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Ciliated Protozoa in the Rumen of Turkish Domestic Cattle (*Bos taurus* L.)

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ABSTRACT. Rumen contents obtained from 28 domesticated cattle (*Bos taurus* L.) slaughtered at abatoirs near Izmir, Turkey were surveyed for ciliate protozoa. Protozoa are known to make an appreciable contribution to ruminal fiber digestion in many different geographical areas; however, little if any information is available on their occurrence in Turkish cattle. As a result of our survey, 13 genera including 52 species were identified. Nine of the species were further divided into 36 forma. The average ciliate density in our cattle (52.44×10^4/ml) was higher than that of Turkish domestic sheep and other domestic cattle reported previously from different geographical areas. *Entodinium basoglui*, *Entodinium williamsi* f. *williamsi*, *E. williamsi* f. *turcicum*, *E. dalli* f. *rudidorsospinatum*, *Entodinium imai*, *Entodinium oektemae*, *Eudiplodinium dehorityi*, *Epidinium graini*, *Ophryoscolex purkynjei* f. *bifidobicinctus*, and *Ophryoscolex purkynjei* f. *bifidoquadricinctus* have previously been reported from Turkey and appear to be endemic. All of the remaining species represent a new host record for domestic Turkish cattle. This study also reports for the second time the presence of *Entodinium constrictum* in herbivorous mammals, and is the first record of its occurrence in domesticated cattle.
Key Words. Ciliate protozoa, fauna, microorganisms, Turkey.

RUMEN protozoa, which can play an important role by contributing nutrients to the host animal (Hungate 1955; Ogimoto, and Imai 1981), also play a role in the digestion of carbohydrate and protein-containing feedstuffs by secreting saccharolytic and proteolytic enzymes (Coleman and Laurie 1974; Nagasawa, Uchida, and Onodera 1992; Shinchi, and Abe 1987a, b; Shinchi et al. 1986; Williams 1979). Although investigations have been conducted in various geographical areas on the ciliate population occurring in ruminants, our knowledge about the overall distribution of protozoa in different animal hosts in different countries around the world is limited. There have been several studies on the rumen fauna of domestic cattle and sheep in Turkey (Göçmen 1993, 1999a, b, c; Göçmen and Öktem 1996; Göçmen, Falakali-Mutaf, and Tosunoglu 2001; Göçmen, Torun, and Öktem 1999; Göçmen Tosunoglu, and Falakali 2001; Öktem and Göçmen 1996; Öktem, Göçmen, and Torun 1997). However, no compilation has been published on the protozoal populations occurring in Turkish domestic cattle. The purpose of the present study was to determine the rumen ciliates in a larger number of Turkish domestic cattle and to compare this information with data from previous studies conducted both in Turkey and other geographical areas.

MATERIALS AND METHODS

Samples of rumen contents were obtained from 28 domestic cattle (*Bos taurus* L.) at the slaughterhouses around Izmir, Turkey (Manavkuyu, Buca, and Kemalpasa), between March 21, 1990 and July 10, 1995. The animals were fed twice a day (0800 h and 1600 h) with about 4 kg of oat straw, clover, and sugar beet rubble. The animals were generally slaughtered 1–2 h after feeding time and samples taken immediately thereafter.

Collection, fixation, storage, and counting of samples have been described in previous publications (Göçmen 1993,1999a, b; Göçmen and Budak 2000; Göçmen et al. 2001). Specimens were examined with a Jena ''NF-binocular'' microscope and ''MF'' photomicrography accessory.

Classification and identification of species were based on previously published species descriptions and taxonomic lists (Dehority 1986a, b; Dogiel 1927; Göçmen 1999a, b, c; Göçmen, Falakali-Mutaf, and Tosunoglu 2001; Göçmen, Tosunoglu, and Falakali 2001; Göçmen et al. 2001; Grain 1994; Hsiung 1932; Imai 1981,1984; Kofoid and MacLennan 1930, 1932, 1933; Latteur 1966; Levine et al. 1980; Lubinsky 1957, 1958; Ogimoto and Imai 1981; Williams and Coleman 1992).

