

## Some Rumen Ciliates (Isotrichidae, Trichostomatida; Epidininae, Ophryoscolecidae) of the Domestic Goat (*Capra hircus* L.) in Turkey

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**Abstract:** Rumen contents obtained from domesticated goats (*Capra hircus* L.) slaughtered at abattoirs in the vicinity of Adana were surveyed for holotrichous ciliate protozoans and the genus *Epidinium*.

The presence of two holotrichous ciliate genera including three species (*Isotricha prostoma*, *I. intestinalis* and *Dasytricha ruminantium*) and also of seven formae of *Epidinium ecaudatum* (*E. e. f. ecaudatum*, *E. e. f. caudatum*, *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum*, *E. e. f. parvicaudatum* and *E. e. f. cattanei*) were established. The mean ciliate density in our surveyed goats,  $34.62 \times 10^4$  cells/ml, was lower than those of domestic sheep and cattle in Turkey and of other goats previously reported from different localities. All of the ciliates determined were first records from Turkish domestic goats. Moreover, the presence of *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum* and *E. e. f. parvicaudatum* is recorded for the first time from the rumen of goats.

**Key Words:** Rumen Ciliates, *Capra hircus*, Turkey.

### Türkiye' de Dağılım Gösteren Evcil Keçilerin (*Capra hircus* L.) İşkembesinde Yaşayan Bazı Siliyatlar (Isotrichidae, Trichostomatida; Epidininae, Ophryoscolecidae)

**Özet:** Bu çalışmada Adana civarındaki salhanelerde kesilen toplam 5 evcil keçi (*Capra hircus* L.)'den elde edilen işkembe içerikleri holotriş ve *Epidinium* cinsine dahil siliyat protozoonlar açısından incelenmiştir.

Araştırmamızın sonucunda Trichostomatida takımına dahil 2 holotriş cinsi ve bu cinslere dahil 3 tür (*Isotricha prostoma*, *I. intestinalis* ve *Dasytricha ruminantium*) belirlenirken; *Epidinium* cinsine dahil tek tür, *Epidinium ecaudatum* ve bu türe dahil 7 forma (*E. e. f. ecaudatum*, *E. e. f. caudatum*, *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum*, *E. e. f. parvicaudatum* ve *E. e. f. cattanei*) tayin edilmiştir. İncelenen keçilerde ortalama siliyat yoğunluğu (mililitredeki toplam siliyat sayısı)  $34.62 \times 10^4$  hücre/ml olarak belirlenmiştir. Bu değer koyun ve sığırlarımızdan, keza farklı alanlardaki diğer keçilerden önceden rapor edilenlere göre daha düşüktür. Diğer taraftan bu çalışma ülkemiz keçi faunasına ilişkin ilk kayıtlar olup, *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum* ve *E. e. f. parvicaudatum* keçilerden ilk kez kaydedilmiştir.

**Anahtar Sözcükler:** İşkembe siliyatları, *Capra hircus*, Türkiye.

### Introduction

In spite of the large number of studies on the rumen ciliate populations of domesticated ruminants (1-30), similar works in Turkey, a country geographically bridging Europe and Asia, are limited to domesticated sheep and cattle (31-38).

Obviously, knowledge of rumen ciliate composition and the establishment and comparison of the faunal similarities and differences between the hosts would yield specific information on the geographical distribution of

both the hosts and the ciliates, the feeding habitats and physiology of the hosts and their specific ciliates (15, 33, 39).

The aim of the present study is to help in establishing the endosymbiont rumen ciliate fauna of domesticated goats (*Capra hircus* L.), an important food source in Turkey, especially in the Mediterranean region. With this aim, the holotrichous (Isotrichidae, Trichostomatida) and epidinine entodiniomorphid (Epidininae, Ophryoscolecidae, Entodiniomorpha) ciliates were investigated and

the results obtained were compared with those of similar works previously conducted in Turkey and some other regions to establish the similarities and differences.

**Materials and Methods**

Rumen content samples were obtained from five mature domestic goats (*Capra hircus* L.) slaughtered in abattoirs in Adana (Kadirli and Ceyhan) between 10.02.1999 and 28.03.1999. The samplings were performed on animals fed twice (6<sup>00</sup> and 17<sup>00</sup> hours) each day, with 0.5-1 kg of wheat straw and broken barley. They were also permitted to graze in the fields. Rumen content samples were usually taken in the evenings, 2-3 hours before the feeding time, and right after the slaughtering of the goats. After opening the rumen with a sharp knife, the contents were obtained according to Göçmen and Öktem (33) and Öktem *et al.* (37).

