISTYLIDÆ Kahl, 1933.

Stalked forms, with the stalk not provided with myoneme thread, and consequently rigid.

Genus **EPISTYLIS** Ehrenberg, 1830.

Epistylis, Ehrenberg, 1830, p. 41 ; 1838, p. 279 ; Dujardin, 1841, p. 539 ; Stein, 1867, pp. 135, 168 ; Claparède & Lachmann, pp. 1858–61, p. 107 ; Engelmann, 1862, p. 390 ; Fromentel, 1874, p. 143 ; Kent, 1880–2, p. 700 ; Bütschli, 1887–9, p. 1766 ; Roux, 1901, p. 123 ; Lepsi, 1926 *a*, p. 87 ; Wenyon, 1926, p. 1223 ; Schoenichen, 1927, p. 254 ; Reichenow, 1929, p. 1211 ; Kudo, 1931, p. 395 ; Calkins, 1933, p. 522 ; Kahl, 1933, p. 125 ; 1930–5, p. 680.

Animalcules campanulate, ovate or pyriform, very small to medium-sized, corresponding structurally with those of *Vorticella* ; attached in numbers to a rigid, uncontractile, more or less branching, tree-like pedicle ; the zooids usually of similar size and shape. Ciliary disc little elevated. Peristomial border thickened, rarely eversible. Anterior part expanded, though slightly. Vestibule normally developed. Contractile vacuole single. Macronucleus variable in form. Colonies sometimes of numerous individuals and reaching several millimetres in height. Inhabiting salt and fresh water, attached to aquatic plants or animals.

Key to Indian Species.

1.		Stalk not wrinkled transversely	2.
2	(7).	Stalk articulated at distant intervals.	3.
3	(5).	Stalk longitudinally striated	4.
4.		Body elongate-conical, cuticular surface smooth, length of zooids 77–126 μ	[p. 414.] *E. articulata* From.,
5	(3).	Stalk not longitudinally striated	6.
6.		Body elongate-conical, cuticular surface smooth, exhibiting transverse folds posteriorly when contracted ; length of zooids 208 μ. Colonies of many individuals	*E. galea* Ehrbg., p. 416.
7	(2).	Stalk not articulated	8.
8	(10).	Stalk with fine longitudinal striæ....	9.
9.		Body elongate-conical, cuticular surface soft and flexible, plicate, or exhibiting several annular folds posteriorly when contracted ; length of zooids 90–150 μ	[p. 417.] *E. plicatilis* Ehrbg.,
10	(8).	Stalk not longitudinally striated	11.

11. Body conical-campanulate, three times as long as broad, anterior end wider, cuticular surface smooth or finely striate transversely; length of zooids 89 μ ..... *E. anastatica* (Linn.), [p. 414.

294. **Epistylis anastatica** (Linnæus) Ehrenberg. (Fig. 204.)

Vorticella anastatica, Linnæus, 1767, p. 1317; Müller, 1773, p. 139; 1786, pl. xliv, fig. 10; pl. xlvi, fig. 5; pl. xxxviii, fig. 18; Ehrenberg, 1830, p. 41; 1831, p. 96; 1838, p. 281, pl. xxvii, fig. ii; Fromentel, 1874, p. 242, pl. ix, figs. 5, 6, 6 *a*; Kent, 1880–2, p. 701, pl. xxxviii, figs. 19–22.
†*Epistylis anastatica*, Daday, 1898, p. 9.
Epistylis anastatica, Lepsi, 1926 *a*, p. 93; Kahl, 1930–5, p. 689, fig. 131, *14–16*.

Bodies conical-campanulate, nearly three times as long as broad, attenuate posteriorly, frontal margin dilated, with a snout-like projection when contracted. Cuticular surface smooth or finely striate transversely. Ciliary disc raised. Pedicle moderately thick, entirely smooth, neither striate nor articulate, branching profusely and dichotomously; secondary branches attenuate, equal to or exceeding the length of the zooids.

Dimensions.—Length of zooids 89 μ, height of entire colony 1·6 mm.

Habitat.—Fresh water, on Copepods: CEYLON.

295. **Epistylis articulata** Fromentel. (Fig. 202.)

Epistylis articulata, Fromentel, 1874, p. 242, pl. ix, fig. 3; Kent, 1880–2, pp. 707–8, pl. xxxix, fig. 3.
†*Epistylis articulata*, Bhatia, 1920, p. 265.
Epistylis articulata, Lepsi, 1926 *a*, p. 92; Kahl, 1930–5, p. 685, fig. 131, *22*.

Bodies elongate-conical, tapering posteriorly, somewhat gibbous, nearly three times as long as broad. Cuticular surface smooth; peristome border slightly dilated; ciliary disc moderately elevated; vestibular seta conspicuously developed. Pedicle dichotomous, short, stout, and sparingly branched, striate longitudinally, articulate at one or two intervals between each bifurcation.

Dimensions.—Length of zooids 77–126 μ.

Remarks.—Found growing abundantly on all sides of a small spirally coiled gastropod shell (probably *Planorbis*), on which it formed a white fluffy mass, at Lahore. The colonies were erect and the height of a colony was 595 μ. The pedicle was dichotomous, sparingly branched, striate longitudinally, articulate at one or two intervals between each bifurcation,

in which respect this species differs from *E. plicatilis*. The body was three to four times as long as broad, individual zooids in a fully extended condition measuring from 105 to 126 μ in length and 26 to 31 μ in width. The body form was as in *E. plicatilis*, but there were two zooids at the termination of each stalk.

Kent, in a note to the description of this species, remarks :— "In shape the animalcules of this species appear to closely resemble those of *E. plicatilis*, and it is a question whether

Fig. 201.



Fig. 202.



Fig. 201.—*Epistylis plicatilis* Ehrbg. *B*, peristomial groove; *Ma*, macronucleus; *M.O*, adoral zone; *V*, vestibule; *V.A*, food-vacuole; *V.C*, contractile vacuole. (After Roux.)
Fig. 202.—*Epistylis articulata* From. (After Kent.)

the chief point of difference cited by Dr. Fromentel, that of the articulation at distant intervals of the pedicle, is sufficient to distinguish them, more especially as, in the last-named form, Stein has remarked that old specimens are similarly jointed. No mention is made as to the form assumed by the zooids when in a state of contraction, which would have been useful in the settlement of this supposed identity, nor as to whether the species forms large or small colonies."

I am able to throw some light on this disputed point, having observed the zooids in the contracted condition. The

form assumed by the contracted zooids is globular, the posterior part showing transverse furrows as in *E. plicatilis*. The size of the colony, which is considerably smaller than that of *E. plicatilis*, and the presence of two zooids perched at the termination of each stalk, along with the articulate character of the stalk, which is a constant feature in one and a rare feature in the other, serves to distinguish the two species.

Habitat.—Fresh water, growing on gastropod shells : PUNJAB, Lahore.

296. **Epistylis galea** Ehrenberg. (Fig. 203.)

Epistylis galea, Ehrenberg, 1831, p. 97 ; 1838, pp. 280–1, pl. xxvii, fig. 1.
†*Epistylis galea* (?), Carter, 1856 *b*, p. 247, pl. vii, fig. 74.
Epistylis galea, Fromentel, 1874, p. 243, pl. xi, fig. 2 ; Kent, 1880–2, p. 701, pl. xxxix, fig. 6 ; Lepsi, 1926 *a*, p. 92 ; Kahl, 1930–5, p. 691, figs. 131, *27* ; 133, *19*.

Bodies elongate-conical, about three times as long as broad, attenuate posteriorly, the frontal margin dilated. Cuticular

Fig. 203.



Fig. 204.

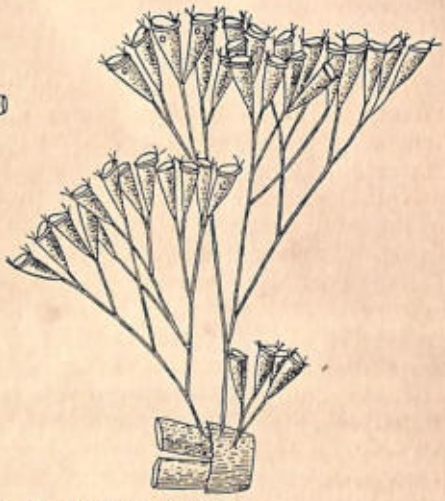


Fig. 203.—*Epistylis galea* Ehrbg. (After Kent.)
Fig. 204.—*Epistylis anastatica* (Linn.). (After Kent.)

surface smooth, exhibiting transverse folds posteriorly when contracted. Vestibular entrance prominent, projecting laterally in a spout-like manner. Zoodendrium relatively short, thick, profusely and dichotomously branched ; secondary

branches not exceeding the zooids in length, articulate at each bifurcation.

Dimensions.—Length of bodies 208 μ, height of entire colony 1 mm.

Habitat.—Fresh water on aquatic plants : BOMBAY.

297. **Epistylis plicatilis** Ehrenberg. (Fig. 201.)

Epistylis plicatilis, Ehrenberg, 1831, p. 96; 1838, pp. 281–2, pl. xxviii, fig. i; Dujardin, 1841, p. 542, pl. xvi, fig. 4; Claparède & Lachmann, 1858–61, p. 110; Fromentel, 1874, pp. 241–2, pl. viii, figs. 5–16; pl. xi, figs. 1, 5; Kent, 1880–2, pp. 701–2, pl. xxxviii, figs. 6–8, pl. xxxix, figs. 12–15; Roux, 1901, p. 123, pl. viii, fig. 3; Schroeder, 1906, pp. 173–85, pl. vi.
†*Epistylis plicatilis*, Bhatia, 1920, p. 264.
Epistylis plicatilis, Lepsi, 1926*a*, p. 92; Schoenichen, 1927, p. 257, fig. 780, pl. xiii, fig. 31; Kahl, 1930–5, p. 690, fig. 131, *17*, *18*.

Bodies elongate-conical, attenuate posteriorly, three or four times as long as broad. Cuticular surface soft and flexible, when contracted plicate or exhibiting several annular folds posteriorly. Peristomial margin dilated; the ciliary disc much elevated. Pedicle slender, finely striate longitudinally, profusely and dichotomously branched, zooids of the colony all reaching the same level. Colony of large numbers, attaining up to 3 mm. in height.

Dimensions.—Length of zooids 90–150 μ.

