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Comparison of Rumen Ciliate Compositions among Hereford, Holstein and Zebu Cattle in Mexico*

Comparación de las Composiciones de Ciliados en el Rumen de Ganados Hereford, Holstein y Cebú en México.

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ABSTRACT

The composition of rumen ciliates in the Hereford, Holstein and zebu cattle bred in northern, central and southern areas in Mexico was surveyed and compared. Of total 16 genera with 50 species detected, 13 genera with 38 species from Hereford fed in northern area, 8 genera with 19 species from Holstein fed in central area, and 12 genera with 39 species and 16 genera with 41 species from zebu fed in central and southern areas, respectively were found, indicating that the rumen ciliate composition is rich in zebu in southern area, while poor in Holstein in central area. Zebu cattle had some peculiar species in their rumen. In generic composition entodiniid ciliates were the highest compared with the other ciliate genera in every hosts; 49.9%, 84.2%, 68.9 % and 64.1 % in Hereford, Holstein, zebu in central part and zebu in southern part, respectively. The highest average value of total ciliate number, 9.8 x 10^4/ml, was obtained from the Holstein in central area, in contrast, the lowest 4.2 x 10^4/ml, from the zebu cattle both in central and southern areas.

Key words: cattle, ciliates, protozoa, rumen

RESUMEN

La composición de ciliados en el rumen del ganado Hereford, Holstein y Cebú fué medida y comparada en el norte, centro y sureste de México. Del total de 16 géneros con 50 especies detectadas; fueron encontrados, 13 genéros con 38 especies para Hereford en el área noreste; 8 géneros con 19 especies para Holstein de la zona centro y 12 géneros con 39 especies y 16 géneros con 41 especies para Cebú en las áreas centro y sureste, respectivamente; destacando que la composición de los ciliados en el rumen es rica en los Cebú del área sureste, y menor en la raza Holstein de la zona centro. El ganado Cebú presenta algunas especies peculiares en su rumen. En cuanto a la composición genérica de ciliados Entodinnidos, fueron los mejor comparados contra los otros géneros de ciliados en todos los hospederos; 49.9%, 84.2%, 68.9 % and 64.1 % en los Hereford, Holstein y Cebú en la parte central y en Cebú de la zona sureste, respectivamente. El mayor valor promediado del número total de los ciliados, 9.8 x 10^4/ml, fue obtenido para Holstein en la zona centro, encontrándose el menor valor 4.2 x 10^4/ml, para la raza Cebú en las áreas centro y sureste de México.

Palabras clave: ganado, ciliados, protozoarios, rumen

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Introduction

Rumen ciliate protozoal population of domestic ruminants would be different among the species of their hosts and/or among the hosts inhabiting separated areas, although they are generally similar to each other (Dogiel, 1927; Eadie, 1956, 1967; Clarke, 1964; Imai et al, 1978, 1979, 1981, 1989; Dehority, 1979). The factors affecting the protozoal populations in the herbivorous domestic animals are chances for protozoal infection and diets fed by hosts (Hungate, 1966; Dehority, 1979; Imai, 1985). Regarding the rumen ciliate compositions of domestic animals in Mexico, Chavarria (1933) described 4 genera with 14 species from cattle, and San Vicente and López-Ochoterena (1978) reported 8 genera with 13 species from sheep. However, the difference of distribution of these symbiotic ciliates among the animals fed various areas in Mexico remains unknown. Surveys and comparisons of rumen ciliate compositions of various ruminants should offer useful information about phylogenetic relationship not only among the rumen ciliates but also among the host ruminants (Imai, 1988b).

The present paper deals with the species compositions of rumen ciliate protozoa obtained from the Hereford, Holstein and zebu cattle fed in Mexico.

Materials and Methods

Animals examined

Samples were collected from 10 male 4 to 8-year-old Hereford cattle which had been bred in the region of northern desert area (Chihuahua), 4 female 2 to 5-year-old Holstein cattle and 6 female 2 to 4-year old zebu cattle which had been bred in the region of central temperate area (Tizayuca Hidalgo and Estadio de Morelos), and 9 female and one male 1 to 5-year-old zebu cattle which had been bred in the region of southern subtropical area (Tizimin, Buetata and Dzilan) (Fig. 1).

Sampling

Rumen contents collected were immediately fixed in twice their volume of methylgreen-formalin-saline (MFS) solution (Ogimoto and Imai, 1981) and brought to the laboratory. Additional MFS was added and well mixed to triple the volume of collected rumen contents. Identification of genera and species of the ciliates and calculation of ciliate numbers were conformed in the main to the descriptions previously published (Ogimoto and Imai, 1981; Imai, 1988a). To obtain the average value for the ciliate density under normal distribution, it was computed from each value of ciliate number converted into logarithms. The generic composition is shown as the percentage of each genus in about 400 cells.

