**Four New Rumen Ciliates, *Entodinium ogimotoi* sp. n.,
E. bubalum sp. n., *E. fujitai* sp. n. and *E. tsunodai* sp. n.
and *Oligoisotricha bubali* (Dogiel, 1928) n. comb.**

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(Received for publication July 3, 1980)

Abstract. A survey was conducted on 29 water buffaloes, *Bubalus bubalis* (Linnaeus), in Taiwan to clarify the geographical distribution of rumen ciliate protozoa. Four new species of the genus *Entodinium* were recognized: *E. ogimotoi* sp. n., *E. bubalum* sp. n., *E. fujitai* sp. n. and *E. tsunodai* sp. n. *E. ogimotoi* is rectangular to nearly square in body contour with 2 flattened triangular lobes at the posterior end of the body. Cytoproct is situated right on the median line. The body is 30–47 μ m long. *E. bubalum* is ovoid or elliptical with 2 caudal spines, which are close to each other and situated near the middle of the posterior end of the body. The upper-right spine is shorter than the lower-left one. The body is 25–45 μ m long. *E. fujitai* is asymmetrical in shape. Its body surface is strongly convex on the right side and concave in the anterior half of the left side. Its tail is composed of 2 heavy spines. The body is 23–32 μ m long. This species is closely related to *E. gibberosum* Kofoed et MacLennan, 1930 and *E. triangulatum* Dehority, 1979. However, *E. fujitai* is distinguished from the former by the presence of a relatively short macronucleus without a notch, and from the latter by the absence of the triangular wedge of ectoplasm. *E. tsunodai* is ovoid, with 4 caudal spines. Of these spines, two are situated laterally and the others centrally. One of the two central spines is larger than any other spine, and the other three are of essentially the same size. The body is 28–40 μ m long. This species is closely related to *E. indicum* Kofoed et MacLennan, 1930, from which it is distinguished by the number of caudal spines and the situation of a contractile vacuole. *Isotricha bubali*, detected and described first by Dogiel from the water buffalo in Turkestan, was redescribed and the new genus, *Oligoisotricha*, was proposed for it.

Water buffalo (*Bubalus bubalis*) is one of the most common domestic ruminants in the tropical zone. It is distributed in Southeast and West Asia, North Africa and South Europe. The rumen ciliate fauna of the water buffalo in these areas has been reported by Dogiel [6] in Turkestan and Banerjee [1] in India. Thirty-five species were described by the former and 20 by the latter. More recently, Dehority [4] described 49 species in Brazilian water buffaloes. The ciliate fauna, however, has scarcely been surveyed in swamp-type water buffaloes of Taiwan.

The author obtained four new species of *Entodinium* from the rumen of 29 water buffaloes of Taiwan. The four species were described as *Entodinium ogimotoi* sp. n., *Entodinium bubalum* sp. n., *Entodinium fujitai* sp. n., and *Entodinium tsunodai* sp. n., respectively. In addition, one species, *Isotricha bubali* Dogiel, 1928, was redescribed as *Oligoisotricha bubali* in this paper.

Materials and Methods

Samples of rumen contents were collected from 29 adult water buffaloes within 1 hour after

slaughter at abattoirs in Taipei and Peitong, Taiwan, in January, 1979. All the hosts had been fed mainly with the sugar cane grass. Thirty milliliters of rumen contents taken from each host was diluted with 60 ml of MFS solutoin, which was composed of 0.06% (W/V) methylgreen and 0.8% (W/V) NaCl in 10% (V/V) formalin, to fix and stain the nuclei of ciliates for temporary preparations. Some samples were fixed in 10% (V/V) formalin and stained with Mayer's hematoxylin for whole mounts. The genera and species of the ciliates were identified mainly on the basis of the descriptions by the previous workers [5, 6, 8–15]. The terminology used for describing the structure and orientation of the ciliates was conformed to the system proposed by Lubinsky [16] and Dehority [4]. The same nomenclature as proposed by Lubinsky [15] was used for genera and family *Ophryoscolecidae*.