Remarks.—Colonies were found forming whitish tufts on shells of a snail (probably *Limnæa*) in pond water, Lahore. The colonies were long, dichotomously branching, and the individual zooids were independently contractile, there being no thread running in the stalks. The secondary branches of the stalk showed longitudinal striations at the attachment of the zooid, but were otherwise granular and somewhat feathery in appearance. The length of the expanded zooids was 84–126 μ. The peristomial margin was dilatable, and the ciliary disc capable of considerable projection in the fully extended condition of the animal. When the zooid was contracted there was an anterior projection, and the posterior half of the body showed the distinct transverse pleating which is characteristic of the species.

Habitat.—Fresh water, attached to the shells of molluscs (*Limnæa* sp.) and various water-plants : PUNJAB, Lahore.

298. **Epistylis** sp.

Epistylis sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

2. Tribe **LORICATA** Kahl, 1933.

PERITRICHA possessing a test or lorica.

Family VAGINICOLIDÆ Kent, 1881.

Forms with tests or houses, which may or may not be stalked.

Key to Indian Genera.

1 (7).	Test with or without stalk, not attached by its broad side to the substratum ..	2.
2 (5).	Test without an operculum, remaining open during contraction	3.
3 (4).	Test with stalk	[p. 418. COTHURNIA Ehrbg.,
4 (3).	Test without stalk, attached directly to a submerged object by its posterior end	[p. 419. VAGINICOLA Ehrbg.,
5 (2).	Test closed during contraction by an operculum or stopper	6.
6	Test closed by a pseudochitinous cover..	[p. 419. PYXICOLA Kent,
7 (1).	Test attached by its broad side to a submerged object, and the animal has a more or less distinct, somewhat ascending neck	[p. 420. PLATYCOLA Kent,

Genus **COTHURNIA** Ehrenberg, 1831, emend. Claparède & Lachmann, 1858.

Cothurnia Ehrenberg, 1831, p. 94; 1838, p. 297; Stein, 1849, pp. 106–7; 1867, p. 168; Claparède & Lachmann, 1858–61, p. 121; Fromentel, 1874, p. 147; Kent, 1880–2, p. 719; Bütschli, 1887–9, p. 1769; Roux, 1901, p. 132; Lepsi, 1926, p. 87; Schoenichen, 1927, p. 263; Reichenow, 1929, p. 1211; Kudo, 1931, p. 397; Calkins, 1933, p. 522; Kahl, 1933, p. 135; 1930–5, p. 769.

Animalcule surrounded by a wide pseudochitinous lorica, which is usually attached to a submerged object by a very short and very thin stalk. Animalcule can withdraw itself into the lorica. Form of the lorica variable, but remaining open during contraction. Structure of the body as in other Vorticellids. Body elongated, narrow behind, especially in a state of complete extension. Very contractile. Inhabiting salt or fresh water, attached to aquatic plants.

299. **Cothurnia** sp.

†*Cothurnia* sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

Genus **VAGINICOLA** (Lamarck, 1816), emend. Claparède & Lachmann, 1858.

Vaginicola, Lamarck, 1816, ii, p. 26.
Vaginicola, part, Ehrenberg, 1838, p. 295 ; Dujardin, 1841, p. 560 ; Stein, 1849, pp. 106–22.
Vaginicola, Claparède & Lachmann, 1858–61, p. 126 ; Fromentel, 1874, p. 149 ; Bütschli, 1887–9, p. 1770 ; Lepsi, 1926 *a*, p. 87 ; Schoenichen, 1927, p. 265 ; Reichenow, 1929, p. 1211 ; Kudo, 1931, p. 398 ; Calkins, 1933, p. 522 ; Kahl, 1933, p. 133 ; 1930–5, p. 759.

Body elongated, club-shaped and changeable in form, with the hinder end attached at the bottom of a wide, transparent lorica, which is without stalk and is attached directly to a submerged object by its posterior end. Structure of the body like that of other Vorticellids.

300. **Vaginicola** sp.

†*Vaginicola* sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

301. **Vaginicola** sp.

†*Vaginicola* sp., Mitchel, 1862, p. 60.

Remarks.—The form is described as resembling *V. crystallina* closely, differing only by its somewhat larger size and absence of green granules. The animal, when feeding, generally had the anterior half of the body at right angles to the sheath. The sheath was provided with a valve, which makes it probable that the species was not correctly identified.

Habitat.—Attached to a common water-weed in a small tank : Bangalore.

Genus **PYXICOLA** Kent, 1881.

Pyxicola, Kent, 1880–2, p. 725.
Cothurnia, part, Bütschli, 1887–9, p. 1769.
Pyxicola, Kahl, 1933, p. 139 ; 1930–5, p. 787.

Animalcules elongated, with the hinder end attached directly or by a short stalk to the bottom of a transparent lorica, which is borne on a short stalk. The anterior end of the body

bears beneath the border of the peristome a pseudo-chitinous discoidal operculum, which covers the lorica during contraction. Structure of the body like that of other Vorticellids.

Remarks.—The genus was merged in *Cothurnia* by Bütschli, but is considered as distinct by Kahl.

302. **Pyxicola carteri** (Kent). (Fig. 205.)

†*Pyxicola carteri*, Kent, 1880–2, p. 729, pl. xl, fig. 40.
Cothurnia sp., Bhatia, 1920, p. 266.
Pyxicola constricta, Kahl, 1930–5, p. 787, fig. 146, *6*, *18*.

Lorica elongate-subcylindrical, three times as long as broad, rounded and attached posteriorly by a very short or rudimentary pedicle, constricted at a little distance below the even,

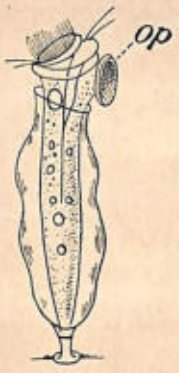


Fig. 205.—*Pyxicola carteri* (Kent). *op*, operculum. (After Kent.)

slightly oblique, anterior margin, the side-walls more or less irregularly undulate. Animalcule attenuate, projecting when extended to a considerable distance beyond the orifice of the lorica. Operculum borne on the infero-lateral surface of a conspicuous conical protuberance that projects from beneath the peristome border. Colour of lorica and operculum yellow or dark brown according to age, animalcule transparent.

Dimensions.—Unrecorded.

Habitat.—Fresh water : Bombay.

Genus **PLATYCOLA** Kent, 1881.

Platycola, Kent, 1880–2, p. 731.
Vaginicola, part, Bütschli, 1887–9, p. 1770.
Platycola, Kahl, 1933, p. 140 ; 1930–5, p. 790.

Animalcule elongated, lying inside a lorica which is attached by its lateral broad side to a submerged object. Lorica without

a stalk, often showing a distinct neck-like constriction anteriorly. Anterior part of the body protruding at right angles to the axis of the lorica. Structure of the body like that of other Vorticellids.

303. **Platycola** sp.

†*Platycola* sp., Simmons, 1891, p. 4.

Habitat.—Pond water : BENGAL, Calcutta.

IV. Order CHONOTRICHA Wallengren.

A small group of forms in which the sessile mode of life has been carried to a high degree of specialization. These ecto-parasites of Crustacea possess anteriorly a funnel-shaped peristome, in the bottom of which parallel ciliary rows run in a clock-wise direction (unlike the PERITRICHA) to the mouth. Other body cilia absent. Reproduction by budding. The bud detaches itself as an irregularly shaped swimming organism which shows no relationship with the PERITRICHA, a group with which these forms were previously united. The swimming bud attaches itself to the host and develops into the adult.

Identification Table of Families.

1. Peristomial area with the adoral zone of membranelles is spirally rolled. Individuals sessile, with or without a stalk	**Spirochonidæ** * Stein.
2. Peristomial area formed by two projecting lips	**Chilodochonidæ** * Poche.

Up to the present time no animals belonging to either of the families in the order have been discovered in India.

Class II. SUCTORIA Bütschli.

(*Syn.* TENTACULIFERA or ACINETARIA.)

The members of this class are distinguished from the CILIATA by the cilia being present only in the young stages, which are free-swimming embryos budded off from the adult. The adult organisms are sedentary, do not bear any cilia, but develop suctorial tentacles, by means of which they imbibe nourishment from the objects or organisms to which they adhere. There is no cytostome. One or more contractile vacuoles are usually present. The nuclear apparatus resembles that of the EUCILIATA, as both macronuclei and micronuclei are present. The macronucleus exhibits a great variety of form. In the colonial form *Dendrosoma* it is branched in the same manner as the colony and extends continuously throughout it.

The form of the body varies greatly, being typically vase-like, with or without a stalk or peduncle. In sessile forms the body is attached by a broad base to the substratum. The organisms are attached to algæ, the bodies of small Crustacea, aquatic larvæ, or other objects. A few are unattached, and are parasitic on free-living or parasitic ciliates. The body is often protected by a secreted theca, continuous with the stalk in pedunculate forms.

The tentacles are stiff processes, the ectoplasm forming a tube enclosing a canal containing fluid and the apex terminating in a sucker-like knob. These sucking tentacles are always present in the adult organism. In addition, in *Ephelota* there are prehensile tentacles, which end in a point.

Reproduction may be by binary fission, but usually is by budding. Budding may be external, one or more buds being formed on the surface of the organism, or internal, in which case the buds are formed in a deep depression of the surface of the body, called a brood-pouch (fig. 206). These buds develop cilia, and the ciliated embryos move about within the sac, and finally come out through a pore and swim away. After swimming

about for some time an embryo becomes attached to a suitable object, loses its cilia, develops tentacles, and grows into the adult pedunculate form.

Details of conjugation are known in a few forms. As in the CILIATA, when two organisms associate the macronuclei degenerate and the micronuclei divide a number of times. Exchange and union of micronuclei takes place, and the organisms then separate. Macronuclei and micronuclei are reformed from the products of division of the combination nucleus.

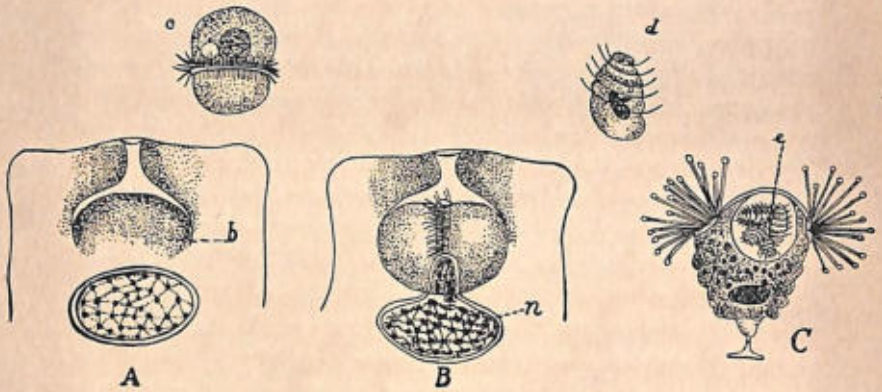


Fig. 206.—Endogenous budding in Suctoria. A, B, two stages in the formation of a bud (*b* and *c*) of *Tokophrya quadripartita*; C, *Acineta tuberosa* with endogenous buds (*e* and *d*). (From Calkins, after Bütschli.)