Results

Species and their frequency from Hereford, Holstein and zebu cattle in each area are shown in Table 1. Fifty species under 16 genera were identified in all. Of them, 13 genera with 38 species from Hereford fed in northern area, 8 genera with 19 species from Holstein fed in central area, and 12 genera with 39 species and 16 genera with 41 species from zebu fed in central and southern areas, respectively were found. Although *Isotricha intestinalis, I. prostoma, Dasytricha ruminantium, Entodinium simplex, E. parvum parvum, E. longinucleatum longinucleatum and E. caudatum caudatum* were the most predominant in all

Figure 1. Regional division on the basis of animal husburndry of cattle in Mexico.
Northern area: desert zone; Central area: temperate zone; Southern area: subtropical zone

Table 1. Frequency (%) of the ciliate species detected from the Hereford, Holstein and Zebu cattle in Mexico

Species	Animal examined			
	Hereford (Central)	Holstein (Northern)	Zebu (Central)	Zebu (Southern)
Parabundleia				
ruminantium Imai & Ogimoto, 1983	-	-	-	29
Polymorphella				
bovis Imai, 1984	-	-	17	43
Dasytricha				
ruminantium Schuberg, 1888	100	100	83	71
Isotricha				
prostoma Stein, 1858	70	67	100	71
intestinalis Stein, 1858	60	67	83	71
Oligoisotricha				
bubali (Dogiel, 1928)	-	-	-	14
Charonina				
ventriculi (Jameson, 1925)	20	-	33	14
Entodinium				
simplex Dogiel, 1925	90	100	100	100
longinucleatum Dogiel, 1925				
f. *longinucleatum* Dogiel, 1925	80	67	83	86
f. *actonucleatum* Kofoid & MacLennan	10	-	33	-
f. *spinolobum* Imai, 1984	10	-	33	43
ovinum Dogiel, 1927	80	100	83	43
exiguum Dogiel, 1925	60	67	83	43
minimum Schuberg, 1888	50	33	83	57
parvum Buisson, 1923				
f. *parvum* Buisson, 1923	70	100	83	86
f. *monospinosum* Imai & Ogimoto, 1983	10	-	33	14
caudatum Stein, 1858	60	67	50	100
f. *caudatum* Stein, 1858				
f. *lobosospinosum* Dogiel, 1925	30	-	50	29
rostratum Fiorentini, 1889	40	67	67	43
nanellum Dogiel, 1923	70	67	50	71
aculeatum Kofoid & MacLennan, 1930	10	-	-	-
chatterjeei Das-Gupta, 1935	-	-	17	57
dubardi Buisson, 1923	-	-	33	43
indicum Kofoid & MacLennan, 1930	-	-	50	14
bimastus Dogiel, 1927	10	-	17	57
costatum MacLennan, 1935	10	-	-	-
biconcavum Kofoid & MacLennan, 1930	-	-	-	14
quadricuspis Dogiel, 1925	20	-	-	-
bovis Wertheim, 1935	10	-	33	29
dilobum (Dogiel, 1927)	10	-	-	-
bursa Stein, 1858	30	-	17	29
Diplodinium				
dentatum (Stein, 1858)	-	-	33	29
anisacanthum da Cunha, 1914				
f. *anacanthum* Dogiel, 1927	70	-	17	29
f. *monacanthum* Dogiel, 1927	10	-	-	-
f. *diacanthum* Dogiel, 1927	20	33	-	-

Table 1. (Continued)