The structural orientation terminology of the ciliates is given according to Dogiel (10), Göçmen and Öktem (33) and Grain (40) (Figure 1). The naming of the skeletal plate complex and related spines of *Epidinium* is after Dogiel (10). Taxonomy and species/forma determinations were done considering the lists of Dogiel (10), Kofoid and MacLennan (26, 41, 42), Lubinsky (27, 28), Göçmen (34, 35), Ogimoto and Imai (39), Grain (40), and Williams and Coleman (43).

The body measurements and related ratios of holotrichous and epidinine ciliates were taken according to Dogiel (10), Kofoid and MacLennan (26, 42) and Grain (44). These are summarized below:

1. *Cell Length* [L]: Known also as body length, it is the straight-line measurement from the anterior tip of the cell to the tip of the cytoproct.
2. *Cell Width* [W]: Measurement taken from the widest part of the cell dorsoventrally.
3. *Ventral (Preanal) Spine Length* [VSL]: In *Epidinium*, the straight-line measurement from the level of the cytoproct to the posterior tip of the preanal spine (Figure 1).
4. *Macronucleus Length* [MaL]: The straight-line measurement from the anterior to the posterior tip of the macronucleus.
5. *Macronucleus Width* [MaW]: The measurement taken from the widest part of the macronucleus dorsoventrally.
6. *Vestibulum Opening* [VO]: Diameter of the vestibulum opening in holotrichous ciliates.
7. *Vestibulum Depth* [VD]: In holotrichous ciliates, depth of vestibulum from the outer cell edge to the cytostome in endoplasm.

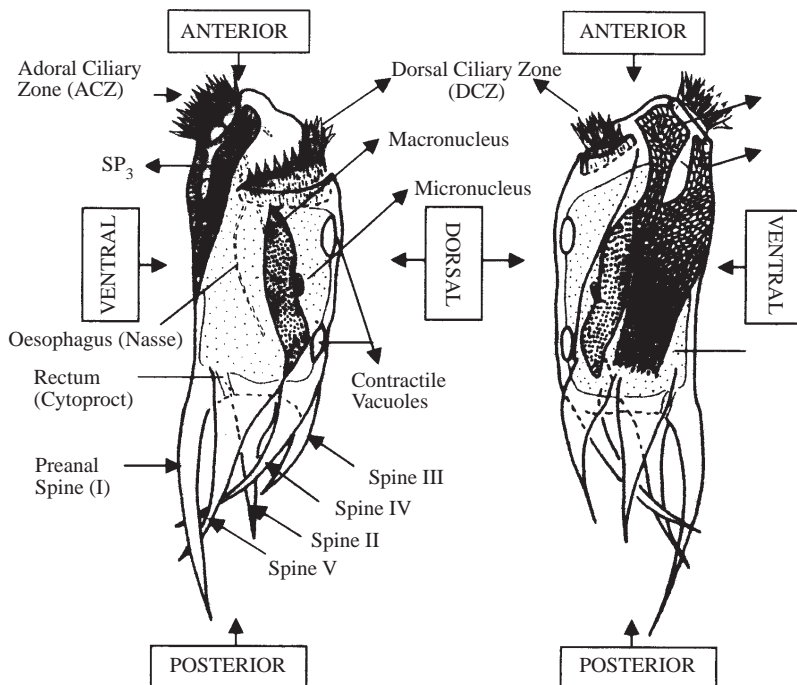


Figure 1. Drawings showing the terminology for morphological descriptions of ciliate protozoans and their orientation models in *Epidinium ecaudatum* f. *cattanei*. A: left, B right lateral views. SP1=Dorsal Skeletal Plate (*Primitiva*), SP2=Median Skeletal Plate (*Sternum*), SP3=Ventral Skeletal Plate (*Parasternum*) (From Göçmen, 1996).

8. Ratio of the cell length to the macronucleus length [L/MaL].

9. Ratio of the cell length to the cell width [L/W].

10. Ratio of the macronucleus length to the macronucleus width [MaL/MaW].

11. Ratio of the cell length to the ventral (preanal) spine length [L/VSL].

The statistical analyses were conducted utilizing the Excel program under Windows 98. Significant difference status between the compared parameters was computed by means of Mayr's (45) Coefficient of Difference (CD).