Collin (1912), in his monograph on the group, has divided the class into eight families, of which Hypcomidæ Bütschli has been transferred to the HYMENOSTOMATA by Reichenow. Of the remaining seven families representatives of only two are known from India so far.

Identification Table of Families.

1	(2).	Prehensile tentacles in addition to suctorial tentacles	**Ephelotidæ** * Sand.
2	(1).	Without prehensile tentacles; suctorial tentacles alone present	3.
3	(8).	Body not bilaterally symmetrical; irregular or branched	4.
4	(5).	Without "proboscis" or special "arms"	[Bütschli. **Dendrosomidæ** *

5 (4).	With retractile " proboscis " or special " arms "	6. [Stein.
6 (7).	With retractile " proboscis "	**Ophryodendridæ** *
7 (6).	With special, tentacle-bearing " arms."	**Dendrocometidæ** *
8 (3).	Body monaxial, more or less bilateral.	9. [Stein.
9 (10).	Reproduction by external budding ..	**Podophryidæ** Bütschli,
10 (9).	Reproduction by internal budding ..	11. [p. 429.
11 (12).	Stalk short, thick. Pellicle coriaceous and tough. Without test or lorica. Tentacles thick-set, knobbed	**Discophryidæ** * Collin.
12 (11).	Pellicle delicate. Naked or enclosed in tests. Tentacles thin, knobbed .	[p. 425. **Acinetidæ** Bütschli,

1. Family ACINETIDÆ Bütschli, 1889.

Forms generally showing a bilateral symmetry. Only suctorial tentacles are present. Individuals are naked or in tests, and with or without a stalk. Reproduction by division or by endogenous budding. Many are ectoparasitic on the gills of fresh- or salt-water animals ; some are endoparasites and are devoid of stalks and tentacles.

Key to Indian Genera.

1.	With tentacles, not parasitic inside Infusoria	2.
2 (3).	Without test, body pyramidal, with stalk, tentacles in fascicles	[Collin, p. 425. TOKOPHRYA (Bütsch.)
3 (2).	With test, test without free margin, membrane-like, stalked	[Collin, p. 428. ACINETA (Ehrbg.)

Genus **TOKOPHRYA** (Bütschli, 1889) Collin, 1911.

Acineta, part, Ehrenberg, 1838, p. 240 ; Stein, 1854.
Podophyra, part, Stein, 1854 ; Claparède & Lachmann, 1858–61, p. 382 ; Kent, 1880–2, p. 813.
Tokophrya, Bütschli, 1887–9, p. 1928 ; Sand, 1901, p. 242 ; Collin, 1911 *b*, pp. 425–40 ; 1912, pp. 330–6 ; Schoenichen, 1927, p. 269.
Tocophrya, Reichenow, 1929, p. 1215.
Tokophrya, Kudo, 1931, p. 404 ; Calkins, 1933, pp. 228, 523.

Body pyriform or pyramidal. Without lorica. Suctorial tentacles arranged in bundles, one to four in number, all springing from the frontal surface. Stalk delicate and of uniform thickness along its whole length. Ciliated embryos egg-shaped, and generally monaxially symmetrical, laterally with an adoral zone. Birth-opening on the lateral surface of the older individuals.

Key to Indian Species.

1.	Pedicle elongated, tentacles in bundles..	2.
2 (3).	Tentacles in four bundles; macronucleus oval	[L.), p. 427. *T. quadripartita* (Cl. &
3 (2).	Tentacles in two bundles; macronucleus pyramidal	[p. 426. *T. bengalensis* Ghosh,

304. **Tokophrya bengalensis** Ghosh. (Fig. 207.)

†*Tokophrya bengalensis*, Ghosh, 1929 *c*, p. 222, fig. 1.

Body more or less pyramidal, length equalling the diameter of the base, with a cup-like depression at the narrow fixed end. Two rounded bosses at the free end, each supporting ten to

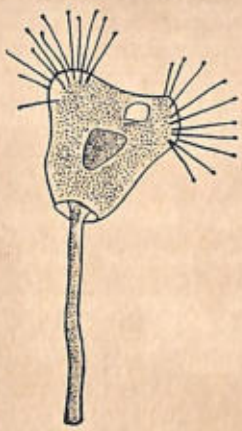


Fig. 207.—*Tokophrya bengalensis* Ghosh. (After Ghosh.)

twelve tentacles. Tentacles subequal and half the body or more in length. Contractile vacuole single, close to one of the two anterior bosses. Macronucleus irregularly pyramidal, central. Micronucleus not detected. Pedicle cylindrical, slightly widened at its junction with the body, and about one and one-half times as long as the body.

Dimensions.—Length of the body, as given in Ghosh's paper, is 75 mm. (probably an error for 75 μ).

Remarks.—The species resembles *T. cyclopum* (Clap. & Lachm.) and *T. infusionum* (St.) in having two bundles of tentacles, but differs in possessing a long stalk and a pyramidal macronucleus.

Habitat.—Sewer water : BENGAL, Calcutta.

305. **Tokophrya quadripartita** (Claparède & Lachmann). (Fig. 208.)

Podophrya quadripartita, Claparède & Lachmann, 1859–61, p. 382 ; 1861, pp. 116–22.
Acineta phase of *Stylonychia* and *Urostyla*, Stein, 1859 *d*, pp. 52, 103.
†*Podophrya quadripartita*, Carter, 1865, p. 287.
Podophrya quadripartita, Kent, 1880–2, p. 820, pl. xlvi, fig. 18.
Tokophrya quadripartita Bütschli, 1887–9, p. 1928, pl. lxxvii, fig. 9 ; Schewiakoff, 1893, p. 151 ; Sand, 1901, p. 263, pl. vi, fig. 6 ; Filipjev, 1911, pp. 117–42, 1 text-fig. ; pl. viii ; Collin, 1911 *b*, pp. 433–8, fig. ii ; pl. x, figs. 15–19 ; 1912, p. 331, pl. v, fig. 96 ; Schoenichen, 1927, p. 270, fig. 802 ; pl. xiii, fig. 47.
Tocophrya quadripartita, Reichenow, 1929, p. 1215, fig. 1195.
Tokophrya quadripartita, Calkins, 1933, pp. 22, 228, figs. 3 *e*, 107.

Body in the form of a quadrangular pyramid, tapering posteriorly ; anterior extremity divided into four blunt lobes,

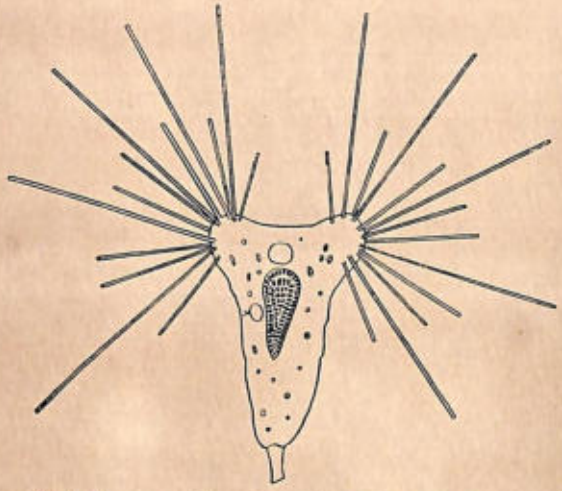


Fig. 208.—*Tokophrya quadripartita* (Cl. & L.). Only a portion of the pedicle is shown. (After Filipjev.)

each of which bears a fascicle of tubular sucking-tentacles. Pedicle thin, cylindrical, from one to one and a half times the length of the body. Contractile vacuoles varying in number from one to six. Macronucleus oval, central.

Dimensions.—Length of body 80–110 μ.

In fresh water, on *Epistylis plicatilis* or attached to water-plants or *Paludina* and other freshwater molluscs.

Habitat.—Fresh water : Bombay.

Genus **ACINETA** (Ehrenberg), Collin.

Acineta, Ehrenberg, 1833, p. 284; 1838, p. 240; Claparède & Lachmann, 1858–61, p. 387; Kent, 1880–2, p. 828; Bütschli, 1889, p. 1929; Sand, 1901, p. 268; Collin, 1912, pp. 636–48; Schoenichen, 1927, p. 271; Reichenow, 1929, p. 1215; Kudo, 1931, p. 404; Calkins, 1933, p. 523; Kahl, 1934, p. 207.

Animalcules solitary, conical or cylindro-conical, secreting a protective lorica, wholly or partly enclosing the organism. Lorica supported on a rigid, more or less extensively developed pedicle. Tentacles suctorial, capitate, variously distributed. Macronucleus rounded or elongated. Budding usually only endogenous. Ciliated embryo with ciliary girdle or complete ciliary coat. Inhabiting salt and fresh water.

306. **Acineta tuberosa** Ehrenberg. (Fig. 209.)

Acineta tuberosa Ehrenberg, 1833, p. 285; 1838, p. 241, pl. xx, fig. x.

†*Acineta tuberosa*, Carter, 1865, p. 287.

Acineta tuberosa, Kent, 1880–2, p. 829, pl. xlviii, figs. 25–8, pl. xlviii A, fig. 7; Bütschli, 1887–9, p. 1929, pl. lxxviii, figs. 1 *a–f* & *h*; Schewiakoff, 1893, p. 151; Sand, 1901, pp. 307–11, pl. vii, figs. 4–6, 11–14; pl. xii, fig. 9; pl. xiii, figs. 3–5, 7; pl. xvi, fig. 14; Collin, 1912, pp. 337–40, figs. lxxxii–lxxxiv; Reichenow, 1929, fig. 1193 *a*; Kudo, 1931, p. 404, fig. 173 *g*; Calkins, 1933, p. 228, fig. 117 c; Kahl, 1934, p. 209, figs. 6, *1–9, 11–23*.

Lorica compressed, subtriangular, widest at its distal margin, and thence tapering gradually towards its point of



Fig. 209.—*Acincta tuberosa* var. *fœtida* Sand, Collin. *a*, showing endogenous buds; *b*, free-swimming embryo. (From Calkins, after Bütschli.)

junction with the pedicle, the lateral walls continuous over the frontal border, leaving two ovate apertures at the anterior angles for the extrusion of the tentacles. Pedicle slender, rectilinear, varying from equal up to as much as four or five times the length of the lorica. Body of the animalcule mostly attenuate posteriorly, rarely filling the cavity of the lorica except towards the anterior border, invaribly adherent to it

by its posterior extremity, in the region of the tentacles, and usually along four lines extending from the posterior extremity towards the anterior border, such lines of adhesion communicating to the body, as seen in vertical optical section, a distinct quadrilateral contour. Tentacles forming two antero-lateral fascicles, protruding, when extended, through the corresponding oval apertures in the lorica, withdrawn in a sheaf-like manner into the substance of the body by invagination when retracted. Macronucleus elongate-ovate or cord-like, often contorted and branched.