RESULTS AND DISCUSSION

The mean number (± SD) of ciliates in rumen contents from the 28 Turkish cattle examined was $52.44 \pm 20.73 \times 10^4$ per ml (CV = 39.52%) (Table 1). The geometric mean is 47.49×10^4 cells per ml. Values ranged from 16.00×10^4 to 87.50×10^4. When compared with ciliate surveys from cattle in other countries (Imai 1986, 1988; Ito and Imai 1990; Imai and Ogimoto 1984; Ito, Imai, and Ogimoto 1994; Imai et al. 1989), the overall mean concentration of ciliates in Turkish domestic cattle was considerably higher, with the exception of Japan (40.3×10^4) (Table 1). The concentration of ciliates found in Turkish domestic cattle is almost identical with the number previously reported from Turkish domestic sheep (53.90×10^4), suggesting that differences between the number of rumen ciliates from different locations may be related with the kind and type of nutrition and geographical location. Thirteen genera; *Charonina*, *Isotricha*, *Dasytricha*, *Entodinium*, *Diplodinium*, *Eodinium*, *Eudiplodinium*, *Metadinium*, *Ostracodinium*, *Polyplastron*, *Enoploplastron*, *Epidinium*, and *Ophryoscolex* were observed (Table 2). The number of species included in these genera was 53, with a total of 36 forma observed in nine of the species.

The number of species and formae living in the rumen of Turkish cattle is similar to those in Japanese cattle (Ito and Imai 1990; Ito, Imai, and Ogimoto 1994). However, *Oligoisotricha* and *Microcetus* were not detected in this study. It is unclear at this time as to why the genus *Oligoisotricha* has been detected in Russia (Dogiel 1927), the Far East (Imai 1985; Ito and Imai 1990; Ito, Imai, and Ogimoto 1994), and USA (Dehority, Damron, and McLaren 1983), but not in Europe.

Entodinium constrictum, originally described from Alaskan Dall mountain sheep (*Ovis dalli*) (Dehority 1974), and not subsequently observed, was detected in the rumen of Turkish cattle. This study is the first report of the occurrence of *E. constrictum* in the rumen of cattle. Another species also originally described from Alaskan Dall sheep, *Entodinium dalli*, was also observed, but had previously been reported from Turkish cattle (*Bos taurus*) (Göçmen and Öktem 1996).

Almost all of the species detected in this survey represent the first report for their occurrence in Turkey, excluding several species that were observed previously: *Entodinium basoglui*, *E. williamsi* f. *williamsi*, *E. williamsi* f. *turcicum*, *E. dalli* f. *rud-*

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Table **1**. Total ciliate concentrations and distribution of the total number of genera, species, and forms of the ciliates in rumen contents of cattle at various locations around the world.

Locality[a]	Total ciliates $\times 10^4$ ml^{-1}	Range $\times 10^4$ m^{-1}	Total no. of genera	Total no. of species	Total no. of formae	References[b]
Japan	40.3 ± 1.9[c]	6.5–172.5	15	48	25	1
Kenya	15.1[d]	6.3–39.8	13	51	19	2
Canada	6.9[d]	2.5–12.6	12	28	—[d]	3
Sri Lanka	2.9 ± 4.9	.08–31.6	16	53	19	4
Mexico	8.3[d]	.07–21.9	13	38	15	5
Thailand	7.1 ± 2.8	0.6–31.6	17	56	19	6
Brazil	26.4 ± 17.7	9.0–51.2	14	55	4	7
Turkey	52.4 ± 20.7	16.0–87.5	13	52	36	Present study

[a] Number of animals and breed: Japan (125 Holstein-Friesian cattle); Kenya (13 Boran Zebu cattle); Canada (11 Holstein cattle); Sri Lanka (20 ''Sinhala'' Zebu cattle); Mexico (10 Hereford cattle); Thailand (46 Zebu cattle); Brazil (4 Zebu cattle); Turkey (28 *Bos taurus* domestic cattle).
[b] (1) Ito, Imai, and Ogimoto 1994; (2) Imai 1988; (3) Imai et al. 1989; (4) Imai 1986; (5) Imai and Kinoshita 1997; (6) Imai and Ogimoto, 1984; (7) Dehority 1986a.
[c] Mean ± SD.
[d] Data not reported.

idorsospinatum, *E. imai*, *E. oektemae*, *Eudiplodinium dehorityi*, *Epidinium graini*, *Ophryoscolex purkynjei* f. *bifidobicinctus* and *O. purkynjei*. f. *bifidoquadricinctus*. These species appear to be endemic in Turkish rumen ciliate faunas.

It is of interest that *Isotricha* was present in all the Turkish cattle studied, while it was less frequent in Japanese cattle (83.2%). Frequency of appearance of *Polyplastron*, *Epidinium* and *Ophryoscolex* was also higher in Turkish domesticated cattle, i.e. 60.7% vs. 34.4%; 50.0% vs. 29.6%; and 25.0% vs. 9.6%, respectively.