## Results and Discussion

### Abundances and Frequencies of the Ciliates

In our investigated sample of goats from Adana, the mean of ciliate numbers per milliliter was  $34.62 \times 10^4$  (SD=10.5, SE=4.7) (Table 1). Compared with the values reported from goats in other countries or with those reported from the cattle and sheep in Turkey, this finding

Table 1. Sampling dates and total ciliate numbers per milliliter in the rumen contents of the investigated five domestic goats (1-5).

Goat Nos.	Sampling Dates	Total Ciliate Numbers per ml ( $\times 10^4$ )
1	10.02.1999	42.8
2	11.02.1999	30.0
3	12.02.1999	21.0
4	13.02.1999	32.1
5	28.03.1999	47.2
Arithmetic Mean $\pm$ SD (SE)		34.62 $\pm$ 10.5 (4.7)

Table 2. Abundances (%) and appearance frequencies (%) of the holotrichous (Isotrichidae, Trichostomatida) and epidinine (Epidiniinae, Ophryoscollecidae, Entodiniomorpha) ciliates found within the rumens of domestic goats in the Adana region.

Species/ Formae	Goat Nos. and Abundances (%)					Frequency of Appearance (%)
	1	2	3	4	5	
1 <i>Isotricha prostoma</i>	1.02	+	4.97	1.37	-	80.00
2 <i>Isotricha intestinalis</i>	0.81	-	-	2.06	-	40.00
3 <i>Dasytricha ruminantium</i>	6.76	5.47	13.74	9.95	-	80.00
4 <i>Epidinium ecaudatum</i> f. <i>ecaudatum</i>	-	-	0.21	-	-	20.00
5 <i>Epidinium ecaudatum</i> f. <i>caudatum</i>	-	-	2.23	-	-	20.00
6 <i>Epidinium ecaudatum</i> f. <i>bicaudatum</i>	-	-	0.85	-	-	20.00
7 <i>Epidinium ecaudatum</i> f. <i>tricaudatum</i>	-	-	0.64	-	-	20.00
8 <i>Epidinium ecaudatum</i> f. <i>quadricaudatum</i>	-	-	1.70	-	-	20.00
9 <i>Epidinium ecaudatum</i> f. <i>parvicaudatum</i>	1.31	1.40	2.87	0.84	-	80.00
10 <i>Epidinium ecaudatum</i> f. <i>cattanei</i>	1.55	0.65	2.55	1.34	-	80.00
11 Other Ciliates	88.55	92.47	70.24	84.44	100.00	100.00

is low. In two different studies on Japanese goats, the findings were  $40.4 \times 10^4$  (18) and  $43.9 \times 10^4$  (25). In an Alaskan goat, the finding was  $53.7 \times 10^4$  (5). A study on goats in India (4) does not give a numerical value. The related values for Turkish domestic sheep and cattle were  $53.9 \times 10^4$  (37) and  $59.2 \times 10^4$  (46), respectively. However, these values were obtained from sheep and cattle in the İzmir region, so the discrepancies in the ciliate abundance may stem from different feeding habitats and/or dissimilar food stuffs.

Ciliate genera, species, formae, their abundances and frequencies of incidence in the five studied goats are given in Table 2.

Of the known four holotrichous ciliate families (*Isotrichidae*, *Paraisotrichidae*, *Blepharocorythidae* and *Buetschliidae*), only one (*Isotrichidae*; order *Trichostomatida*) is represented by *Isotricha prostoma*, *I. intestinalis* and *Dasytricha ruminantium* in our five goat specimens (Table 2). Das-Gupta (4) did not find any *I. intestinalis* in goats in India, while in Japan (18, 25) three species were found to be present in goats. In 12 goats investigated in India, both *I. prostoma* and *D. ruminantium* were present (100%), while in Japan the frequency of the two species was 53.3% and 86.7% respectively in 15 domestic goats. The frequency of *I. intestinalis* was reported to be 60.0% (25). Significantly, the abundances and frequencies of *D. ruminantium* in goats are higher than those of the other ciliates, including our present results. This probably stems from the better adaptation of *D. ruminantium* to the goat rumen with respect to the other holotrichous ciliates.

Our results indicate the presence of only *Epidinium ecaudatum* as seven formae: *E. e. f. ecaudatum*, *E. e. f. caudatum*, *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum*, *E. e. f. parvicaudatum* and *E. e. f. cattanei* (order Entodiniomorpha, family Ophryoscolecidae, subfamily Epidiniinae) within the rumens of our domestic goats (Table 2).