Dimensions.—Length of lorica 50–100 μ.

Remarks.—Three distinct varieties of this species are recognized. In *A. tuberosa* Ehrbg. var. *fraiponti* Sand, Collin the pedicle varies from two to five times the height of the body; but in *A. tuberosa* forma *brevipes* Collin and *A. tuberosa* var. *fœtida* Sand, Collin the pedicle is less than the height of the body.

Habitat.—Fresh water: Bombay.

2. Family PODOPHRYIDÆ Bütschli, 1889.

Forms generally showing a bilateral symmetry. Only suctorial tentacles are present, over the entire body or grouped in fascicles. Individuals are naked or enclosed in delicate and close-fitting or coarse and loose-fitting test. Reproduction by division or by exogenous budding. Free-living or parasitic.

Key to Indian Genera.

1.	Without test or cup	2. [Bütsch., p. 429.
2 (3).	Normally with stalk, attached	Podophrya (Ehrbg.)
3 (2).	Free-swimming or parasitic	Sphærophrya Clap. & [Lach., p. 433.

Genus **PODOPHRYA** (Ehrenberg, 1833) emend. Bütschli, 1889.

Podophrya Ehrenberg, 1833, p. 306; 1838, p. 305; Claparède & Lachmann, 1858–61, p. 382; Carter, 1865, p. 287; Kent, 1880–2, p. 813; Bütschli, 1887–9, p. 1927; Sand, 1901, p. 217; Collin, 1912, pp. 396–401; Schoenichen, 1927, p. 289; Reichenow, 1929, p. 1217; Kudo, 1931, p. 402; Calkins, 1933, p. 524; Kahl, 1934, p. 198.

Body form somewhat spherical, without lorica; knobbed tentacles arising from the whole of the surface. Length of the

stalk varying greatly. Contractile vacuole usually single. Macronucleus oval, central. Multiplication by fission into nearly equal parts; ciliated embryo provided with a broad ciliary girdle. Salt and fresh water.

Key to Indian Species

1 (4).	Body nearly spherical, pedicle less than the diameter of the body	2.
2 (3).	Macronucleus elongate-oval or kidney-shaped. Contractile vacuoles 1 or 2.	[Ehrbg., p. 431. *P. fixa* (O. F. Müll.)
3 (2).	Macronucleus spherical. Contractile vacuole absent	[p. 430. *P. bengalensis* Ghosh,
4 (1).	Body pyriform, pedicle longer than the body. Macronucleus oval or spherical, contractile vacuole eccentric	*P. sandi* Collin, p. 432.

307. **Podophrya bengalensis** Ghosh. (Fig. 210.)

†*Podophrya bengalensis* Ghosh, 1929 *c*, p. 223, fig. 2.

Body subspherical. Pedicle cylindrical, slightly dilated at its proximal end, and nearly two-thirds the diameter of the

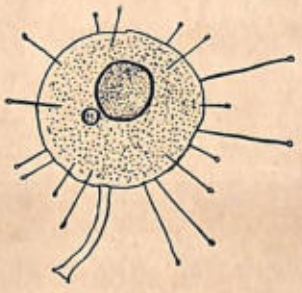


Fig. 210.—*Podophrya bengalensis*, Ghosh. (After Ghosh.)

body in length. Tentacles cylindrical, straight, capitate, unequal in length, less than the body diameter in length, arranged radially, seventeen in number. Cytoplasm finely granular. No contractile vacuole. Macronucleus spherical, subcentral.

Dimensions.—Diameter of the body as given in Ghosh's paper is 32 mm. (probably an error for 32 μ); length of the pedicle 22 mm. (probably an error for 22 μ).

Habitat.—Sewer water: BENGAL, Calcutta.

308. **Podophrya fixa** (O. F. Müller) Ehrenberg. (Fig. 211.)

Trichoda fixa, O. F. Müller, 1786, p. 217, pl. xxx, figs. 11–12.
Podophrya fixa, Ehrenberg, 1833, p. 306; 1838, p. 306, pl. xxxi, fig. x.
Actinophrys pedicellata, Dujardin, 1841, p. 266.
Actinophrys sol, part, Stein, 1849, pp. 133, 147, 148; 1854, pp. 140–50.
Acineta phase of *Vorticella microstoma*, Stein, 1849, pp. 142–5.
Podophrya fixa Claparède & Lachmann, 1858–61, p. 384.
†*Podophrya fixa*, Carter, 1865, pp. 287–8, pl. xii, figs. 9 *e*, 10 *d*.
Podophrya fixa, Kent, 1880–2, p. 813, pl. xlvi, figs. 24–30; Schewiakoff, 1893, p. 151; Sand, 1901, pp. 223–4; Collin, 1912, pp. 396–7, pl. i, figs. 13, 14; Schoenichen, 1927, p. 289, fig. 819; Reichenow, 1929, p. 1217; Kudo, 1931, p. 402, fig. 172, *d*, *e*; Calkins, 1933, pp. 81, 480, figs. 43, 198; Kahl, 1934, p. 198.

Body spherical. Pedicle slender and usually sinuous, with its distal extremity abruptly expanded, its length rarely

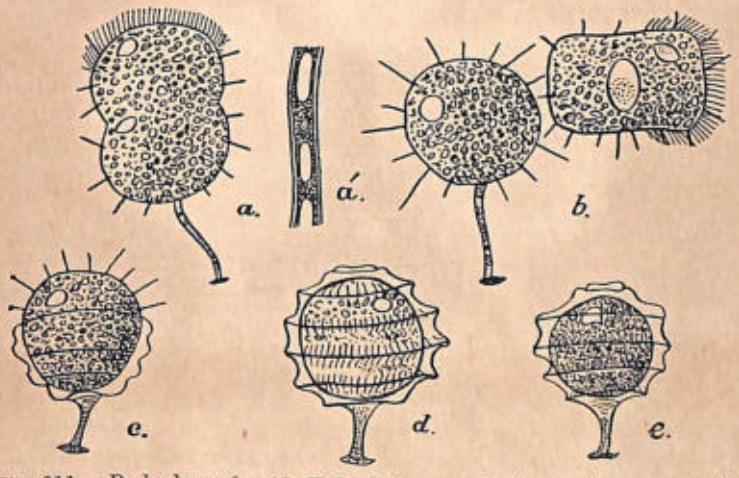


Fig. 211.—*Podophrya fixa* (O. F. Müll.). *a*, animal showing commencement of budding; *a'*, stalk highly magnified; *b*, setting free of the embryo; *c*, beginning of encystment; *d* & *e*, cysts. (From Schoenichen, after Collin.)

exceeding the diameter of the body. Tentacles numerous, slender, distinctly capitate, not exceeding the body-length, distributed throughout the surface of the periphery. Contractile vacuole single or double. Macronucleus elongate-oval or kidney-shaped, subcentral. Cysts barrel-shaped, with three or four prominent transversely annular crests or ridges.

Dimensions.—Length of the body 50–72 μ.

Habitat.—Fresh and salt water: Bombay.

309. **Podophrya sandi** Collin. (Fig. 212.)

Acineta gelatinosa, Buck, 1884, pp. 298–304.
Trichophrya gelatinosa, Schewiakoff, 1893.
Podophrya sp., Maupas, 1881, p. 305, pl. xix, fig. v.
†*Podophrya* sp., Simmons, 1889, p. 145.
Podophrya gelatinosa Sand, 1901, pp. 224–6, pl. vi, figs. 9, 11; pl. x, figs. 8–13; pl. xviii, figs. 8, 11, 13; pl. xxiii, fig. 9.
Podophrya sandi, Collin, 1912, pp. 398–401, fig. cv; Schoenichen, 1927, p. 291, fig. 820.

Pedicle straight, inserted on a conical prolongation of the body, which gives it a pyriform appearance. Tentacles numerous, unequal, knobbed, not exceeding in length three times the diameter of the body, uniformly distributed or in

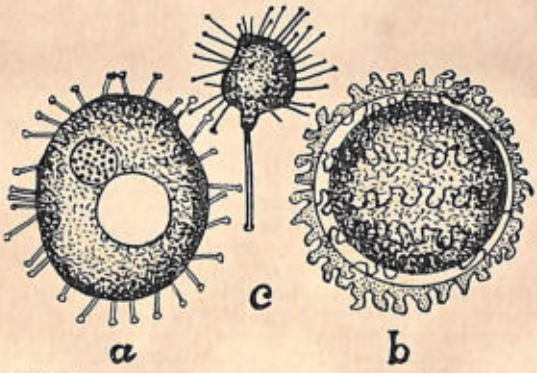


Fig. 212.—*Podophrya sandi* Collin. *a*, stalkless stage; *b*, cyst; *c*, adult stalked stage. *a* and *b* more highly magnified than *c*. (After Sand.)

one to three bundles. Contractile vacuole eccentric. Macronucleus central, spherical or oval. The motile stage has a complete girdle of cilia, two bundles of drawn-out tentacles, and a spherical macronucleus. Cysts are non-pedunculate.

Remarks.—Sand (1901) referred the form described by Simmons from Calcutta to *Podophrya gelatinosa* (Buck), but Collin (1912) considered it a distinct species which he named *P. sandi*.

Habitat.—Pond water: BENGAL, Calcutta.

Genus **SPHÆROPHRYA** Claparède & Lachmann, 1859.

Sphærophrya, Claparède & Lachmann, 1858–61, p. 385; Mecznikow, 1864, pp. 258–61, pl. 7 A; Kent, 1880–2, p. 808; Bütschli, 1887–9, p. 1926; Sand, 1901, p. 226; Collin, 1912, pp. 401–3; Schenichen, 1927, p. 292; Reichenow, 1929, p. 1217; Kudo, 1931, p. 402; Calkins, 1933, p. 524; Kahl, 1934, p. 198.

Animalcules without a lorica, usually more or less spherical in form, with distinctly capitate sucking-tentacles scattered irregularly throughout the periphery, freely movable, and never developing a fixed pedicle as in the genera *Podophrya* and *Acineta*. Multiplication by equal or unequal division, and also through exogenous budding. Free-living or parasitic on or within other animalcules.