Measurement of the ciliates was made by an ocular micrometer. Mean body length and width were calculated from the measurements of 20 individuals selected at random.

Results and Discussion

Of the 23 species detected in the present investigation and belonging to the genus *Entodinium*, four were considered to be new to science.

Family *Ophryoscolecidae*

Entodinium ogimotoi sp. n.

(Figs. 1, 6, and 7)

Diagnosis: Rectangular to nearly square, $30\text{--}47 \times 22\text{--}25\ \mu\text{m}$; a length to width ratio 1.46; with two flattened triangular lobes at the posterior end of body; cytoproct situated right to median line.

Description: Viewed from the upper side, the body is rectangular to nearly square in outline. Its surface is smooth. Two flattened and triangular lobes are present at the posterior end of body; the left one is larger than the right. The cytoproct is situated between the two lobes, right to the median line of body. The rectum is present approximately parallel to the body axis. The esophagus is funnel-

shaped and bent toward the macronucleus. The macronucleus is rod-shaped and fairly long. The macronucleus is about a half of the body length. The anterior end of the macronucleus is thick and the posterior end thin. An elliptical micronucleus is situated above the left edge of macronucleus, somewhat anterior to the middle. A contractile vacuole lies just anterior to the macronucleus.

Dimension:

Length: $38.7 \pm 4.9\ \mu\text{m}$ (30–47 μm)

Width: $26.7 \pm 2.9\ \mu\text{m}$ (22–35 μm)

L/W: 1.46 ± 0.15 (1.07–1.67)

Type Host: *Bubalus bubalis*, Taipei, Taiwan.

Incidence: *E. ogimotoi* was detected in 17.2% of the water buffaloes surveyed.

REMARKS.

E. ogimotoi is similar to *E. bimastus* Dogiel, 1927, *E. rectangulatum* forma *dubardi* Buisson, 1923, and *E. truncatum* Bush et Kofoed, 1948 in morphology [2, 5, 13]. The new species differs from *E. bimastus*, since the posterior part of its body is not slender, and from *E. rectangulatum* forma *dubardi*, since its contractile vacuole is situated just anterior to the macronucleus. It also differs from the two species, since its cytoproct is situated right to the median line. *E. ogimotoi* is also similar to *E. truncatum*, except that the latter species has a single short macronucleus. In addition, triangular lobes are found in *E. ogimotoi*, but not in any of the other three species.

Entodinium bubalum sp. n.

(Figs. 2 and 8)

Diagnosis: Ovoid or elliptical with two caudal spines, $25\text{--}45 \times 20\text{--}25\ \mu\text{m}$; a length to width ratio 1.49; two caudal spines are situated close to each other near the middle of the posterior end of body, the upper-

Fig. 1. *Entodinium ogimotoi* sp. n. A: lower side; B: upper side.

Fig. 2. *Entodinium bubalum* sp. n. A: lower side; B: upper side.

right spine being shorter than the lower-left one; the upper surface of the posterior end concave.

Description: Viewed from the upper side, the body is ovoid or elliptical. The anterior end of body is flattened. Two caudal spines protrude at the posterior extremity of body. They are very close to each other. The upper-right spine is shorter than the lower-left one. Both spines appear as if they were a single spine. The extremity of each spine is bent rightward. The posterior end of body collapses on the upper side, but not on the lower side. The esophagus is funnel-shaped. The macro-

nucleus is sausage-shaped and longer than two-thirds of body length. The anterior end of the macronucleus is approximately the same in thickness as the posterior end. An elliptical micronucleus is situated on the left-upper side of the macronucleus at about one-third of the distance from the anterior end. A contractile vacuole lies just anterior to the macronucleus.

