Rumen Ciliates from the Mongolian Gazelle, *Procapra gutturosa*

Soichi IMAI and GUI RUNG¹⁾

Department of Parasitology, Nippon Veterinary and Zootechnical College, Musashino-shi, Tokyo 180, Japan and

¹⁾Institute of Animal Husbandry and Veterinary Science, Hulunboir District, Inner-Mongolia Autonomous Region, China

(Received 4 April 1990/Accepted 20 June 1990)

ABSTRACT. Rumen ciliate composition was surveyed on the Mongolian gazelle, *Procapra gutturosa* in Inner-Mongolia, China. As a result of survey, 4 species belonging to the genus *Entodinium*, *E. convexum*, *E. dubardi*, *E. nanellum* and *E. exiguum*, were detected. All the ciliates were devoid of caudal appendages. Of the species detected, *E. convexum* was found from all the hosts with a relatively high composition rate of 53.0–100.0%. The ciliate density ranged from 12.3 to 67.7×10^4 , with an average of 24.8×10^4 per 1 ml of the rumen fluid.—**KEY WORDS:** *Entodinium*, Mongolian gazelle, protozoa, rumen ciliates.

Jpn. J. Vet. Sci. 52(5): 1063–1067, 1990

Although gazelles belonging to the tribe Antilopini mainly inhabit savanna in Africa, the animals of the genus *Procapra* are in Central Asia from Tibett to Mongol [20]. The Mongolian gazelle, *Procapra gutturosa*, is distributed around Mongol, and its rumen ciliate composition has been entirely left unsurveyed up to the present. The present examination was carried out as one of the studies to provide informations to the phylogenetic relation among rumen ciliates. The ciliate composition obtained was compared with that of the related animals in Africa, which has been reported by previous investigators.

MATERIALS AND METHODS

Rumen contents examined were collected from the rumina of 5 wild Mongolian gazelles killed during winter at Inner-Mongolia, China from 1987 to 1988. The contents collected were fixed in 3 times volume of MFS solution [19] as soon as possible after the animals were killed, sealed up, and brought to the laboratory. Then, the samples were further added to 3 times volume of MFS solution, and examined with

a light microscope. Counting method and the terminology for the ciliates were in accordance with those used in our previous papers [9, 10].

RESULTS AND DISCUSSION

Only the species belonging to the genus *Entodinium* were detected from the rumen of Mongolian gazelle. These contained 4 species identified on the basis of the descriptions by Dogiel [4, 5], MacLennan [17] and Ogimoto and Imai [19] as shown in Table 1. All the ciliates were devoid of caudal appendages.

The present report of *E. convexum* with relatively high composition rates from all the hosts examined is the second since that by MacLennan from the mule-deer [17]. This species closely resembled *E. dubardi* in body length, body width and the ratio of length to width (L/W) as shown in Table 2. However, *E. convexum* was easily distinguished from *E. dubardi* in the longer macronucleus often bending inward at the anterior end and the presence of longitudinal cuticular groove running on the lower-right side of body (Fig. 1).

Table 1. Species of rumen ciliate protozoa found in the Mongolian gazelle and their percentage composition

Species	Host No.				
	1	2	3	4	5
<i>Entodinium</i>					
<i>convexum</i> MacLennan, 1935	59.5	100.0	92.5	57.1	53.0
<i>dubardi</i> Buisson, 1923	25.0	— ^{a)}	—	42.9	47.0
<i>nanellum</i> Dogiel, 1923	15.5	—	—	—	—
<i>exiguum</i> Dogiel, 1925	—	—	7.5	—	—

a) Not detected.

Table 2. Dimensions of *Entodinium convexum* and *E. dubardi* from the Mongolian gazelle^{a)}

	<i>E. convexum</i>			<i>E. dubardi</i>		
	Mean	SD	(Range)	Mean	SD	(Range)
Body length (μm)	37.3	4.8	(30.0–48.8)	34.3	2.9	(28.8–36.3)
Body width (μm)	26.3	2.6	(22.5–32.5)	24.4	1.4	(22.0–25.8)
L/W	1.41	0.07	(1.27–1.50)	1.41	0.07	(1.31–1.49)
Length of macronucleus (μm)	25.3*	3.6	(17.5–32.5)	18.2	2.8	(15.0–22.5)

a) Except for the individuals just before or after binary fission.