310. **Sphærophrya pusilla** Claparède & Lachmann. (Figs. 213 & 214.)

Sphærophrya pusilla, Claparède & Lachmann, 1858–61, p. 385, pl. i, fig. 11.
Embryo of *Paramœcium bursarium*, Stein, 1859 *d*, p. 99.
Embryo of *Urostyla grandis*, Stein, 1859 *d*, p. 103.
Embryo of *Stylonichia mytilus*, Stein, 1859 *d*, p. 103.
†*Sphærophrya* sp., Carter, 1861.
Sphærophrya sol, Mecznikow, 1864, p. 261, fig. 6.
Sphærophrya stylonychiæ, Kent, 1880–2, p. 810.
Sphærophrya pusilla, Kent, 1880–2, p. 808, pl. xlvi, fig. 6.
Sphærophrya sol, Kent, 1880–2, p. 810, pl. xlvii, figs. 6, 7.
Sphærophrya parameciorum, Maupas, 1881, p. 304.
Sphærophrya urostylæ, Maupas, 1881, p. 304; Kent, 1880–2, pp. 809–10, pl. xlvi, figs. 3–5.
Sphærophrya, sp., Schewiakoff, 1893, p. 151.
Sphærophrya pusilla, Sand, 1901, pp. 228–30; Collin, 1912, pp. 402–3.
†*Sphærophrya pusilla*, Bhatia, 1920, p. 265.
Sphærophrya sol, Schoenichen, 1927, p. 292, fig. 823; Reichenow, 1929, p. 1217, fig. 1201; p. 391, fig. 378.
Sphærophrya pusilla, Wenyon, 1926, pp. 1228–9, fig. 534; Schoenichen, 1927, p. 292; Kahl, 1934, p. 198.

Body minute, spherical, bearing a variable number of short, widely scattered knobbed tentacles. Contractile vacuole single. Macronucleus rounded or ovate. Multiplication by transverse fission.

Diameter.—Diameter 12–15 μ.

Free-living or parasitic within many HYPOTRICHA, *Paramecium*, *Nassula*, etc.

Remarks.—A specimen of *Paramecium caudatum* containing four young individuals of this species was encountered at Lahore. Two of these individuals, provided with knobbed

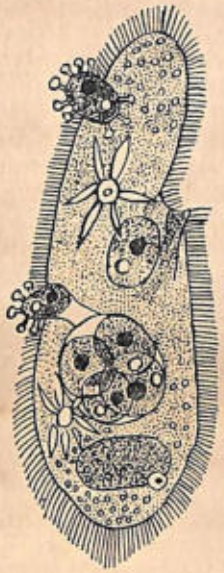


Fig. 213.—*Sphærophrya pusilla* Clap. & Lachm. One embryo is making its way into the cytoplasm of *Paramecium caudatum* near its anterior end. In the hinder part a vacuole contains four organisms, from an opening of which an embryo is escaping. (From Reichenow, after Bütschli.)

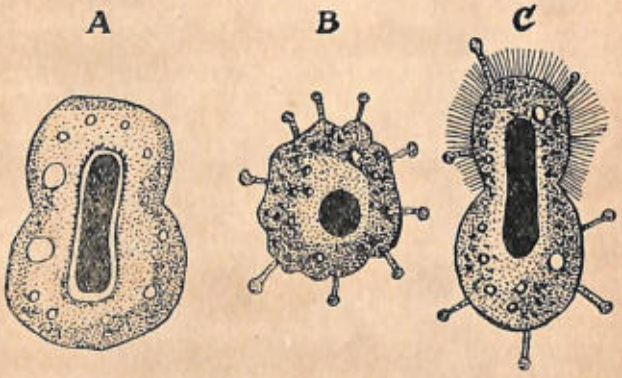


Fig. 214.—*Sphærophrya pusilla* Clap. & Lachm. *A*, dividing stage; *B*, free-living individual with tentacles; *C*, development of a free-swimming embryo with tentacles and cilia. (From Reichenow, after Bütschli.)

tentacles all round, escaped under observation and began to swim freely. The body of these individuals was very small. Bütschli (1887–9) identified the form occurring in *Paramecium* and described by Maupas as *Sphærophrya parameciorum* with *Sphærophrya pusilla* Claparède & Lachmann. Schoenichen (1927) and Reichenow (1929) consider the form occurring in *Paramecium*, *Nassula*, etc., as *Sphærophrya sol* Mecznikow. Mecznikow's work is not available to me, but according to the brief abstract given in the 'Zoological Record' (1864) *S. sol* Mecznikow was found in a marsh in a wood.

Habitat.—Endoparasite of *Paramecium caudatum* Ehrbg.: PUNJAB, Lahore. Fresh water: PUNJAB, Hoshiarpur; Bombay.

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† prefixed to a reference indicates that it records some species from India, Burma or Ceylon.

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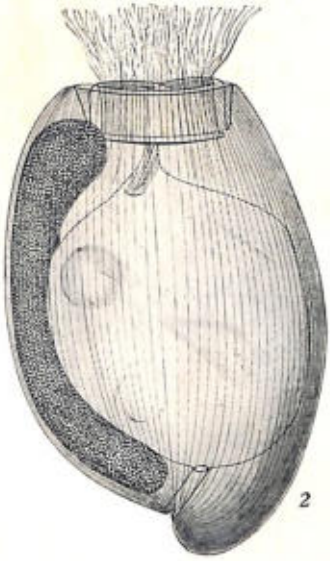
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PLATE I.

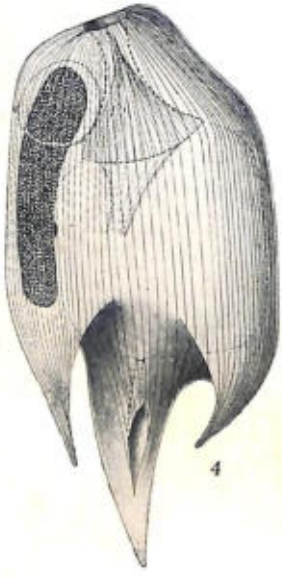
Fig. 1. *Entodinium acutonucleatum* Kof. & MacL.
2. „ *longinucleatum* Dogiel.
3. „ *laterospinum* Kof. & MacL.
4. „ *indicum* Kof. & MacL.
5. „ *tricostatum* Kof. & MacL.

[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1930.]


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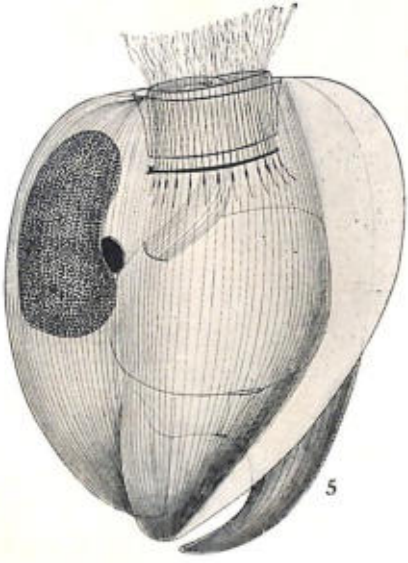
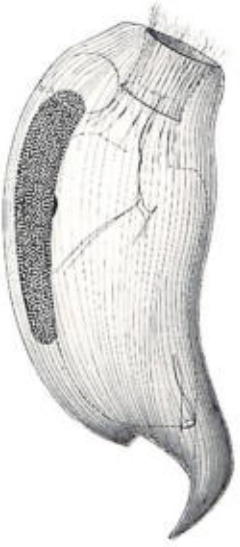
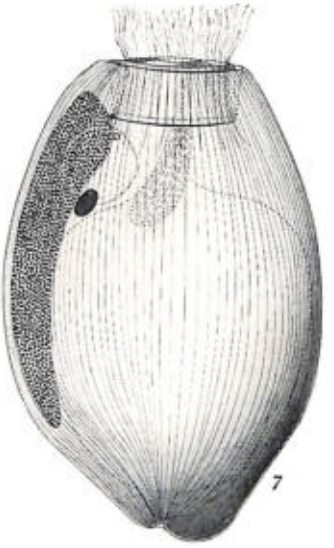

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PLATE II.

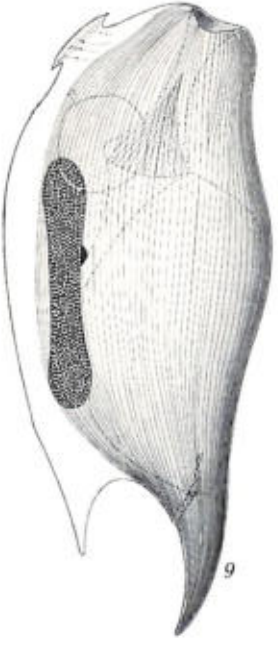
Fig. 6. *Entodinium rostratum* Fiorentini.
7. ,, *rhomboideum* Kof. & MacL.
8. ,, *nanellum* Dogiel.
9. ,, *pisciculum* Kof. & MacL.
10. ,, *bimastus* Dogiel.

[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1930.]


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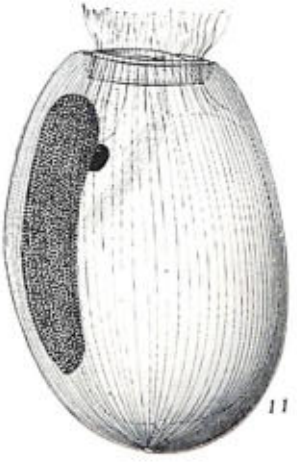

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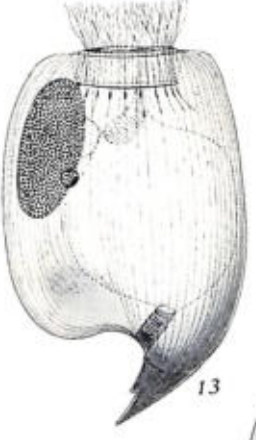
PLATE III.

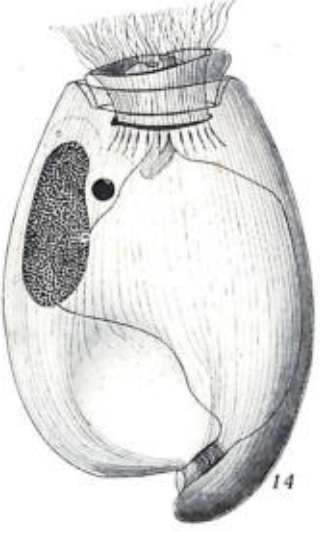
Fig. 11. *Entodinium ovoideum* Kof. & MacL.
12. ,, *aculeatum* Kof. & MacL.
13. ,, *bifidum* (Dogiel).
14. ,, *biconcavum* Kof. & MacL.
15. ,, *acutum* Kof. & MacL.