Das-Gupta (4) did not find *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum* or *E. e. f. parvicaudatum* in the rumens of goats in India, while in Japan only one study (18) mentions the presence of *E. e. f. ecaudatum* and *E. e. f. caudatum*. From this viewpoint, *E. e. f. bicaudatum*, *E. e. f. tricaudatum*, *E. e. f. quadricaudatum* and *E. e. f. parvicaudatum* are reported for the first time from domestic goats. In four of the investigated goats (80.00%), *E. e. f. parvicaudatum* and *E. e. f. cattanei* were found together, i.e., the co-occurrence tendency of the two forms in Adana goats is 100.00% (Table 2).

While the frequencies of incidence of *E. e. f. ecaudatum*, *E. e. f. caudatum* and *E. e. f. cattanei* were 16.67%, 25% and 33.33% respectively in goats in India (4), in Japan the related frequencies for the first two formae were both 50% (18). In our material, *E. e. f. ecaudatum* has a similar frequency to that of India, while the same frequency was higher in Japan (Table 2).

#### Morphological and Taxonomical Evaluation

*Isotricha prostoma* Stein, 1858 [Figure 2a; Table 3]

A comparison of the present measurements with those of Göçmen (31) on cattle and of Öktem *et al.* (37) on sheep shows the only significant difference is in L/W. The related CD values are above 1.60 in comparisons both with sheep and with cattle. In goats this value reaches 2.63. Generally speaking, this species is quite long and thin in goats but stout in cattle and sheep.

*Isotricha intestinalis* Stein, 1858 [Figures 2b and 2c; Table 3]

Specimens of the present work were quite similar to those of Göçmen (31) in cattle and of Öktem *et al.* (37) in sheep in terms of all of the measured parameters (CD<0.82).

*Dasytricha ruminantium* Schuberg, 1888 [Figure 2d; Table 3]

Values obtained from our material were found to be similar to those of Ogimoto and Imai (39) and Williams

and Coleman (43), and also to those of Öktem *et al.* (37), obtained from Turkish sheep.

*Epidinium ecaudatum* forma *ecaudatum* (Fiorentini, 1889) [Figure 3a; Tables 4-5]

The morphometrical data of this form (Table 4) are basically similar to those previously established by various authors, especially in L, W and L/W (Table 5). However, the values obtained by Kleyhans and Van Hoven (47) were almost the same as those from Turkish cattle (34, 35) but much lower than those we obtained from goats.

*Epidinium ecaudatum* forma *caudatum* (Fiorentini, 1889)[Figure 3b; Table 6]

The related morphometrical values obtained from our goat material (Table 6), were found to be similar (CD<0.91) to those previously reported from Turkish cattle (34, 35) and sheep (36, 38).

*Epidinium ecaudatum* forma *bicaudatum* (Sharp, 1914)[Figures 3c and 3d; Table 6]

This is the first record of this form in goats. A variation is evident, even within the same host, in terms of the lengths and orientations of the caudal spines. In all of the examined specimens, the ventral (preanal) spine (I) is almost two times longer than the other one. Its length varies between 11.65 and 34.95 µm, with a mean of 27.59 µm. In some of the specimens, the inner side of the ventral spine was serrated. The dorsal position (IV) of the second spine is constant. Morphometrical data obtained from the material within the goats are given in Table 6. Compared with the previously reported data from Turkish cattle and sheep (34-36, 38), similarities are evident in all characteristics (CD<0.73).

*Epidinium ecaudatum* forma *tricaudatum* (Sharp, 1914) [Figures 3e and 3f; Tables 6 and 7]

This is the first record of this form in goats; the relative lengths, orientations and placements of the caudal spines of this form also show some variation within the same host. Except the ventral spine, the spines are usually oriented right-ventrally and dorsally (I+II+IV). In a few specimens, one of these spines was observed at the middle level of the left surface.