Dimension:

Length: $35.4 \pm 5.0 \mu\text{m}$ (25–45 μm)

Width: $23.6 \pm 1.8 \mu\text{m}$ (20–25 μm)

Caudal spine: $9.2 \pm 2.4 \mu\text{m}$ (5–13 μm)

L/W: 1.49 ± 0.14 (1.25–1.80)

Variation: The ratio of caudal spines to

Fig. 3. *Entodinium fujitai* sp. n. A: lower side; B: upper side.

body length shows a fairly wide variation of 0.2–0.5.

Type Host: *Bubalus bubalis*, Taipei, Taiwan.

Incidence: *E. bubalum* was detected in 6.9% of the water buffaloes surveyed.

REMARKS.

There are considerable differences in the shape and situation of the caudal spines between *E. bubalum* and any other species of the same genus. That species is rather similar to *E. incurvatum* Dogiel, 1932 [7] in morphological characters. The new species is easily distinguished from *E. incurvatum* by morphological characteristics, such as the size of caudal spine and the shape of macronucleus.

Entodinium fujitai sp. n.
(Figs. 3, 9, and 10)

Diagnosis: Right surface of body strongly convex, in nearly a quarter-round shape; left surface concave especially in another half, $23\text{--}32 \times 18\text{--}25 \mu\text{m}$; a length to width ratio 1.27; tail composed of two heavy spines, left one curves so sharply as to be surrounded by right one.

Description: Viewed from the upper side, the body is asymmetrical. The right

surface is strongly convex, in nearly a quarter-round shape. The left surface is concave in the anterior half. The curved and heavy caudal spines are both situated side by side. The right spine curves toward the left and the left spine so sharply toward the right as to be surrounded by the right spine. These two spines are close to each other. The esophagus is funnel-shaped and bent rightward. A short and rod-shaped macronucleus is situated in the antero-lateral part of the body, which is about one-fourth of the body length. The anterior end of the macronucleus is thick and the posterior end thin. An elliptical micronucleus lies on the left margin of the macronucleus somewhat anterior to the middle. A contractile vacuole is situated anterior to the micronucleus and close to the upper wall of the body.

Dimension:

Length: $26.4 \pm 2.5 \mu\text{m}$ (23–32 μm)

Width: $20.8 \pm 1.5 \mu\text{m}$ (18–25 μm)

Caudal spine: $4.6 \pm 0.8 \mu\text{m}$ (3–6 μm)

L/W: 1.27 ± 0.10 (1.15–1.50)

Type Host: *Bubalus bubalis*, Taipei, Taiwan.

Incidence: *E. fujitai* was detected in 13.8% of the water buffaloes surveyed.

Fig. 4. *Entodinium tsunodai* sp. n. A: lower side; B: upper side.

REMARKS.

E. fujitai is closely related to *E. gibberosum* Kofoid et MacLennan, 1930 [9] and *E. triangulatum* Dehority, 1979 [4] in general morphological features. It is, however, distinguished from *E. gibberosum* by the following points: (1) the shorter macronucleus without a notch at the anterior end, and (2) the right caudal spine longer than the left one. It is also easily distinguished from *E. triangulatum* by the absence of the triangular wedge of ectoplasm.

Entodinium tsunodai sp. n.
(Figs. 4, 11, and 12)

Diagnosis: Body ovoid or elliptical, $28\text{--}40 \times 23\text{--}28 \mu\text{m}$; a length to width ratio 1.33; with four caudal spines, of which two situated laterally and the other two centrally; one of the central spines the largest and the other three approximately the same in size.

Description: Viewed from the upper side, the body is ovoid or elliptical. The upper surface is slightly concave. Four caudal spines protrude on the posterior extremity of the body. Of them, one is situated on the right side, one on the left, and the other two are near the center. One of the central spines is situated at the upper

level than the other and is the biggest of all. The other three spines are approximately the same in size. Two lateral spines curve somewhat inwards. The esophagus is funnel-shaped and slightly bent rightward. The macronucleus is rod-shaped and nearly straight. Its length is about three-fourths of the body length. Each extremity of the macronucleus is almost flat. A spherical micronucleus is situated near the middle of the left margin of the macronucleus. A contractile vacuole lies above the macronucleus near its anterior extremity.

