(From the Department of Zoology, Calcutta University, India.)

# Preliminary observations on the Protozoan fauna of the rumen of the Indian goat, *Capra hircus* Linn [1].

By

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(With 6 figures in the text.)

## Contents.



## Introduction.

Protozoa in the rumen of the ruminants in general present many interesting features, both from morphological and physiological stand point. The methods for culturing cattle ciliates *in vitro* by Sydney (1930) have opened a field for research which promises to reveal the basic principles connected with the mutual relationship between these protozoa and the host. So, before venturing to take up any kind of experimental work, I have, in this article, put down the results of my systematic survey of the protozoan fauna of the rumen of the Indian goat.

This host was selected because the material was obtained with great ease. The list of protozoa given here is by no means a

[1]) Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Zoology in the University of Calcutta, 1933.

complete one and is, therefore, not applicable to every part of India, but it can certainly claim to be the first of its kind from our country.

Previous works which refer to protozoa from Indian ruminants are by KNOWLES and DAS GUPTA (1931) who have described two new flagellates from the intestine of Indian bull, and by KOFOID and MAC LENNAN (1930, 1932) who have given a list of ciliates belonging to genera Entodinium and Diplodinium from *Bos indicus* LINN.

Here I wish to express my indebtedness to Dr. HARENDRANATH RAY, for kindly suggesting this problem to me and rendering valuable help and guidance during this work. I am also indebted to Rai Bahadur Dr. G. C. CHATTERJEE, Honorary Lecturer in Protozoology, Calcutta University, for kindly placing at my disposal his years of experience in staining protozoa, particularly the flagellates. To Mr. MUKUNDAMURARI CHAKRAVARTY I am grateful for helping me in making permanent preparations of the ciliates.

## Material and Methods.

The material was procured from a public abbatoir at Tangra (Calcutta). On the removal of the stomach the reticulum was slit open and its contents poured into a thermus flask. As the laboratory is situated far off from the abbatoir and as it was necessary to examine the contents in fresh condition for detecting the flagellate and amoeba, this method of carrying the specimens in thermus flask was found to be very useful.

For rapid indentification of the flagellates DONALDSON'S iodine-eosin solution was used. This reagent at once killed the flagellates and showed the number of flagella clearly. SCHAUDINN'S fluid (20 minutes) and BRASIL'S modification of BOUIN-DUBOSCQ fluid (20 minutes) was employed in fixing the flagellates for making permanent preparations. In carrying out this operation the usual method employed in this laboratory, that is, fine streaks of the fluid containing the organisms allowed to run on clean slide from end to end through a fine pippette, was applied with great advantage. In such a preparation one could examine the streaks one by one in less time and with greater ease than a smear.

In order to study the morphology of the ciliates the reticular contents were fixed in several fixatives, such as, warm formalin (5 %) for 30 minutes, hot SCHAUDINN'S fluid for 30 minutes and BOUIN-DUBOSCQ BRASIL'S fluid for one hour. The material fixed in formalin was stored in 4 % formalin, and those in SCHAUDINN'S were

treated with iodine-alcohol and then preserved in 70 % alcohol, while others were washed in a few changes of Lithium carbonated 70 % alcohol and subsequently kept in 70 % alcohol. Glycerine mounts of the material fixed in any one of the above fluids were used in studying the general morphology for the ciliates. Such preparations, it must be said, supply much more detailed informations on the morphology of the ciliates than the stained ones, because it gives one an opportunity to turn the organisms in every possible direction.

The stains used were Heidenhain's and Delafield's haematoxylin, Borax Carmine and Haemalum. For staining the flagellates in Giemsa they were fixed in osmic vapour for two to five minutes prior to the addition of the stain. The skeletal plates in certain ciliates were stained with Chlor-Zinc-iodine.

## Observations.

### Rhizopoda.

*Entamoeba ovis* Swellengrebel, 1914.

This is a very minute organism, 5—8 $\mu$ in diameter, and is apt to escape ones eyes, particularly when large number of flagellates and ciliates are briskly moving about in the field. Uninucleated cysts have also been observed. All the goats examined were infected with this species but their number in any one case was very small.

### Zoomastigina.

Under this sub-class six species have been met with in the goats examined.

*Oikomonas communis* Liebetanz, 1910.

This is a small spherical or ovoidal organism with a long flagellum at one end. The cytoplasm is filled with minute granules which stain green with Giemsa.

Liebetanz (1910) distinguished flagellates bolonging to three different genera in the contents of the rumen of Cattle: *Oikomonas*, *Sphaeromonas* and *Piromonas* Fonseca in 1916 pointed out that Liebetanz's *Piromonas* was identical with *Sphaeromonas*. I agree with Wenyon in suggesting that both *Piromonas* and *Sphaeromonas* belong to the genus *Oikomonas*. Wenyon (1926) is also of opinion that the two species of flagellates representing the genus *Craigia* Calkins, discovered by Kofoid and Swezy in 1921 in human faeces, also belong to the genus *Oikomonas*.

*Selenomonas ruminatium* var. *caprae* nov. var. (Fig. 1 a—f).