[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1930.]


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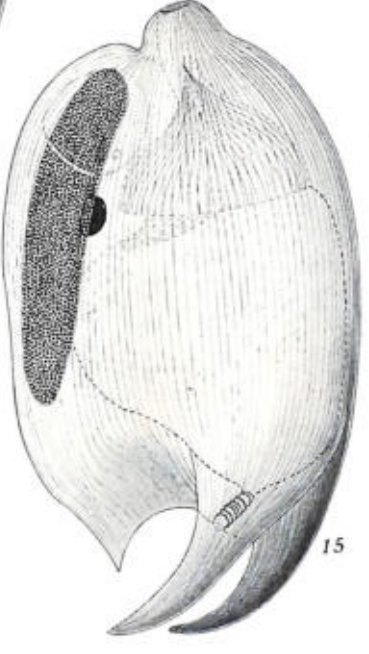
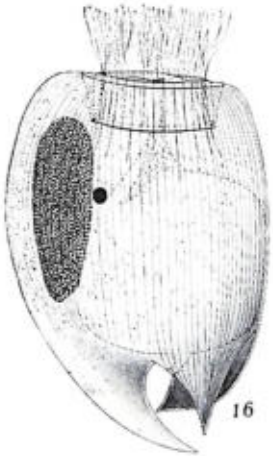

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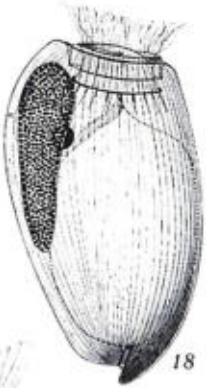
PLATE IV.

Fig. 16. *Entodinium laterale* Kof. & MacL.
17. ,, *ellipsoideum* Kof. & MacL.
18. ,, *brevispinum* Kof. & MacL.
19. ,, *rectangulatum* Kof. & MacL.
20. ,, *gibberosum* Kof. & MacL.

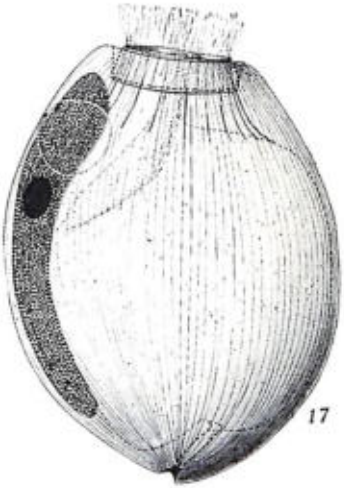
[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1930.]



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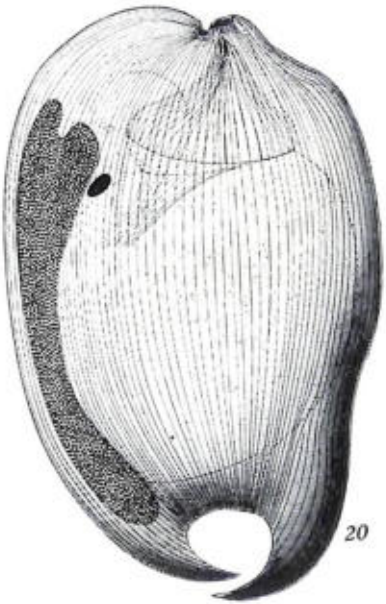
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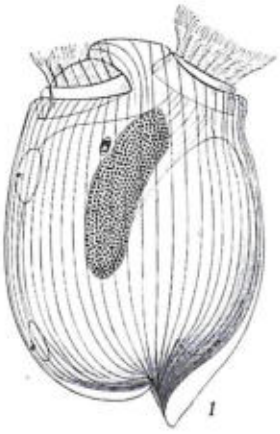


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PLATE V.

Fig. 1. *Diplodinium psittaceum* Dogiel.
2. ,, *dentatum* Schuberg.
3. *Eodinium lobatum* Kof. & MacL.
4. ,, *rectangulatum* Kof. & MacL.
5. *Diplodinium ceylonicum* Kof. & Christ.
6. ,, *flabellum* Kof. & MacL.

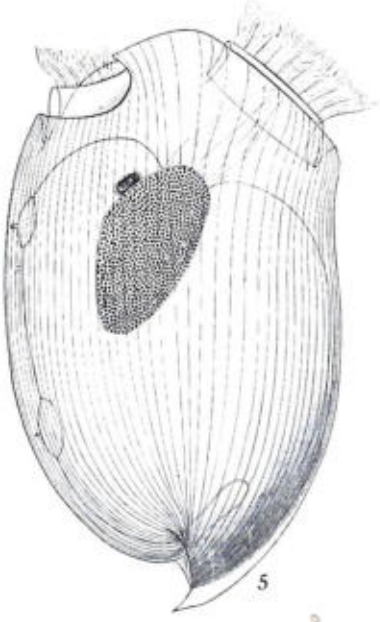
[From Kofoid & MacLennan's Cilates from *Bos indicus* Linn., 1932.]


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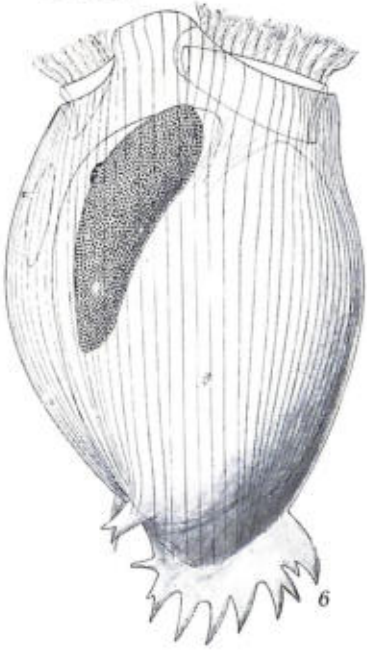
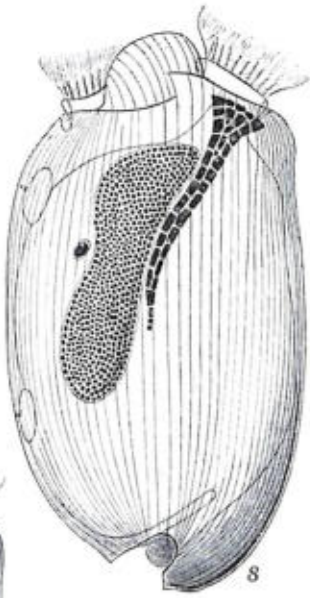

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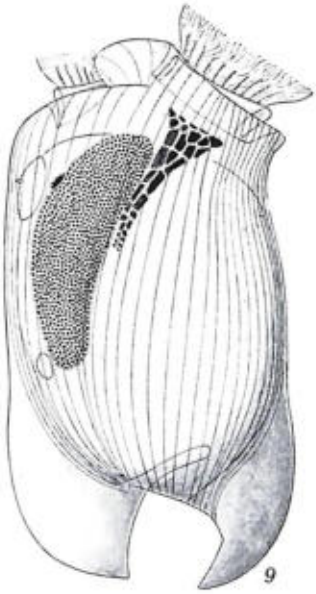
PLATE VI.

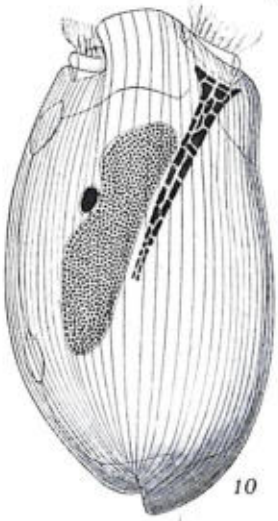
Fig. 7. *Eremoplastron rostratum* (Fiorentini).
8. ,, *brevispinum* Kof. & MacL.
9. ,, *magnodentatum* Kof. & MacL.
10. ,, *bovis* (Dogiel).
11. ,, *rotundatum* Kof. & MacL.
12. *Eudiplodinium maggi* (Fiorentini).

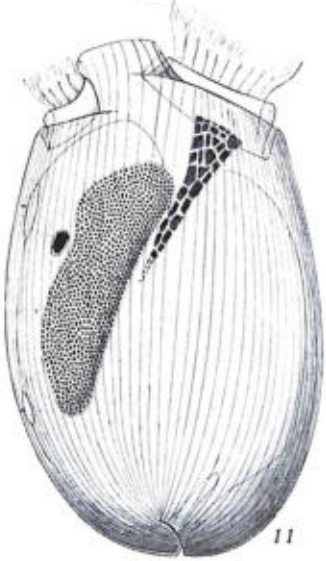
[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1932.]


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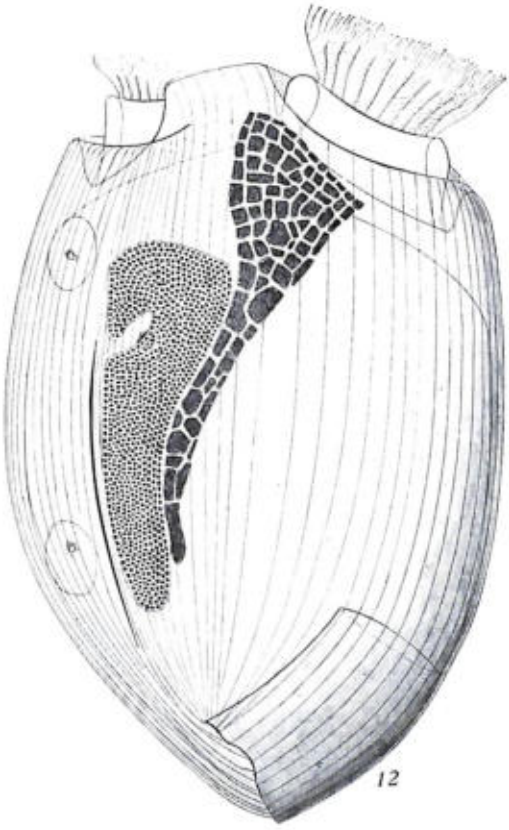
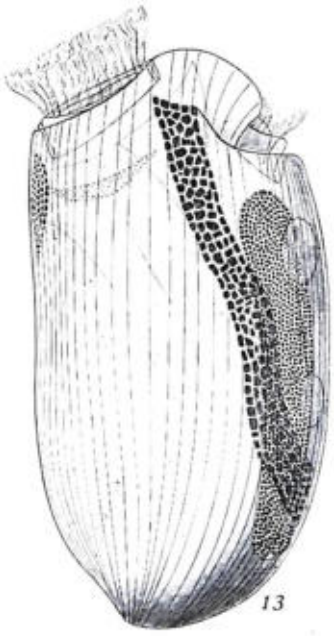

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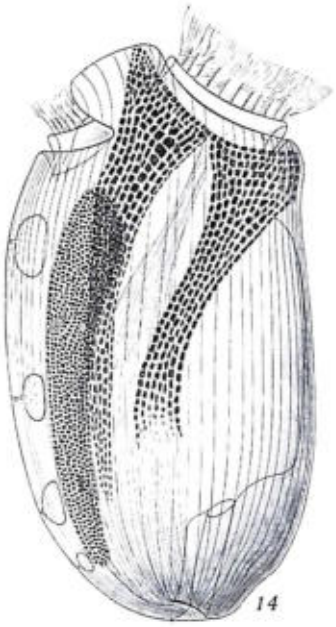
PLATE VII.