Species	Animal examined			
	Hereford (Central)	Holstein (Northern)	Zebu (Central)	Zebu (Southern)
Diplodinium				
anisacanthum da Cunha, 1914				
f. *triacanthum* Dogiel, 1927	10	-	-	-
f. *tetracanthum* Dogiel, 1927	10	-	17	-
f. *anisacanthum* da Cunha, 1914	20	33	83	71
polygonale (Dogiel, 1925)	-	-	33	29
minor (Dogiel, 1925)	10	-	17	-
mahidoli Imai & Ogimoto, 1983	-	-	-	29
cristagalli Dogiel, 1927	-	-	33	-
Eodinium				
posterovesiculatum (Dogiel, 1927)	10	-	17	57
lobatum Kofoid & MacLennan, 1932	10	-	17	29
rectangulatum Kofoid & MacLennan, 1932	-	-	17	-
Eudiplodinium				
maggii (Fiorentini, 1889)	70	33	83	57
rostratum (Fiorentini, 1889)	10	-	50	57
bovis Dogiel, 1927				
f. *bovis* Dogiel, 1927	20	10	50	29
f. *monolobum* Dogiel, 1927	20	-	-	-
Metadinium				
medium Awerinzew & Mutafowa, 1914	30	-	83	71
affine (Dogiel & Fedorowa, 1925)	30	-	33	71
Polyplastron				
Multivesiculatum (Dogiel & Fedorowa, 1925)	20	33	-	14
Elytroplastron				
bubali (Dogiel, 1928)	30	-	14	43
Ostracodinium				
obtusum (Dogiel & Fedorowa, 1925)	70	33	67	14
gracile (Dogiel, 1925)	30	33	50	57
mammosum (Railliet, 1890)	40	-	-	-
clipeolum Kofoid & MacLennan, 1932	40	-	14	-
trivesiculatrum Kofoid & MacLennan, 1932	50	-	50	14
Epidinium				
Ecaudatum (Fiorentini, 1889)				
f. *ecaudatum* Fiorentini, 1889	30	-	-	-
f. *caudatum* Fiorentini, 1889	60	-	-	-
f. *bicaudatum* Sharp, 1914	10	-	-	-
f. *quadricaudatum* Sharp, 1914	40	-	-	-
f. *cattanei* Fiorentini, 1889	-	-	17	29
Ophryoscolex				
purkynjei Stein, 1858	20	33	-	43

animals, which frequencies were up to 60 %, there were slight differences among three host species; that is, *Parabundleia ruminantium, Polymorphella bovis, Diplodinium mahidoli* and some species of the genus *Entodinium* were only detected from zebu cattle, while *Entodinium costatum, E. quadricuspis, E. dilobum,* and some forms of *Diplodinium anisacanthum* and *Epidinium ecaudatum* only from Hereford. No peculiar ciliate species were detected from Holstein.

Table 2. Generic composition (%) of ciliates in Hereford, Holstein and Zebu cattle in Mexico

Species	Animal examined			
	Hereford (Central)	Holstein (Northern)	Zebu (Central)	Zebu (Southern)
Entodinium	49.9	84.2	68.9	64.1
Dasytricha	4.8	4.5	7.0	5.1
Diplodinium	6.5	4.2	3.5	4.0
Isotricha	7.4	13.5	8.4	9.7
Eudiplodinium	4.8	1.8	5.6	7.3
Ostracodinium	6.0	0.2	2.0	1.8
Metadinium	2.9	-	1.3	1.8
Epidinium	15.0	-	0.6	0.3
Eodinium	0.2	-	1.5	2.9
Elytroplastron	1.2	-	<0.1	0.4
Polyplastron	0.5	0.5	-	<0.1
Ophryoscolex	0.4	0.2	-	0.6
Charonina	0.9	-	0.8	0.8
Polymorphella	-	-	1.0	0.3
Oligoisotricha	-	-	-	0.4
Parabundleia	-	-	-	0.4

Table 2 shows the percentage composition of genera of the ciliates in each host examined. In all the hosts the percentage occupied by the genus *Entodinium* was the highest, the ratio of which was 49.9 %, 84.2 %, 68.9 % and 64.1 %, respectively on average. The genera *Isotricha* and *Dasytricha* were next highest in number.

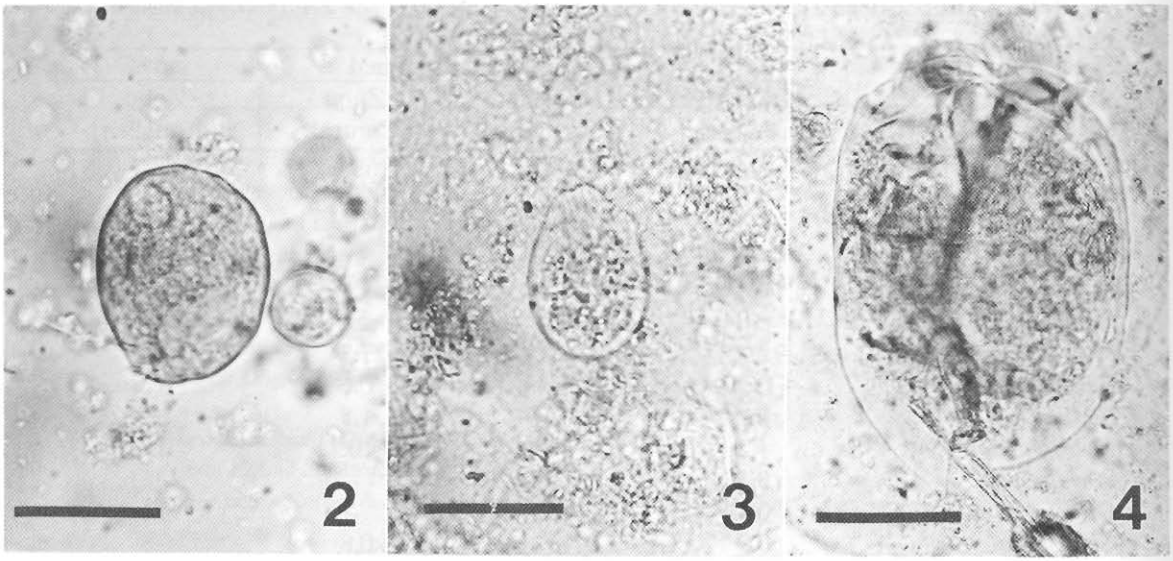
The average values of total ciliate number per one milliliter of rumen contents of respective hosts are shown in Table 3. The highest value was obtained from the Holstein cattle in which the value was 9.8×10^4, in contrast, the lowest from the zebu cattle both in central and southern areas, 4.2×10^4.