It is a small crescent-shaped organism present in large numbers in all the goats examined. From its concave side arises an undulating membrane which is broad at the base and pointed at its free end. By the movement of this membrane in different directions the organism gives a picture which is peculiar to it. In stained preparation (GIEMSA and LIESHMAN) this undulating membrane appears to be composed of three to four flagella (see Fig. b) and never as many as has been figured by FONSECA (1916) or BOSKAMP (1922). It is on this ground that I have preferred to call it *Selenomonas ruminatium* var. *caprae* nov. var. The nucleus is situated at the centre of the crescent and stains deeply with HEIDENHAIN's haematoxylin (long method). With LIESHMAN or GIEMSA the space occupied by the nucleus remains unstained, while the two ends of the crescent demonstrate a mass of deep pink or bluish pink granules. There is a definite cell-wall which takes up deep pink stain with GIEMSA or LIESHMAN. In the dividing forms however, the nuclei are seen to take up a pink stain with a darkly staining granule situated at the anterior end of each nucleus (see Fig. d). From this it is evident that during the precess of division the chemical composition of the cell-wall of this organism is altered and thus allows the stain to penetrate it and stain the nuclei. The undulating membrane in such forms again composed of three to four flagella, are seen to arise from the concave side of the crescent posterior to the nucleus (see Fig. d). Precystic stages with very much shortened and curled up flagella, as shown by BOSKAMP, and mature cysts have also been seen by me (see Fig. e).

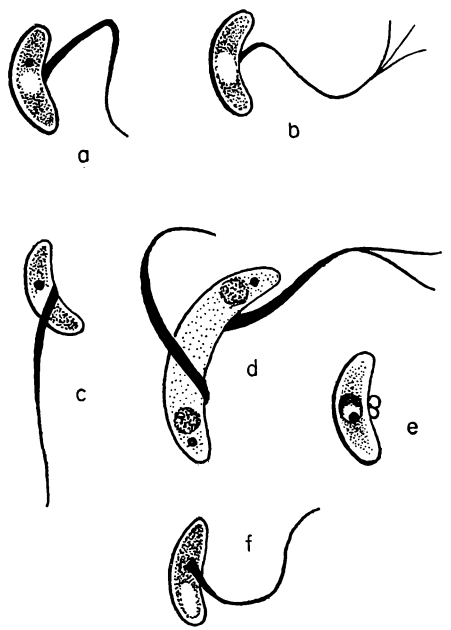


Fig. 1 a—f. *Selenomonas ruminatium* var. *caprae* nov. var. × 1666. *Camera lucida* drawing made from smear stained with GIEMSA stain.

Dimensions 6,15—8,2 $\mu$ long
1,5—2,05 $\mu$ broad.

Boskamp believes that this organisms is not a Protozoon but is related to the *Spirilla.*

*Callimastix frontalis* Braune, 1913.

This organism was seen only once. It has a spherical or ovoid body about 12 $\mu$ in diameter. There are about six to eight long flagella arising from one end of the body. Wenyon (1926) suggests that *Callimastix* is the rounded form of *Selenomonas* but, like Hsiung (1931), I also fail to contribute to this view.

*Trichomonas ruminatium* Braune, 1913.

This flagellate is distinguished at once from others by its peculiar jerky movement. It has three anterior flagella, a posteriorly directed undulating membrane with a bordering flagellum which becomes free at this end, a rigid axostyle, and a cytostome. Dimensions 8—17 $\mu$ in length, 5—15 $\mu$ in breadth. It was present in small numbers in all the goats examined.

*Chilomastix caprae* Fonseca, 1915.

Pear-shaped body with three anteriorly directed flagella, a large cytostomal cleft within which is a fourth flagellum and gyroscopic movement are the salient features which mark out the flagellates of this genus from the rest.

Dimensions 8—10 $\mu$ in length.
4— 6 $\mu$ in breadth.

Forms with rounded posterior end called *forma atypica* by Fonseca are also seen to occur.

This organism was present in small numbers only in three cases.

*Monocercomonas caprae* n. sp. (Fig. 2 a, b).

This is a minute oval organism with four free anterior flagella found in all the goats examined. These four flagella arise in groups of two from two blepharoplasts. These blepharoplasts are situated at some distance from the nucleus and do not rest on the nuclear membrane as in *M. melolonthae* (Grassi) or *M. cetoniae* Jollos (1911), which according to Swezy (1916), are the only authenticated species in the genus. There is a chromatic line bordering the anterior edge of the body which joins the belpharoplasts. Between this chromatic line and the nucleus there is a slight depression which may be taken to correspond with the cytostome of *Chilomitus* Fonseca. From one

of the blepharoplasts arises an axoneme which runs towards the posterior end but never projects beyond the body like the axostyle in Trichomonas. SWEZY (1916) thinks that this axoneme is not intracytoplasmic but is placed on the pellicle but as far as I have been able to judge from my preparations I am of opinion that it is an intracytoplasmic structure. Similar organisms were observed by Dr. RAY[1]) in the coecum of Guinea pigs and Rats in Calcutta. He is of opinion that FONSECA'S *Chilomitus* 1915 perhaps is the same as *Monocercomonas* and that FONSECA failed to see the axoneme. I find a support of Dr. RAY'S view in a communication of LAVIER to WENYON (1926) in which he said that he had observed *Chilomitus caviae* in a rodent but then there was an axial fibre present. Therefore, as GARSSI'S genus *Monocercomonas* has priority over *Chilomitus* of FONSECA and as the main characters of the genus *Chilomitus* do not seem to differ from that of *Monocercomonas* I believe, I am justified in suggesting that *Chilomitus* be treated as a synonym of *Monocercomonas*.