Dimension:

Length: $34.0 \pm 3.6 \mu\text{m}$ (28–40 μm)

Width: $25.6 \pm 1.9 \mu\text{m}$ (23–28 μm)

Caudal spine: $9.9 \pm 2.0 \mu\text{m}$ (8–13 μm)

L/W: 1.33 ± 0.11 (1.18–1.60)

Type Host: *Bubalus bubalis*, Taipei, Taiwan.

Incidence: *E. tsunodai* was detected in 13.8% of the water buffaloes surveyed.

REMARKS.

E. tsunodai is closely related to *E. indicum* Kofoid et MacLennan, 1930 [9] in general morphological characteristics and size. It is distinguished, however, from *E. indicum* by (1) the number of caudal spines and (2) the situation of the contractile vacuole,

Fig. 5. *Oligoisotricha bubali* (Dogiel, 1928).

which lies above the anterior end of the macronucleus.

Family *Isotrichidae*

Oligoisotricha gen. n.

Diagnosis: Body ovoid with a depression at the posterior end; somatic ciliature covers body surface, except vestibular opening and posterior one-sixth of the surface; one contractile vacuole usually at the posterior part of body.

Type species: *Oligoisotricha bubali* (Dogiel, 1928); the only species of the genus.

Oligoisotricha bubali (Dogiel, 1928)
(Figs. 5, 13, and 14)

Diagnosis: With characters of the genus.

Description: Body is ovoid and flattened bilaterally. A shallow depression is present at the posterior end of body. The body surface bears fairly long, uniform somatic cilia, except the vestibular opening and the posterior one-sixth of the surface, including the depression. Rows of ciliature are arranged almost parallel to the body axis. the vestibulum is wide and long. The macronucleus is spherical and located variably in the endoplasm. A spherical micronucleus is situated near the anterior margin of the macronucleus. A contractile vacuole is usually found at the posterior end of the

body, but sometimes situated variably.

Dimension:

Length: $15.8 \pm 1.9 \mu\text{m}$ (12–20 μm)

Width: $12.2 \pm 1.8 \mu\text{m}$ (8–15 μm)

L/W: 1.30 ± 0.14 (1.07–1.60)

Type Host: *Bubalus bubalis*, Baku, U.S.S.R.

Incidence: *O. bubali* was detected in 41.4% of the water buffaloes surveyed.

REMARKS.

The shape and size of *O. bubali* distinctly differ from those of any other species of the same family in ruminants.

O. bubali was first described as *Isotricha bubali* by Dogiel [6] when detected from a water buffalo in Turkestan. Since then, however, it has not been recorded by any investigator. There were minor differences in morphological features between the present specimens and *I. bubali* described by Dogiel [6]. The former were slightly smaller in body size than the latter and showed a different arrangement of rows of ciliature from that in the latter. All the other characteristics, however, were the same in *O. bubali* as in *I. bubali* described by Dogiel. The genus *Isotricha* has somatic cilia all over the surface and the nucleo-suspensory apparatus [3]. On the other hand, the genus *Dasytricha* has somatic cilia, which are arranged in spiral form around the body axis, all over the surface, and has no nucleo-suspensory apparatus. The present species lacks somatic cilia on the posterior one-sixth of the body surface, but has rows of ciliature arranged parallel to the body axis. It has no nucleo-suspensory apparatus either. So the author proposes the new genus, *Oligoisotricha*, for the present species.

Acknowledgments. This investigation is a part of the joint research with Dr. C. H. Chang, of the Department of Veterinary Medicine, National

Taiwan University, Taipei, Taiwan, and Dr. J. S. Wang, of the Department of Veterinary Medicine, National Chung Hsing University, Taichung, Taiwan. The author is greatly indebted to them and their colleagues for their collaboration in the research. He also wishes to thank Dr. K. Ogimoto, of the Department of Animal Science, Tohoku University, Sendai-shi, for review of this manuscript and Mr. Y. Tazawa, of the Department of Parasitology, Nippon Veterinary and Zootechnical College, Tokyo, for technical assistance.