Discussion

Rumen ciliate compositions of the cattle in Mexico were formerly surveyed by Chavarria (1933) who described 14 species in 4 genera. Twelve species other than *E. triacum* and *E. tricuspis* described by Chavarria were also detected in the present examination. When the ciliate compositions of respective hosts were compared, the largest number of species was detected from zebu fed in southern area, and the least from Holstein fed in central area. Although the most of common species found from every host were those already detected from the various races of humpless cattle (*Bos taurus taurus*) in various areas (Dogiel, 1927; Weltheim, 1935; Clarke, 1964; Imai *et al.*, 1989; Ito and Imai, 1990), *Parabundleia ruminantium, Polymorphella bovis* and *Diplodinium mahidoli* (Figs. 2-4), which had been described only from zebu cattle were also detected only from the same host in the present examination, suggesting that these species are peculiar in zebu cattle. In African zebu, many peculiar ciliate species have been described (Imai, 1988a), and suggested a greater ciliate diversity in domestic stock in central Africa. However, the ciliate composition of zebu in Mexico was rather similar to those in southeastern Asia (Shimizu *et al.*, 1983; Imai and Ogimoto, 1984) and those in humpless cattle. It is thought that the domestic zebu originated in India (Epstein and Mason, 1984).

Table 3. Average ciliate density (x 10^4 ml^{-1}) in the Holstein, Hereford and Zebu cattle in Mexico

Animal	Ciliate density	
	Average	Range
Hereford (Northern area)	8.3	0.07 - 21.9
Holstein (Central area)	9.8	0.4 - 21.9
Zebu (Central area)	4.2	1.4 - 6.5
Zebu (Southern area)	4.2	0.07 - 10.7



Figures. 2-4 Ciliate species which seem to be peculiar in zebu cattle. 2. *Parabundleia ruminatium* Imai & Ogimoto, 1983. bar=30 μm. 3. *Polymorphella bovis* Imai, 1984. bar=30 μm. 4. *Diplodium mahidolli* Imai & Ogimoto, 1983. bar=50 μm.

Zebu cattle in Mexico might continue to keep some peculiar rumen ciliates of Indian zebu, although the ciliate composition had been affected from humpless cattle after and/or before introduction to Mexico. On the other hand, San Vicente and López-Ochoterena (1978) reported the rumen ciliate composition of sheep in Mexico and described 13 species in 8 genera. The composition was fairly different from those of cattle in the present examination and Chavarria (1933), suggesting that these sheep had fewer chances to obtain additional species by the contact with cattle and kept relatively characteristic ciliate species.

The average ciliate density in each host was slightly lower than those reported in various areas (Imai, 1988; Imai *et al.*, 1989; Ito and Imai, 1990). The percentage composition of genera in Holstein also almost coincided with the data from the humpless cattle formerly reported (Imai *et al.*, 1989; Ito and Imai, 1990), however, in Hereford and zebu cattle the composition of *Entodinium* was relatively low. It is known that the ciliate density and composition of genera are strongly affected by the kinds and amounts of food taken by the host (Warner, 1962; Hungate, 1966; Williams and Coleman, 1992). Entodiniid ciliates and the total ciliate density become higher when the host is fed with concentrate-rich ration (Hungate, 1966). The higher value of entodiniids and high total ciliate density in Holstein may reflect that these animals had fed with concentrates-rich ration. In contrast, lower composition rate of *Entodinium* and appearance of higher number of species in Hereford and zebu cattle may be due to the feeding condition with roughage-rich ration. The question whether high composition rate of *Entodinium* is favorable for the host or not will be a problem which should be cleared from the examinations on the metabolic characteristics of respective ciliate genera and on the relation between them and bacterial metabolism in rumen fermentation.

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