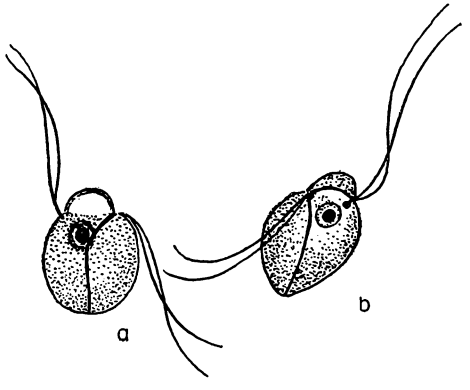


Fig. 2a—b. *Monocercomonas caprae* n. sp. × 1666. *Camera lucida* drawing made from smear stained with GIEMSA stain.

Dimensions 6—12 $\mu$ in length.
4— 8 $\mu$ in breadth.

Diagnosis — Oval organism 6—12 $\mu$ long.
4— 8 $\mu$ broad.

Four free flagella arising in groups of two from two anterior blepharoplasts: two belpharoplsts joined by a chromatic line: axoneme originates from one of the blepharoplasts and runs towards posterior end.

## *Ciliophora.*

Under this sub-phylum the following genera are represented: *Isotricha, Dasytricha, Entodinium, Diplodinium, Eremoplastron, Epidinium* and *Ophryoscolex.*

[1]) Unpublished observation of 1925.

*Isotricha prostoma* Stein, 1858.

This species was met with in all the goats examined. It occurred in large numbers in goat No. 8 along with *Dasytricha ruminatium*. This can at once be identified by its large size and the longitudinal ciliary rows. There is a ciliated infundibulum situated at the broad end of the organism which may be termed as oral instead of being called the anterior, as this latter term may lead to a confusion while considering the movement of this organism. At the aboral end there is a canal which opens to the exterior. While progressing the organism also spins round its longitudinal axis and has its oral end always directed backwards.

*Dasytricha ruminatium* Schuberg, 1888.

This species is smaller than the previous one and is characterised by the arrangement of cilia in spiral rows. It occurred along with the *I. prostoma*.

***Ophryoscolecidae*** Dogiel, 1925.

Before describing the ciliates of this family few words about the use of the term "forma" may be found helpful. Sharp in 1914 united five species of *Epidinium* (*Diplodinium*) into one as they differed from one another, only in number of spines and designated them as "formae" of the species. He pointed out that these differences were stable and were carried from generation to generation. Therefore, according to Sharp "forma" is a taxonomic unit. Dogiel (1927), however, introduced a change in the definition of this term. According to him a "forma" is a taxonomic unit half-way between an individual variation and a species. He states that as a result of repeated vegitative multiplication in *Caloscolex camelinus*, occassionally the anterior daughter changed into another forma by changing the number of spines. Kofoid and Mac Lennan (1930) have correctly pointed out that this difference in definition presents practical difficulty from taxonomic stand point and that the term "forma" instead of adding a taxonomic unit of any value, introduces a confusion in the nomenclature. Therefore, having followed Kofoid and Mac Lennan, I have also refrained from using the term "forma" in this paper. All the ciliates described under this family are for the first time recorded from the Indian goat.

*Entodinium simplex* DOGIEL, 1925.

This species is present in all the individuals examined but never in large numbers. The lateral sides are flattened an the macronucleus scarcely extends up to the distal half of the dorsal side.

*Entodinium dubardi* BUISSON, 1923.

This species is present in large numbers and occurs more or less constantly. The macronucleus is variable in size and usually reaches the middle of the dorsal side. It is slightly broader than the previous species. The goat No. 5 which had almost a pure culture of several species of *Entodinium* contained this species in large number.

*Entodinium vorax* DOGIEL, 1925.

This species also occurs pretty constantly and is distinguished by its large size and convex dorsal and ventral surfaces. Ciliates of smaller dimensions are often found in the endoplasmic sac of this organism.

*Entodinium ovinum* DOGIEL, 1927.

This is an oval species with long macronucleus which reaches almost to the posterior third of the body. It has been noted in two cases.

Dimensions are slightly smaller than the type species:

| | |
|---|---|
| Body length | 45—50 $\mu$ |
| Dorsoventral diameter | 15—21 $\mu$ |
| Transdiameter | 18—21 $\mu$ |
| Macronucleus | 25—28 $\mu$ |

*Entodinium longinucleatum* DOGIEL, 1925.

This species can at once be distinguished from others by its long macronucleus which reaches upto the posterior end. This was present in three cases.

*Entodinium loboso-spinosum* DOGIEL, 1925.

Syn. *E. dubardi* BUISSON, 1923 forma *spinosum* DOGIEL, 1925.

This species is marked by its dorsal surface being drawn into a small posterior spine and the ventral surface to a blunt lobe. It was found to occur in small numbers in two goats.

*Entodinium dilobum* Cunha, 1914.

Syn. *E. furca* Cunha, 1914 forma *dilobum* Dogiel, 1927.