Although *Entodinium* spp. and the ''holotrichs'' are generally present in the rumen contents of domesticated sheep, cattle, and goats under normal farm conditions, some entodiniomorphid protozoa are peculiar to given populations because of both predatory activity and antagonism. Rumen ciliate populations have been divided into four types, A, B, K, and O, all of which contain *Entodinium* spp. and the ''holotrichs'' (Eadie 1956, 1962; Imai, Katsuno, and Ogimoto 1978, 1979; Ogimoto and Imai 1981; Williams and Coleman 1992) . A type A population specifically includes *Polyplastron multivesiculatum* and usually but not always, *Metadinium affine*; a type B population is characterized by *Epidinium* spp., *Eudiplodinium maggii* or both; a type K population is characterized by *Elytroplastron bubali*; while type O contains none of the type A, B, or K species. Nine of the 28 cattle (32.14%) were type A, eight were type B (28.57%), two were type K (7.14%) and one was type O (3.57%). The remaining eight cattle (28.57%) included some or all of the ciliates belonging to type A and B populations together. Ogimoto and Imai (1981) and Imai, Katsuno, and Ogimoto (1979) reported that the type A population was dominant in cattle from Japan and other far eastern countries (44.1% type A, 28.4% type B, and 4.9% type K). Similarly, the type A population is a little more frequent in Turkish cattle. When we consider that *Eudiplodinium* and/or *Epidinium* are generally eliminated by the predatory activity of *Polyplastron multivesiculatum*, animals with a mixed A and B fauna type are probably in a transitory stage, i.e. predation and removal of *Eudiplodinium* and/or *Epidinium* species was not complete. All cattle that have a mixed A and B type population will probably form a type A population and on that basis, the type A population can be considered to be the dominant one, 60.71% (32.14% + 28.57%).

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Table **2**. Percentage distribution and frequency of occurrence of rumen ciliate protozoa in rumen contents from 28 Turkish domesticated cattle.