Fig. 13. *Elytroplastron bubali* (Dogiel). Left lateral view.
14. „ „ „ Right lateral view.
15. *Ostracodinium clipeolum* Kof. & MacL.
16. *Metadinium medium* Awerinzew & Mutafowa.

[From Kofoid & MacLennan's Ciliates
from *Bos indicus* Linn., 1932.]



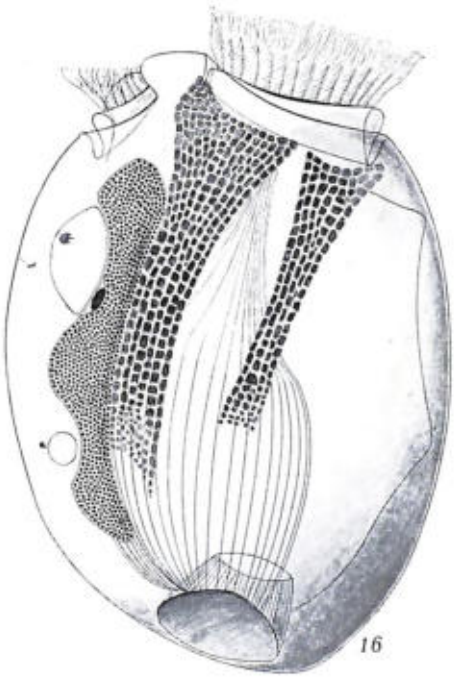
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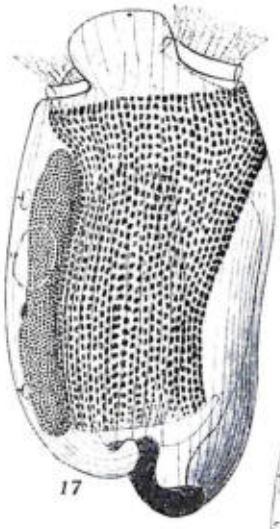


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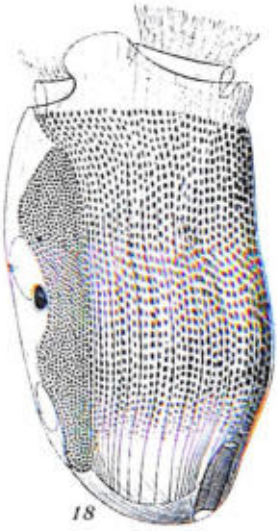
PLATE VIII.

Fig. 17. *Ostracodinium mammosum* (Railliet).
18. ,, *gracile* (Dogiel).
19. ,, *quadrivesiculatum* Kof. & MacL.
20. ,, *rugoloricatum* Kof. & MacL.
21. ,, *venustum* Kof. & MacL.
22. ,, *trivesiculatum* Kof. & MacL.

[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1932.]



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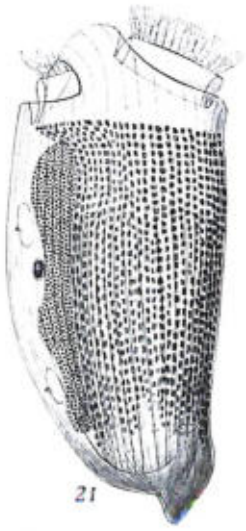
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PLATE VIII.

Fig. 17. *Ostracodinium mammosum* (Railliet).

18. ,, *gracile* (Dogiel).

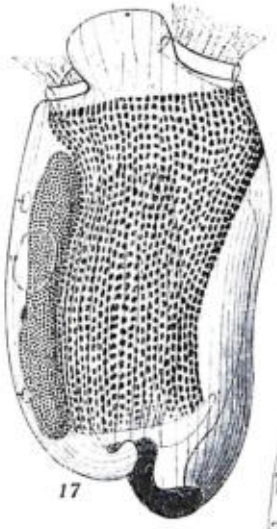
19. ,, *quadrivesiculatum* Kof. & MacL.

20. ,, *rugoloricatum* Kof. & MacL.

21. ,, *venustum* Kof. & MacL.

22. ,, *trivesiculatum* Kof. & MacL.

[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1932.]



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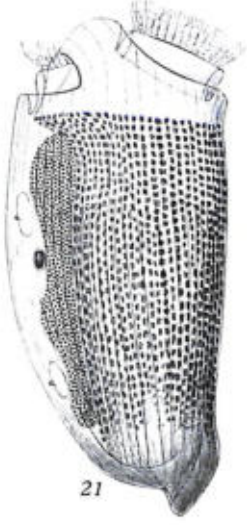
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PLATE IX.

Fig. 1. *Epidinium caudatum* (Fiorentini).
2. „ *tricaudatum* (Sharp).
3. „ *quadricaudatum* (Sharp).
4. „ *bicaudatum* (Sharp).
5. „ *eberleini* (da Cunha).
6. *Ophryoscolex spinosus* Kof. & MacL.
7. *Epidinium cattanei* (Fiorentini).

[From Kofoid & MacLennan's Ciliates from *Bos indicus* Linn., 1933.]

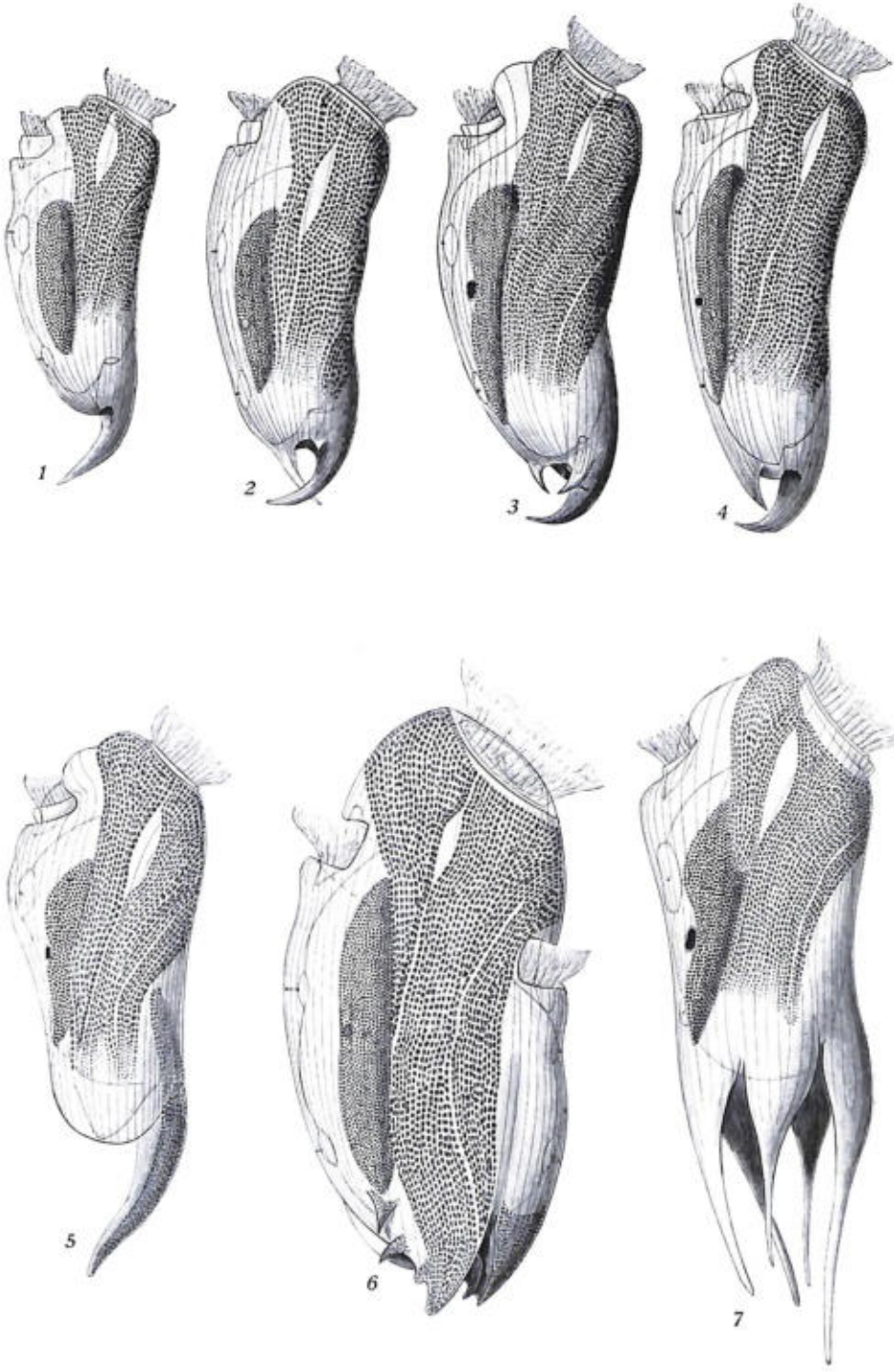

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PLATE X.

Fig. 1. *Entodinium contractum* Kof. & Christ.
2. „ *curtum* Kof. & Christ.
3. *Eodinium bilobosum* (Dogiel).
4. *Diplodinium minor* (Dogiel).
5. „ *diacanthum* (Dogiel).
6. „ *triacanthum* (Dogiel).
7. „ *tetracanthum* (Dogiel).
8. „ *pentacanthum* (Dogiel).
9. „ *anisacanthum* da Cunha.

[From Kofoid & Christenson's Ciliates from *Bos gaurus* H. Smith, 1934.]