This species has been met with only in two cases. The two posterior lobes, one dorsal and the other ventral, are slightly curved towards the middle but are not so wide apart as has been figured by Dogiel. The macronucleus is elongated and extends slightly beyond the middle of the body. In few cases the nucleus is found to be ovoidal instead of being elongated.

*Entodinium nanellum* Dogiel, 1927.

This organism was found in only one case. It slightly differed from the type species in dimensions and the position of the sausage-shaped nucleus which was often seen to lie towards the posterior end of the dorsal side.

| | |
|---|---|
| Body length | 30—35 $\mu$ |
| Dorsoventral diameter | 17—20 $\mu$ |
| Transdiameter | 18—20 $\mu$ |
| Macronucleus | 2— 3 $\mu$. |

The ventral side is slightly concave but not so much as has been figured by Dogiel. This is for the first time recorded from goat.

*Entodinium elongatum* Dogiel, 1927.

This species was encountered in one case only. It is very much similar to *E. nanellum* in appearance except it is larger in dimensions and that the endoplasmic sac is comparatively clear.

*Entodinium monolobum* Dogiel, 1925.

Syn. *E. anteronucleatum* forma *monolobum* Dogiel, 1925.

In three cases this species was found to occur in fairly large numbers. The nucleus is elongately oval and is situated at the extreme anterior end of the dorsal side. The posterior end of the dorsal side evenly curves towards the middle while the ventral side is drawn out into a small process. The endoplasmic sac is filled with food particles of vegetable nature. This is a new record from goat.

*Entodinium anteronucleatum* Dogiel, 1925.

Syn. *E. anteronucleatum* forma *dilobum* Dogiel, 1925.

In two cases it was found to occur along with the previous species. It agrees with *E. monolobum* in all respects except that the dorsal surface is also drawn out into a small lappet which is

smaller than the left one. The endoplasmic sac in this species too is filled with vegetable particles. This species is also a new record from goat.

*Entodinium laeve* DOGIEL, 1925.

forma *laeve* DOGIEL, 1927.

This species was encountered in small numbers in one case only. The nucleus is situated at the extreme anterior end of the dorsal side. The posterior end is not drawn out into process of any kind. The ventral side is not flattened but like the dorsal it is slightly convex. This has not been recorded before from goat.

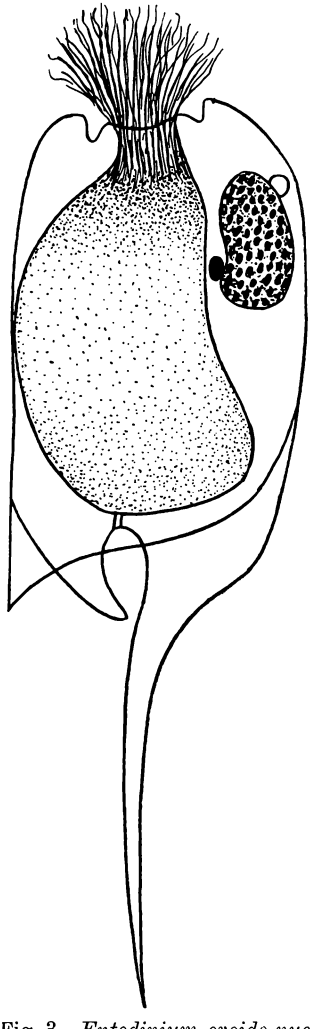

Fig. 3. *Entodinium ovoido nucleatum* n. sp. × 1666.

*Entodinium caudatum* STEIN, 1859

This species was found to occur in large numbers in two cases. The posterior end of the dorsal side is drawn out into a long spine 14—18 $\mu$ long, while the ventral side has two lateral projections. These two lateral projections vary in their arrangement, they may either lie parallel to each other or one of them may pass inwards mesially. Forms with shorter dorsal spine are also present and I believe that they are the developmental forms of the same species. This is a new record from goat. In some of the specimens the presence of organisms like Sphoeritta appeared to have a degenerating effect on the nucleus of this protozoa.

*Entodinium ovoido-nucleatum* n. sp. (Fig. 3).

This species was present in small numbers in two cases only. As regards its posterior end it is very much similar to the previous species while other features are quite different from any known species of *Entodinium*. The most impor-

tant character which singles it out is the ovoid macronucleus which does not extend beyond the middle of the dorsal side of the body. The micronucleus is situated on the inner posterior side of the macronucleus. The contractile vacoule is placed on the outer anterior side of the macronucleus. The ventral side is almost straight and flattened while the dorsal side is slightly convex.

Dimensions:

| | |
|---|---|
| Body length | 25—30 $\mu$ |
| Dorsoventral diameter | 22—25 $\mu$ |
| Transdiameter | 22—24 $\mu$ |
| Macronucleus | 11— 7 $\mu$ |
| Spine | 28—30 $\mu$. |

*Entodinium laterale* Kofoid and MacLennan, 1930.

This species was found in two cases. It is a new record from goat.

*Entodinium rectangulatum* Kofoid and MacLennan, 1930.

This species was found to occur in two cases along with the above species. It differs from the type species in dimensions:

| | |
|---|---|
| Body length | 40—50 $\mu$ |
| Dorsoventral diameter | 25—30 $\mu$ |
| Transdiameter | 23—30 $\mu$ |
| Macronucleus | 18—10 $\mu$ |
| Tail | 14—20 $\mu$. |

The micronucleus is placed at the inner anterior end instead of middle of the macronucleus. It is a new record from goat.