Genus/Species/Formae	Occurrence rate (%)		Frequency of occurrence (%)
	Mean ± SD	Range	
Isotricha prostoma	12.68 ± 15.21	0.45–52.94	100.00
Isotricha intestinalis	2.53 ± 3.45	0–10.29	75.00
Dasytricha ruminantium	8.81 ± 16.40	0–82.36	75.00
Charonina ventriculi	0.10 ± 0.21	0–0.70	25.00
Entodinium exiguum	4.37 ± 4.73	0–19.50	85.71
Entodinium nanellum	21.54 ± 19.28	0–62.27	85.71
Entodinium minimum	0.22 ± 0.41	0–1.40	32.14
Entodinium parvum f. *parvum*	1.08 ± 1.42	0–6.08	57.14
Entodinium simplex	6.57 ± 6.51	0–25.65	89.29
Entodinium dubardi f. *dubardi*	0.81 ± 2.08	0–8.83	32.14
Entodinium ovinum	2.51 ± 5.14	0–19.07	64.29
Entodinium dilobum	0.87 ± 2.58	0–12.82	28.57
Entodinium constrictum	0.12 ± 0.37	0–1.21	10.71
Entodinium bimastis	0.08 ± 0.28	0–1.26	14.29
Entodinium bovis	4.34 ± 17.58	0–93.44	53.57
Entodinium bursa	1.33 ± 4.87	0–25.70	42.86
Entodinium ellipsoideum	1.38 ± 3.68	0–14.39	25.00
Entodinium rostratum	0.41 ± 0.74	0–2.10	32.14
Entodinium anteronucleatum f. *laeve*	0.23 ± 0.69	0–3.28	14.29
Entodinium longinucleatum f. *longinucleatum*	6.10 ± 5.65	0–20.73	96.43
Entodinium furca f. *furca*	0.07 ± 0.20	0–0.72	10.71
Entodinium triacum f. *dextrum*	0.87 ± 2.61	0–13.10	32.14
Entodinium caudatum f. *caudatum*	6.07 ± 7.20	0–28.9	82.14
Entodinium caudatum f. *lobosospinosum*	0.31 ± 0.52	0–1.89	35.71
Entodinium simulans f. *caudatum*	0.16 ± 0.76	0–0.56	7.14
Entodinium rectangulatum f. *rectangulatum*	0.06 ± 0.18	0–0.72	10.71
Entodinium rectangulatum f. *lobosospinosum*	0.03 ± 0.09	0–0.36	7.14
Entodinium rectangulatum f. *dubardi*	0.01 ± 0.07	0–0.36	3.57
Entodinium quadricuspis	0.05 ± 0.15	0–0.60	10.71
Entodinium dalli f. *rudidorsospinatum*	0.64 ± 3.24	0–17.18	7.14
Entodinium williamsi f. *williamsi*	0.23 ± 1.12	0–5.90	7.14
Entodinium williamsi f. *turcicum*	0.15 ± 0.60	0–3.00	7.14
Entodinium basoglui	2.05 ± 5.70	0–22.12	25.00
Entodinium bifidum	0.01 ± 0.04	0–0.20	7.14
Entodinium imaii	0.10 ± 0.24	0–1.08	21.43
Entodinium oektemae	0.43 ± 2.25	0–11.90	7.14
Diplodinium dentatum f. *anacanthum*	0.27 ± 0.99	0–5.17	17.86
Diplodinium dentatum f. *monacanthum*	0.01 ± 0.04	0–0.23	7.14
Diplodinium dentatum f. *diacanthum*	0.01 ± 0.04	0–0.20	7.14
Diplodinium dentatum f. *triacanthum*	0.01 ± 0.08	0–0.40	7.14
Diplodinium dentatum f. *tetracanthum*	0.02 ± 0.11	0–0.60	3.57
Diplodinium dentatum f. *pentacanthum*	0.08 ± 0.28	0–1.40	10.71
Diplodinium dentatum f. *anisacanthum*	0.50 ± 0.83	0–2.90	42.86
Diplodinium minor	0.02 ± 0.08	0–0.42	10.71
Eodinium posterovesiculatum	0.07 ± 0.23	0–1.05	14.29
Eodinium monolobosum	0.20 ± 0.80	0–4.19	14.29
Eudiplodinium rostratum	0.43 ± 0.52	0–1.80	67.86
Eudiplodinium maggi	0.30 ± 0.66	0–2.66	50.00
Eudiplodinium bovis f. *bovis*	2.48 ± 3.82	0–11.84	57.14
Eudiplodinium bovis f. *monolobum*	0.03 ± 0.09	0–0.36	7.14
Eudiplodinium bovis f. *dilobum*	0.08 ± 0.28	0–1.06	7.14
Eudiplodinium dehorityi	1.04 ± 3.77	0–13.31	14.29
Metadinium affine	0.47 ± 0.70	0–2.76	50.00
Metadinium medium	0.03 ± 0.10	0–0.41	10.71
Ostracodinium gracile f. *gracile*	0.40 ± 0.83	0–3.14	28.57
Ostracodinium gracile f. *monolobum*	0.05 ± 0.20	0–1.05	7.14
Ostracodinium trivesiculatum	0.28 ± 0.49	0–1.85	42.86
Ostracodinium obtusum	0.02 ± 0.08	0–0.40	14.29
Ostracodinium quadrivesiculatum	0.04 ± 0.15	0–0.69	7.14
Ostracodinium clipeolum	0.04 ± 0.13	0–0.60	7.14
Polyplastron multivesiculatum	0.92 ± 3.05	0–16.18	60.71
Enoploplastron triloricatum	0.04 ± 0.20	0–1.08	7.14
Epidinium ecaudatum f. *ecaudatum*	1.50 ± 3.43	0–14.08	46.43
Epidinium ecaudatum f. *bulbiferum*	0.04 ± 0.12	0–0.57	42.86
Epidinium ecaudatum f. *diodonta*	0.09 ± 0.41	0–2.18	42.86
Epidinium ecaudatum f. *triodonta*	0.02 ± 0.06	0–0.23	42.86

Table **2**. Continued

Genus/Species/Formae	Occurrence rate (%) Mean ± SD	Range	Frequency of occurrence (%)
Epidinium ecaudatum f. *tetrodonta*	0.03 ± 0.12	0–0.57	42.86
Epidinium ecaudatum f. *pentodonta*	0.03 ± 0.10	0–0.46	42.86
Epidinium ecaudatum f. *caudatum*	1.82 ± 4.75	0–24.57	42.86
Epidinium ecaudatum f. *bicaudatum*	0.07 ± 0.16	0–0.66	17.85
Epidinium ecaudatum f. *tricaudatum*	0.01 ± 0.04	0–0.21	7.14
Epidinium ecaudatum f. *quadricaudatum*	0.01 ± 0.02	0–0.11	3.57
Epidinium ecaudatum f. *cattanei*	0.10 ± 0.29	0–1.10	14.29
Epidinium graini f. *graini*	0.29 ± 0.67	0–2.76	21.43
Epidinium graini f. *caudotricoronatum*	0.34 ± 0.91	0–3.62	17.86
Epidinium graini f. *caudoquadricoronatum*	0.06 ± 0.23	0–1.05	7.14
Ophryoscolex purkynjei f. *bifidobicinctus*	0.05 ± 0.16	0–0.70	25.00
Ophryoscolex purkynjei f. *purkynjei*	0.37 ± 0.79	0–3.00	25.00
Ophryoscolex purkynjei f. *bifidoquadricinctus*	0.03 ± 0.08	0–0.40	10.71

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