*: $P < 0.01$. Fig. 1. *Entodinium convexum* MacLennan, 1935. Variations in the body shape and the length of macronucleus are shown.

The other three species detected in the present examination were also quite similar to each other in shape. Small sized and non-spinated entodinia, such as *E. dubardi*, *E. simplex*, *E. nanellum* and *E. ovinum*, have been often confused in identification because of slight differences in their morphological characters [22, 23, 26]. Also in the present examination, fairly wide variation in morphological characters was observed in *E. convexum* (Fig. 1). Poljansky and Strelkow [22] and Henpel-Zawitkowska and Latteur [8] contended that the situation and length of macronucleus, by which several species are differentiated, are poor characters for diagnosis, as well as caudal appendages. Synonymy of these species should be reinvestigated carefully in the future.

The rumen ciliate compositions of the Thomson's gazelle, *Gazella thomsoni* [5] and springbok, *Antidorcas marsupialis* [26], which are members phylogenetically related to Mongolian gazelle and inhabit Africa, have been reported: only *E. dubardi* was detected from the Thomson's gazelle, and ten species of *Entodinium* without caudal appendages from the springbok. Of the species described from the springbok by Wilkinson and Van Hoven [26], "*E. parvum*" differs from the original description [1] in the presence of longitudinal cuticular groove and body size, but is quite similar to *E. convexum* reported in the present examination. Both these two species may be the same species.

The detection of only non-spinated entodiniid ciliates in various hosts has also been reported by MacLennan [17], Pearson [21] and Zielyk [27] in *Odocoileus* spp. (mule-deer and white-tailed deer), by Wertheim [25] and Sládeček [23] in *Capreolus capreolus* (roe deer) and by Dehority [3] in *Alces americana* (moose) in addition to Dogiel [5] and Wilkinson and Van Hoven [26]. As the possible reason for the "*Entodi-*

nium only condition", Wilkinson and Van Hoven [26] surmised the low pH ranges of rumen contents. Eadie [6] also reported that only small entodinia were found in the rumen at a pH below 6.5. There are two types of ruminants, browsers and grazers, on the basis of their feeding habit. The composition of rumen ciliates has been reported to be simple in browsers mainly eating food with high nutritive value such as browse [7], and Mongolian gazelles eat mainly browse and partially young grass [20]. Such food can be easily and rapidly fermented by rumen bacteria, so that the pH value in the rumen would fall. This fact may be related to the case in domestic grazers; that is, when they are fed with rich concentrates, rumen pH value would fall due to the increase in lactic acid concentration [16], and populations of rumen ciliates would change from the complex to the simple composition, especially sole *Entodinium* condition [18]. On the other hand, small entodinia having the simplest body structure and very wide host range in the family Ophryoscolecidae are considered to be the most primitive in this family [15]. Most of wild ruminants form very exclusive groups to other species of animals. This habit may reduce the chances for them to be orally infected with additional ciliates. Therefore, this may be a phylogenetic factor for such a ciliate composition.

The lack of caudal appendages in all the species detected may also show the primitivity of these species. However, Lubinsky [14] advocated that when animals are fed a diet with low starch value, ciliates without caudal appendages are predominant, while ciliates with well-developed caudal spines become predominant when the food is rich in starch. Coleman [2] reported that when *E. caudatum* is consecutively cultured *in vitro*, the caudal spines disappear, but when *E. bursa* which feeds on small entodinia is cultured *in vitro* with *E. caudatum* as a food,

Table 3. Ciliate concentration in the Mongolian gazelle

	Host No.					Mean ^{a)}
	1	2	3	4	5	
Density ($\times 10^4/\text{ml}$)	21.1	40.2	67.7	13.4	12.3	24.8

a) Geometric mean.

the caudal spines of *E. caudatum* well develop. From this fact, he considered that the caudal spines of *E. caudatum* develop to protect against engulfment. Both phylogenetic and ecological factors may affect the present ciliate composition consisting of only non-spinated entodinia.