*Entodinium ekendrae* n. sp. (Fig. 4 a, b).

This species whas present in two cases. The dorsal side is convex and posteriorly the right side is drawn into a long spine. The ventral side is flat and the left posterior side has got two lateral projections which are smaller than one on the right side.

The broadly oval nucleus is situated at the

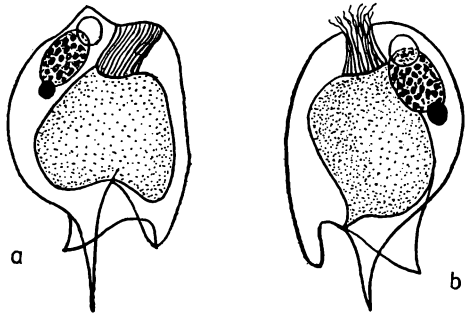


Fig. 4. *Entodinium ekendrae* n. sp. × 730. a right view, b left view.

anterior end and never reaches beyond the middle. The micronucleus is placed at the posterior end of the macronucleus. The endoplasmic sac is clear.

Dimensions:

| | |
|---|---|
| Body length | 30—35 $\mu$ |
| Dorsoventral diameter | 30—33 $\mu$ |
| Transdiameter | 28—30 $\mu$ |
| Macronucleus | 12—16 by 8—10 $\mu$ |
| Tail | 18—20 $\mu$. |

*Entodinium biconcavum* KOFOID and MAC LENNAN, 1930.

This species was found in one case. It is marked by having its left and right sides concave or deeply compressed. The macronucleus is narrow towards the anterior end and massive towards the posterior. The micronucleus is placed at the inner anterior end of the macronucleus. It is larger in size than the type species.

| | |
|---|---|
| Body length | 39—45 $\mu$ |
| Dorsoventral diameter | 30—34 $\mu$ |
| Transdiameter | 22—26 $\mu$ |
| Macronucleus | 18—23 $\mu$ |
| Ventral lobe | 5— 8 $\mu$. |

*Entodinium setnai* n. sp. (Fig. 5 a, b).

This species was present in one case only. The anterior end is broader than the posterior. The dorsal side is convex anteriorly and ends in a blunt lobe posteriorly, while the ventral side is more or less straight and terminates in two small and pointed processes — the left one being more pointed than the right which has a broad base. The most important feature, however, is the spherical nature of the macronucleus which is situated at the middle of the dorsal side. The contractile vacuole is placed anterior to the nucleus. The endoplasmic sac is clear.

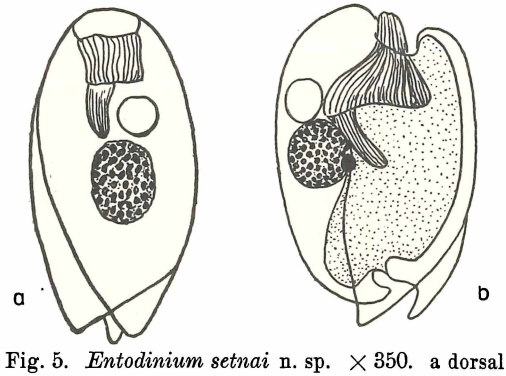


Fig. 5. *Entodinium setnai* n. sp. × 350. a dorsal view, b right view.

Dimensions:

| | |
|---|---|
| Body length (including the process) | 50—60 $\mu$ |
| Dorsoventral diameter | 38—42 $\mu$ |
| Transdiameter | 26—30 $\mu$ |
| Macronucleus (spherical) | 10—12 $\mu$. |

*Entodinium chatterjeei* n. sp. (Fig. 6).

This species was found to occur in six cases. It is broad anteriorly and gradually tapers towards the posterior end. The ventral side is slightly concave or straight. The macronucleus is ovoidal to spherical in shape, and has the micronucleus situated towards its inner anterior end.

Dimensions:

| | |
|---|---|
| Body length | 26—35 $\mu$ |
| Dorsoventral diameter | 15—18 $\mu$ |
| Transdiameter | 15—18 $\mu$ |
| Macronucleus | 16×8 $\mu$ or 16 $\mu$. |

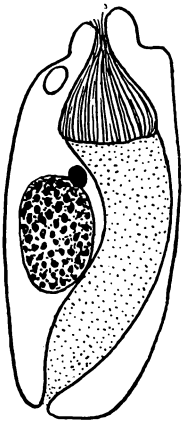

Fig. 6. *Entodinium chatterjeei* n. sp. × 730.