A part of this work was supported by Grant-in-Aid No. 476214 from the Scientific Research Fund of the Ministry of Education, Science and Culture, Japan.

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要 約

台湾産スイギュウより見いだされたルーメン内繊毛虫の4新種 *Entodinium ogimotoi* sp. n., *E. bubalum* sp. n., *E. fujitai* sp. n., *E. tsunodai* sp. n. の記載および *Isotricha bubali* Dogiel, 1928 の再記載: 今井壯一 (日本獣医畜産大学寄生虫学教室)——台湾産スイギュウ (*Bubalus bubalis*) 29 頭より得たルーメン内容に見いだされる繊毛虫の種類構成について調査した結果, *Entodinium* 属の4種の新種を認め, それぞれ *E. ogimotoi* sp. n., *E. bubalum* sp. n., *E. fujitai* sp. n., *E. tsunodai* sp. n. として記載した. *E. ogimotoi* は長方形を呈し, 後部に2個の扁平な三角形の lobe を有する. 細胞肛門は正中線より大核側に位置する. 体長 30–47 μm . *E. bubalum* は卵形ないし長円形で, 体後端中央部に密接して存在する比較的短い2本の尾棘を有する. 体上部右側の尾棘は体下部左側のものより小さい. 体長 25–45 μm . *E. fujitai* は非対称の外形を呈し, 体右側は凸面を描くが, 体左側はへこむ. 体後端に太く短い2本の尾棘を有し, 左側のものは強く湾曲する. 体長 23–32 μm . 本種は *E. gibberosum* Kofoed et MacLennan, 1930 および *E. triangulatum* Dehority, 1979 に極めて類似するが, 前者とは大核が短く, 大核前端にくぼみがない点で, 後者とは外質の三角形のくさび状突起がない点で異なる. *E. tsunodai* は卵円形を呈し, 体後端に4本の尾棘をもつ. これらのうち, 1本は体左側に, 1本は体右側に, 他の2本は体中央部に存在し, 中央部の1本が最も長く, 他の3本はほぼ同じ長さである. 本種は *E. indicum* Kofoed et MacLennan, 1930 と類似するが, 尾棘の数および収縮胞の位置が異なる. 体長 28–40 μm . また Dogiel (1928) が, トルキスタンのスイギュウで記載した *Isotricha bubali* は, その後報告が見られなかったが, 今回の検索では41.4%のスイギュウから見い出された. しかし, 形態学的検討の結果, *Isotricha* 属とは異なる形質が多いことから, 新たに新属 *Oligoisotricha* を設け, *Oligoisotricha bubali* として再記載した.

Explanation of Figures

Figs. 6 and 7. Optical photomicrographs of *Entodinium ogimotoi* sp. n. Fig. 6. Lower side. Fixed in MFS solution. $\times 630$. Fig. 7. Lower side. Macro- and micronuclei are shown. Mayer's hematoxylin. $\times 630$.

Fig. 8. Optical photomicrograph of *Entodinium bubalum* sp. n. Lower side. Fixed in MFS solution. $\times 600$.

Figs. 9 and 10. Optical photomicrographs of *Entodinium fujitai* sp. n. Fig. 9. Lower side. Fixed in MFS solution. $\times 630$. Fig. 10. Upper side.

Macronucleus is shown. Mayer's hematoxylin. $\times 600$.

Figs. 11 and 12. Optical photomicrographs of *Entodinium tsunodai* sp. n. Fig. 11. Lower side. Fixed in MFS solution. $\times 700$. Fig. 12. Upper side. Macronucleus is shown. Mayer's hematoxylin. $\times 600$.

Figs. 13 and 14. Optical photomicrographs of *Oligoisotricha bubali* (Dogiel). Fig. 13. Fixed in MFS solution. $\times 700$. Fig. 14. Macronucleus is shown. Mayer's hematoxylin. $\times 1,700$.