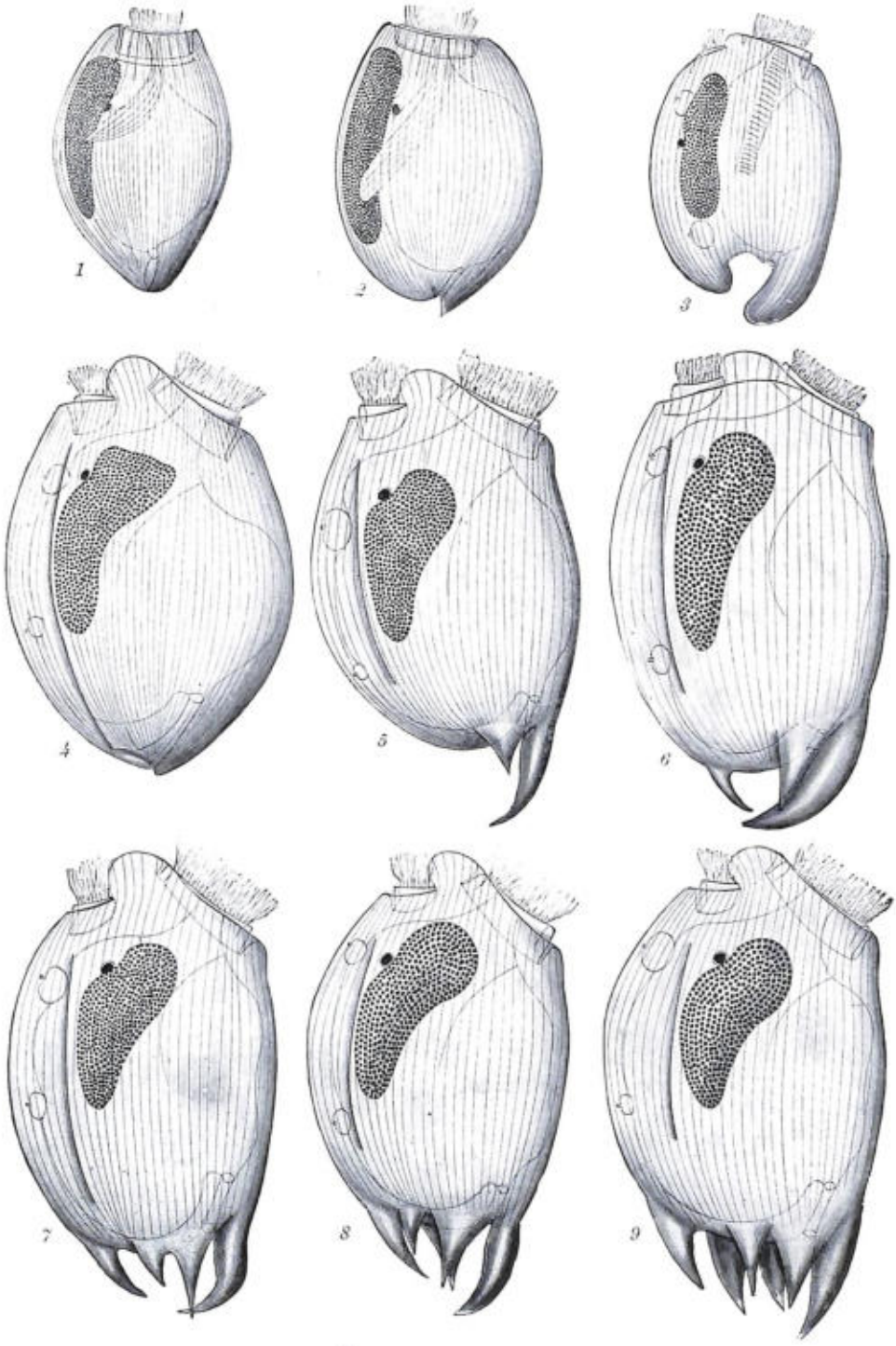

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PLATE XI.

Fig. 10. *Epidinium parvicaudatum* (Awerinzew & Mutafowa).

11. *Metadinium rotundatum* Kof. & Christ.

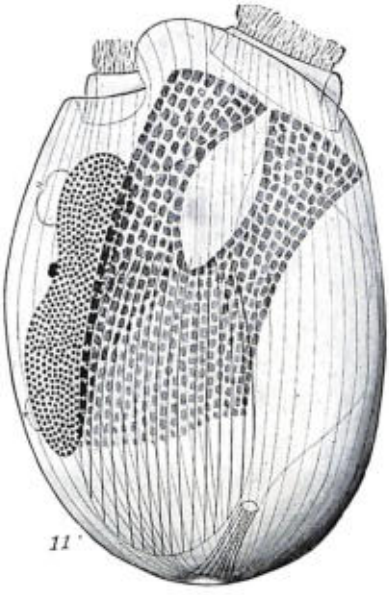
12. *Eremoplastron rostratum* (Fiorentini).

13. *Eudiplodinium maggi* (Fiorentini).

14. *Ostracodinium gauri* Kof. & MacL.

15. „ *mysorei* Kof. & MacL.

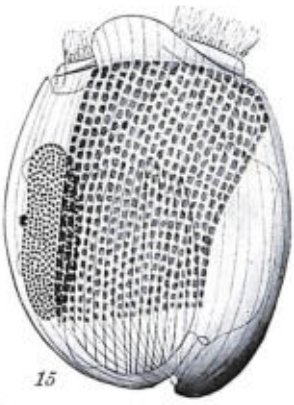
[From Kofoid & Christenson's Ciliates from *Bos gaurus* H. Smith, 1934.]



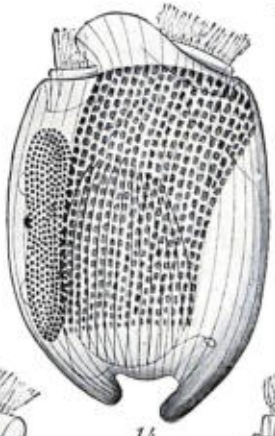
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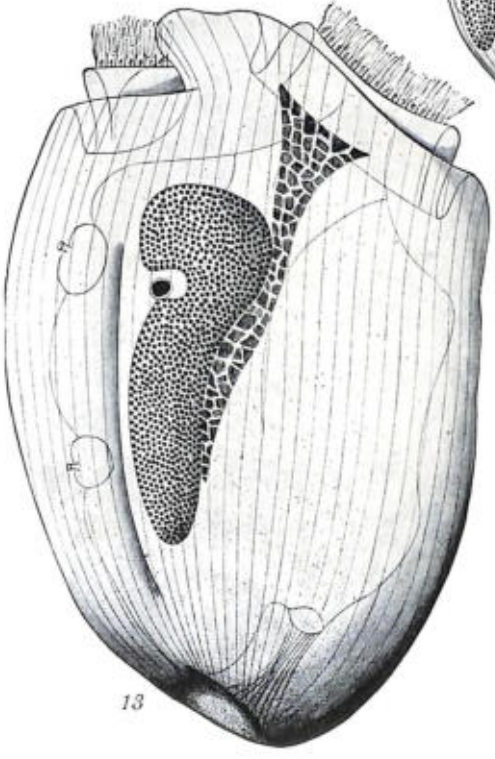
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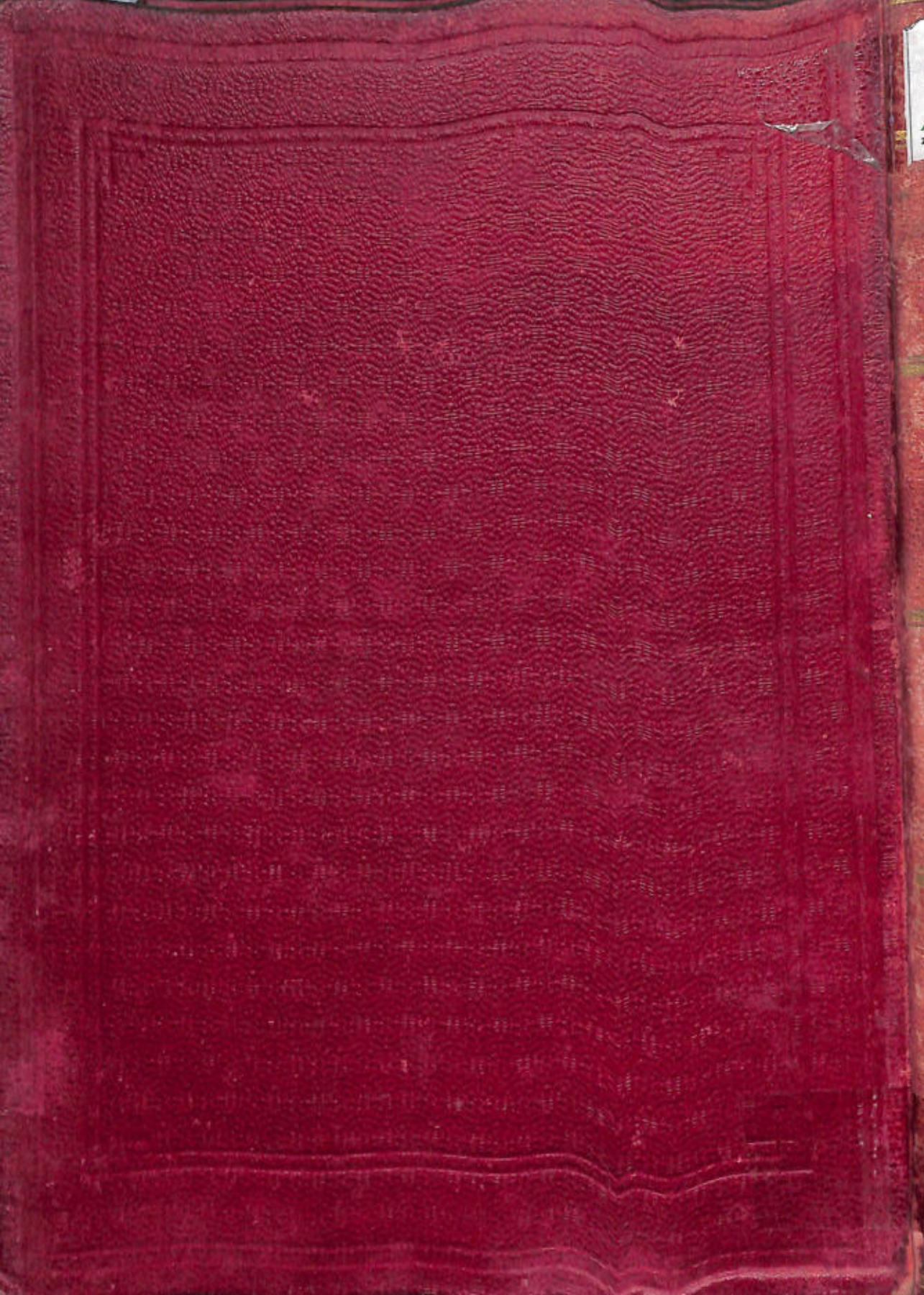
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