## Genus *Diplodinium* Schuberg, 1888.

This genus was established by Schuberg in 1888 for including those species of Ophryoscolecidae which have a short membranelle zone in addition to the adoral membranelle zone. Dogiel in 1927 established four sub-genera of *Diplodinium*, *Anoplodinium*, *Eudiplodinium*, *Ostracodinium* and *Polyplastron*. But Becker and Hsiung in 1930 (in Hegner and Andrews, 1930, p. 50) drew attention to Art. 9 of "The International Rules of Zoological momenclature" which states: "If a genus is divided into sub-genera, the name of the typical sub-genus must be the same as the name of the genus". Dogiel has, therefore, disregarded this rule and hence this name of his first sub-genus should read *Diplodinium* and not *Anoplodinium*, the name *Anoplodinium* is a synonym of *Diplodinium*. Kofoid and Mac Lennan in 1932 pointed out that "the four sub-genera established by Dogiel show important differences in nuclear structure and skeletal plates, which distinctly separate them". They have, therefore, raised the sub-genera to the full generic rank, re-established the genus *Metadinium* Awerinzew and Mutafowa (1914), which was suppressed by Dogiel, and have described five new genera: *Eodinium*, *Eremoplastron*,

*Diploplastron*, *Elytroplastron* and *Enoplastron*. Of these five genera species belonging to *Eremoplastron*, *Diploplastron* and *Elytroplastron* have also been found to occur in the goats examined. I believe that KOFOID and MACLENNAN (1932) are justified in raising the sub-genera to the generic rank and erecting new genera for receiving forms which have hitherto been knocked about from one sub-genus or other.

*Anacanthum group.*

The species of *Diplodinium* belonging to this group as pointed out by KOFOID and MACLENNAN (1932) are marked by "a tapering of the posterior half of the body, giving it a somewhat conical aspect".

*Diplodinium anisacanthum* DA CUNHA, 1914.

Syn. *Anoplodinium denticulatum* forma *anisacanthum* DOGIEL, 1927.
*Metadinium anisacanthum* CRAWLEY, 1923.

This species was met with in small numbers only in four cases. It can at once be diagnised by six posterior spines — one dorsal, one ventral and two on each side. It is for the first time recorded from goat. It differs from *Diplodinium dentatum* in having its posterior end narrow and conical and not broad and abruptly truncated as in the other.

*Bubalidis group.*

In this group of *Diplodinium* the organisms have a small longitudinal, cuticular groove extending a short distance anteriorly from the right border of the anus and the endoplasmic sac reaches anteriorly into the operculum. Sometimes a long, thin ventral spine which has narrow base, may be present.

*Diplodinium consors* DOGIEL, 1925.

Syn. *Diplodinium bubalidis* forma *consors* DOGIEL, 1915.
*Anoplodinium bubalidis* forma *consors* DOGIEL, 1927.

This species was found to occur in one case only. The body is oval with dorsal side being more convex than the ventral. A thin ventral spine is present. The anterior end of the macronucleus is bent at about 90° towards the median axis. The micronucleus is situated at this bend dorsally. There are two contractile vacuoles. It is for the first time recorded from goat.

*Rangiferi group.*

*Diplodinium* of this group are marked out 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 being 1.2—1.6 dorsoventral diameters in length.

*Diplodinium costatum* Dogiel, 1925.

Syn. *Diplodinium costatum* forma *major* Dogiel, 1925.
*Anoplodinium costatum* forma *major* Dogiel, 1927.

It occurred in two cases. Body is broadly oval — truncated anteriorly and triangular posteriorly. The endoplasmic sac extends into the operculum. 1.4 dorsoventral diameters in length. It is a new record from goat.

*Crista-galli group.*

Species of *Diplodinium* included in this group have roughly triangular outline, truncate anteriorly and tapering posteriorly. The rectum is long and, circular in transverse section.

*Diplodinium crista-galli* Dogiel, 1927.

Syn. *Anoplodinium crista-galli* forma *crista-galli* Dogiel, 1927.

This species was found to occur in small number in two cases. The posterior fan-wise extension of the left side marks this species out from others. This fan-like extension consisted of five to six small spines. The macronucleus in sausage-shaped, anterior end being more broad than the posterior. The typical anterior dorsal notch in the macronucleus is absent and the micronucleus is situated at its dorsal anterior extermity. There is a single contractile vacuole and not two as in the type species.

## Genus *Eremoplastron* Kofoid and MacLennan, 1932.

Ophryoscolecidae with two membranelle zones, adoral and dorsal zone; a single narrow skeletal plate beneath the right surface; triangular of rod-like macronucleus, anterior end often bent ventrally; two contractile vacuoles.

Two species of this genus are found to occur in the goats examined.

*Eremoplastron rostratum* Fiorentini, 1889.

Syn. *Diplodinium rostratum* Fiorentini, 1889; Eberlein 1890.
*Eudiplodinium rostratum* Dogiel, 1927.
*Diplodinium helseri* Becker and Talbott, 1927.

This species occurred in very small numbers in two cases. The ventral spine is comparatively long. The right skeletal plate unlike

the type species reaches beyond the posterior end of the macronucleus. It is a new record from goat.

*Eremoplastron brevispinum* KOFOID and MACLENNAN, 1932.

This species occured side by side with the previous one and is nearly double in size. The ventral spine is smaller than in the previous species. Here too the right skeletal plate reaches beyond the posterior end of the macronucleus. It is a new record from the goat.

## Genus *Eudiplodinium* DOGIEL, 1927.

Ophryoscolecidae with two membranelle zone, one adoral and the other a dorsal zone; a single narrow skeletal plate beneath the right surface; fork-like macronucleus with a hook-like anterior end opening dorsally; cuticle and ectoplasm thick; two contractile vacuoles. One species *Eudiplodinium maggii* occurs commonly among the goats examined.