Protozoal concentration in Mongolian gazelles was $24.8 \times 10^4/\text{ml}$ on average ($12.3\text{--}67.7 \times 10^4/\text{ml}$ in range), and generally higher than those in domestic animals [10–13] in spite of simple species composition (Table 3). Rumen of foregut-fermenting herbivores is considered to have a capacity to contain several million ciliates per milliliter of the contents [3, 21, 24, 26]. When a kind of food taken by the host is very suitable for a specific ciliate to grow, it is likely that the ciliate increases in number to the highest concentration level regardless of ciliate composition.

ACKNOWLEDGMENTS. This work was supported by a cooperative research project of the Science and Technology Department of Hulunboir League, Inner-Mongolia Autonomous Region, China and Nippon Veterinary and Zootechnical College, Japan. The authors are greatly indebted to the colleagues of those two research stations for their collaboration in the research. They also wish to thank Dr. Cui Gui Wen, Deputy League Chief of the Administrative Office of Hulunboir League, and Mr. Guan Bu, Section Chief of the Science and Technology Education of Stockbreeding Department, Hulunboir League, Inner-Mongolia, for their helpful arrangements for collection of samples.

REFERENCES

1. Buisson, J. 1923. Sur quelques infusoires nouveaux ou peu connus parasites des mammifères. *Ann. Parasitol. Hum. Comp.* 1: 209–246.
2. Coleman, G. S. 1980. Rumen ciliate protozoa. pp. 121–173. In: *Advances in Parasitology* (Lumsden, W. H. R., Muller, R., and Baker, J. R. eds.), Vol. 18, Academic Press, London & New York.
3. Dehority, B. A. 1974. Rumen ciliate fauna of Alaskan moose (*Alces americana*), musk-ox (*Ovibos moschatus*) and dall mountain sheep (*Ovibos dalli*). *J. Protozool.* 21: 26–32.
4. Dogiel, V. A. 1927. Monographie der Familie Ophryoscolecidae. *Arch. Protistenkd.* 59: 1–288.
5. Dogiel, V. A. 1932. Beschreibung einiger neuer Vertreter der Familie Ophryoscolecidae aus afrikanischen Antilopen nebst Revision der Infusorienfauna afrikanischen Wiederkäuer. *Arch. Protistenkd.* 77: 92–107.
6. Eadie, J. M. 1962. The development of rumen microbial populations in lambs and calves under various conditions of management. *J. Gen. Microbiol.* 29: 563–578.
7. Giesecke, G. 1970. Comparative microbiology of the alimentary tract. pp. 307–318. In: *Physiology of Digestion and Metabolism in the Ruminant* (Phillipson, A. T. ed.), Oriel Press, New Castle upon Tyne.
8. Henpel-Zawitkowska, J. and Latteur, B. 1977. Quelques remarques sur la systematique du genre *Entodinium* Stein, 1858. *Acta Zool. Pathol. Antv.* 69: 189–202.
9. Imai, S. 1986. Rumen ciliate protozoal fauna of zebu cattle (*Bos taurus indicus*) in Sri Lanka, with the description of a new species, *Diplodinium sinhalicum* sp. nov. *Zool. Sci.* 3: 699–706.
10. Imai, S. 1988. Ciliate protozoa in the rumen of Kenyan zebu cattle, *Bos taurus indicus*, with the description of four new species. *J. Protozool.* 35: 130–136.
11. Imai, S. and Ogimoto, K. 1984. Rumen ciliate protozoal fauna and bacterial flora of the zebu cattle (*Bos indicus*) and the water buffalo (*Bubalus bubalis*) in Thailand. *Jpn. J. Zootech. Sci.* 55: 576–583.
12. Imai, S., Han, S.-S., Cheng, K.-J., and Kudo, H. 1989. Composition of the rumen ciliate population in experimental herds of cattle and sheep in Lethbridge, Alberta, Western Canada. *Can. J.*