*Eudiplodinium maggii* FIORENTINI, 1899.

Syn. *Diplodinium maggii* FIORENTINI, 1889; EBERLEIN, 1895; BUISSON, 1923.
*Diplodinium bursa* SCHULZE, 1924; *Eudiplodinium magii* DOGIEL, 1927.

In four cases this species was present in fair number. Macronucleus with dorsal anterior hook-shaped opening and a single skeletal plate on the right lateral side marks this organism out from others. The endoplasmic sac contains vegetable particles.

## Genus *Dipoplastron* KOFOID and MACLENNAN, 1932.

Ophryoscolecidae with two membranelle zones, one adoral and the other a dorsal zone; two skeletal plates on the right side; the anterior end of the plates are separate, while the posterior part come close together, but do not fuse; rectum is a narrow, tubular structure with thin walls; anus circular and small.

*Diplaplostron affine* DOGIEL and FEDOROWA, 1925.

Syn. *Diplodinium affine* DOGIEL and FEDOROWA, 1925.
*Eudiplodinium affine* DOGIEL, 1927.

This species was found in one case only. It is smaller in size than *Metadinium* with which it is otherwise identical. KOFOID and MACLENNAN (1932), state that "*Diploplastron* has the general structures of *Eremoplastron* combined with the two skeletal plates of *Metadinium* and may represent an evolutionary stage between *Eremoplastron* and *Metadinium*".

**Genus *Metadinium*** Awerinzew and Mutafowa, 1914.

Ophryoscolecidae with dorsal and adoral membranelle zones at anterior and of the body; two skeletal plates on the right surface occassionally fused at posterior end; large macronucleus with two or three prominent dorsal lobes; two contractile vacuoles lying close to the nucleus.

*Metadinium medium* Awerinzew and Mutafowa, 1914.

It occurred side by side with the *Diploplastron affine*. Its large size and prominent dorsal lobes on the dorsal side of the macronucleus helps one to distinguish it from the former.

**Genus *Elytroplastron*** Kofoid and MacLennan, 1932.

Ophryoscolecidae with dorsal and adoral membranelle zones; two skeletal plates beneath right surface, small plate beneath ventral surface, and a long plate beneath the left surface.

*Elytroplastron bubali* Dogiel, 1928.

Syn. *Diplodinium* (*Polyplastron*) *bubali* Dogiel, 1928.

It occurred in four cases. Four distinct skeletal plates and a narrow triangular area between the anterior ends of the ventral and left skeletal plates clearly distinguishes this organism from others. This triangular area may or may not stain with Chlor-zinc-iodine. There are usually two contractile vacuoles, very rarely three, but never more than that. In this respect it does not agree with the type species where four or sometimes five contractile vacuoles are known to occur. The ventral skeletal plate is also slightly longer than what it is in the type species. It is a new record from the goat.

**Genus *Epidinium*** Crawley, 1923.

Ophryoscolecidae with the dorsal membranelle zone situated a little distance behind the adoral membranelle zone; three skeletal plates, one ventral, one right and the other left; macronucleus club-shaped; two contractile vacuoles; the posterior end may or may not be drawn out in to spines of varying lengths.

In order to avoid confusion the genus *Epidinium* should be allowed to stand separate and not merged into *Diplodinium* as Hsiung (1931) has apparently done. Moreover, in the light of the research of Kofoid and MacLennan (1932), who have thoroughly revised the genus *Diplodinium*, this genus is not to be included in *Diplodinium*. The situation of the dorsal membranelle zone a little distance behind the adoral zone, and constantly occurring three skeletal plates are characters of sufficient importance to merit a distinct genus.

*Epidinium ecaudatum* (FIORENTINI, 1889); CRAWLEY, 1923.
Syn. *Diplodinium ecaudatum* FIORENTINI, 1889.
*Diplodinium ecaudatum* forma *ecaudatum* SHARP, 1914.
*Ophryoscolex inermis* RAILLET, 1890.
*Ophryoscolex labiatus* AWERINZEW and MUTAFOWA, 1914.

This species was found to occur in two cases side by side with other species of *Epidinium*. The posterior end is not drawn out into any kind of process and thus marks it out from all other members of this genus.

*Epidinium caudatum* FIORENTINI, 1889.
Syn. *Epidinium ecaudatum* forma *ecaudatum* (FIORENTINI, 1889) DOGIEL, 1927.
*Diplodinium ecaudatum* FIORENTINI, 1889.
*Ophryoscolex inermis* RAILLET, 1890.
*Ophryoscolex inermis* var. *caudatus* DA CUNHA, 1914.
*Ophryoscolex intermixtus* AWERINZEW and MUTAFOWA, 1914.
*Diplodinium ecaudatum* forma *caudatum* SHARP, 1914.

This species occurred in small numbers in three cases. The ventral posterior end is drawn out into a long tail which is broad at the base and pointed at the extremity. It is a new record from goat.

*Epidinium cattenoi* FIORENTINI, 1889.
Syn. *Epidinium ecaudatum* forma *cattenoi* (FIORENTINI, 1889) DOGIEL, 1927.
*Diplodininm cattenoi* FIORENTINI, 1889.
*Ophryoscolex cattenoi* RAILLET, 1890.
*Ophryoscolex parvicaudata* AWERINZEW and MUTAFOWA, 1914.
*Diplodinium ecaudatum cattenoi* SHARP, 1914.

This species was found to occur in fair numbers in four cases. There are five caudal spines, one dorsal, one ventral or preanal, two on the right, and one on the left. The left is almost of the same length as the ventral and not smaller than the latter as in the type species.

## Genus *Ophryoscolex* STEIN, 1858.

Ophryoscolecidae with the dorsal zone of membranelle situated much behind the adoral zone of membranelle and girdle round the whole of the dorsal and part of the ventral side; there are two rows of contractile vacuoles; posterior end is drawn out into many processes or spines variously arranged; there are three skeletal plates one right, one left and the other ventral.

Only one species, *Ophryoscolex tricoronatus* was found to occur in goats examined.

## *Ophryoscolex tricoronatus* Eberlein, 1895.

Syn. *Ophryoscolex caudatus* Eberlein, 1895.
*Ophryoscolex caudatus* forma *tricoronatus* Dogiel, 1927.

This species was found in fair number in two cases. The posterior end has three crowns of spines which are usually triforked. The posterior most crown sends out a long caudal spine.

Table showing the incidence of various species of protozoa found in rumen of the goat in Calcutta.

| Name of protozoa | Designation of goat | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| *Entamoeba ovis* | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Oikomnas communis* | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Selenomonas ruminatium* var. *caprae* nova var. | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Callimastix frontalis* | · | · | · | · | · | · | · | · | · | · | · | " | 1 |
| *Trichomonas ruminatium* | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Chilomastix caprae* | · | · | · | · | · | · | · | · | · | " | " | " | 3 |
| *Monocercomonas caprae* n. sp. | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Isotricha prostoma* | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Dasytricha ruminatium* | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *Entodinium simplex* | " | " | " | " | " | " | " | " | " | " | " | " | 12 |
| *E. dubardi* | · | · | " | " | " | " | " | " | " | " | " | " | 10 |
| *E. vorax* | " | " | · | · | " | " | " | " | " | " | " | " | 10 |
| *E. ovinum* | " | " | · | " | · | · | · | · | · | · | · | · | 3 |
| *E. longinucleatum* | · | · | " | " | · | " | · | · | · | · | · | · | 3 |
| *E. loboso-spinosum* | · | " | · | · | " | · | · | · | · | · | · | · | 2 |
| *E. dilobum* | · | " | · | · | " | · | · | · | · | · | · | · | 2 |
| **E. nanellum* | " | · | · | · | · | · | · | · | · | · | · | · | 1 |
| *E. elongatum* | · | · | · | · | · | · | · | · | · | · | · | · | 1 |
| **E. monolobum* | · | " | · | · | " | · | · | " | · | · | · | · | 3 |
| **E. anteronucleatum* | · | " | · | · | " | · | · | · | · | · | · | · | 2 |
| **E. leave* | " | · | · | · | · | · | · | · | · | · | · | · | 1 |
| **E. caudatum* | " | · | " | · | · | · | · | · | · | · | · | · | 2 |
| *E. oviodo-nucleatum* n. sp. | " | · | " | · | · | · | · | · | · | · | · | · | 2 |
| **E. laterale* | · | " | · | " | · | · | · | · | · | · | · | · | 2 |
| **E. rectangulatum* | " | · | " | · | · | · | · | · | · | · | · | · | 2 |
| *E. ekendrae* n. sp. | · | " | · | · | " | · | · | · | · | · | · | · | 2 |
| *E. biconcavum* | · | · | · | · | " | · | · | · | · | · | · | · | 1 |
| *E. setnai* n. sp. | · | · | · | · | " | · | · | · | · | · | · | · | 1 |
| *E. chatterjeei* n. sp. | " | " | · | · | " | " | · | " | " | · | · | · | 6 |
| **Diplodinium anisacanthum* | · | " | · | " | · | " | · | " | · | · | · | · | 4 |
| **D. consors* | · | · | · | " | · | · | · | · | · | · | · | · | 1 |
| **D. costatum* | · | · | · | · | · | · | · | " | · | · | · | · | 2 |
| *D. crista-galli* | · | · | · | " | · | " | · | · | · | · | · | · | 2 |
| **Eremoplastron rostratum* | · | · | · | " | · | " | · | · | · | · | · | · | 2 |
| *Eudiplodinium maggii* | · | · | · | " | · | " | · | " | · | " | · | · | 4 |
| *Diploplastron affine* | · | · | · | · | · | " | · | · | · | · | · | · | 1 |
| *Metadinium medium* | · | · | · | · | · | " | · | · | · | · | · | · | 1 |
| **Elytroplastron bubali* | · | · | · | " | · | " | · | " | · | · | · | " | 4 |
| *Epidinium ecaudatum* | · | · | · | " | · | " | · | · | · | · | · | · | 2 |
| **E. caudatum* | · | · | · | " | · | " | · | " | · | · | · | · | 3 |
| *E. cattenoi* | · | · | · | " | · | " | · | " | · | · | " | · | 4 |
| *Ophryoscolex tricoronatus* | · | · | · | " | · | · | · | " | · | · | · | · | 2 |

* New record from goat.

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[1]) For full list consult DOGIEL (1927), and KOFOID and MAC LENNAN (1930, 1932).