- Microbiol.* 35: 686–690.
13. Imai, S., Shimizu, M., Kinoshita, M., Toguchi, M., Ishii, T., and Fujita, J. 1982. Rumen ciliate protozoal fauna and composition of the cattle in Japan. *Bull. Nippon Vet. Zootech. Coll.* 31: 70–74 (in Japanese with English summary).
  14. Lubinsky, G. 1957. Studies on the evolution of the Ophryoscolecidae. 1. A new species of *Entodinium* with "caudatum", "lobosopinosum" and "dubardi" forms and others. *Can. J. Zool.* 35: 111–133.
  15. Lubinsky, G. 1957. Studies on the evolution of the Ophryoscolecidae. 3. Phylogeny of the Ophryoscolecidae based on their comparative morphology. *Can. J. Zool.* 35: 141–159.
  16. Mackenzie, D. D. S. 1967. Production and utilization of lactic acid by the ruminant. A review. *J. Dairy Sci.* 50: 1772–1786.
  17. MacLennan, R. F. 1935. Ciliates from the stomach of mule-deer. *Trans. Am. Microsc. Soc.* 54: 181–188.
  18. Nakamura, I., Ogimoto, K., Imai, S., and Nakamura, M. 1988. Production of lactic acid isomers and change of microbial features in the rumen of feedlot cattle. *J. Anim. Physiol. Anim. Nutr.* 61: 139–144.
  19. Ogimoto, K. and Imai, S. 1981. Atlas of Rumen Microbiology, Japan Scientific Soc. Press, Tokyo.
  20. O'Regan, B. P. 1986. Small antelopes and gazelles. pp. 134–141. In: The Encyclopaedia of Animals (MacDonald, D. W. ed.), Japanese Edition. Vol. 4, Heibonsha Ltd. Publ., Tokyo.
  21. Pearson, H. A. 1969. Rumen microbial ecology in mule deer. *Appl. Microbiol.* 17: 819–824.
  22. Poljansky, G. and Strelkow, A. 1938. Étude expérimentale sur la variabilité de quelques Ophryoscolécidés. *Arch. Zool. Expl. Gen.* 80: 1–123.
  23. Sládeček, F. 1946. Ophryoscolecidae from the stomach of *Cervus elaphus* L., *Dama dama* L. and *Capreolus capreolus* L. *Vestník. Cesk. Spol. Zool.* 10: 201–231.
  24. Towne, G., Nagaraja, T. G., and Kemp, K. K. 1988. Ruminant ciliated protozoa in bison. *Appl. Environ. Microbiol.* 54: 2733–2736.
  25. Wertheim, P. 1934. Über die Beschaffenheit der Infusorienmagenfauna von *Capreolus capreolus* L. *Zool. Anz.* 106: 67–70.
  26. Wilkinson, R. C. and Van Hoven, W. 1976. Rumen ciliate fauna of the springbok (*Antidorcas marsupialis*) in southern Africa. *Zool. Afr.* 11: 1–22.
  27. Zielyk, M. W. 1961. Ophryoscolecoid fauna from the stomach of the white-tailed deer (*Odocoileus virginianus borealis*), and observation on the division of *Entodinium dubardi* Buisson, 1923 (Ciliata, Entodiniomorpha). *J. Protozool.* 8: 33–41.

要 約

モウコガゼルに見られたルーメン内繊毛虫：今井壮一・桂 栄¹⁾(日本獣医畜産大学獣医寄生虫学教室, ¹⁾中国内蒙古自治区呼伦贝尔盟畜牧兽医研究所)——モンゴルに産する5頭のモウコガゼル(*Procapra gutturosa*)のルーメン内繊毛虫相について検索した結果, *Entodinium* 属に属する尾棘を有しない4種, *E. convexum*, *E. dubardi*, *E. nanellum* および *E. exiguum* が検出された。これらのうち, *E. convexum* は, はじめアメリカ合衆国のミュールジカ(*Odocoileus hemionus*)から報告されたもので, 本報告が2番目の記載であるが, 今回の調査では全ての宿主から比較的高い構成比で認められ, 1頭では全て本種であった。このような繊毛虫構成は, 反芻家畜に比べて著しく単純なものであるが, 繊毛虫密度はむしろ家畜より高く, 平均 $24.8 \times 10^4/\text{ml}$ を示した。