Some morphometrical data on *Epidinium ecaudatum* f. *tricaudatum* from various authors are summarized in Table 7. As can be seen from these data, specimens obtained from Turkish cattle and sheep are similar in terms of measurable values and L/W ratio to those given

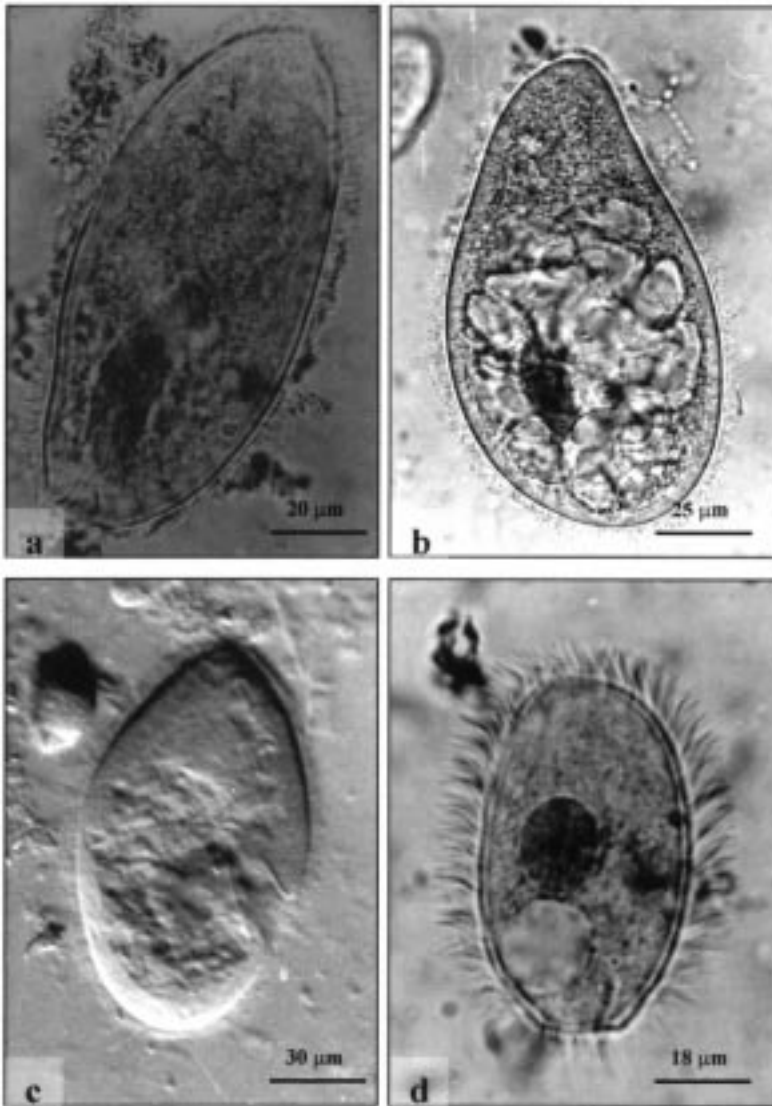


Figure 2. Photomicrographs of trichostomatid ciliates from goats in Adana, Turkey. a: *Isotricha prostoma* (from left), b-c: *I. intestinalis* (from dorsal on right), d: *Dasytricha ruminantium* (from left) (a, b and d: transmitted light microscopy, c: oblique illumination).

Table 3. Measurements, ratios and other related data concerning the trichostomatid species from our goats (n=sample size, measurements are in micrometers).

	<i>Isotricha prostoma</i> [n=50]			<i>Isotricha intestinalis</i> [n=50]			<i>Dasytricha ruminantium</i> [n=50]		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
L	100.19-174.75	132.67	16.08	104.85-174.75	140.29	14.96	34.95-116.50	72.84	18.07
W	34.95-69.90	51.45	9.31	53.59-97.86	71.48	10.96	25.63-41.94	33.88	4.22
MaL	23.30-67.57	41.61	9.61	18.64-53.59	37.51	6.94	11.65-27.96	19.34	4.14
MaW	9.32-18.64	13.65	2.82	13.98-30.29	20.36	3.88	9.32-27.96	14.66	3.60
L/MaL	2.36-4.61	3.29	0.54	2.14-6.50	3.87	0.82	2.14-5.60	3.84	0.86
LW	2.00-4.00	2.63	0.37	1.55-2.70	1.99	0.24	1.07-3.42	2.17	0.54
MaL/MaW	2.00-4.20	3.07	0.43	1.00-2.88	1.91	0.52	1.00-2.50	1.39	0.45
VO	9.32-18.64	13.58	2.15	9.32-30.29	18.13	3.92	3.50-5.83	4.64	0.50
VD	20.97-41.94	29.00	5.54	23.30-51.26	30.90	5.17	9.32-23.30	13.93	2.65

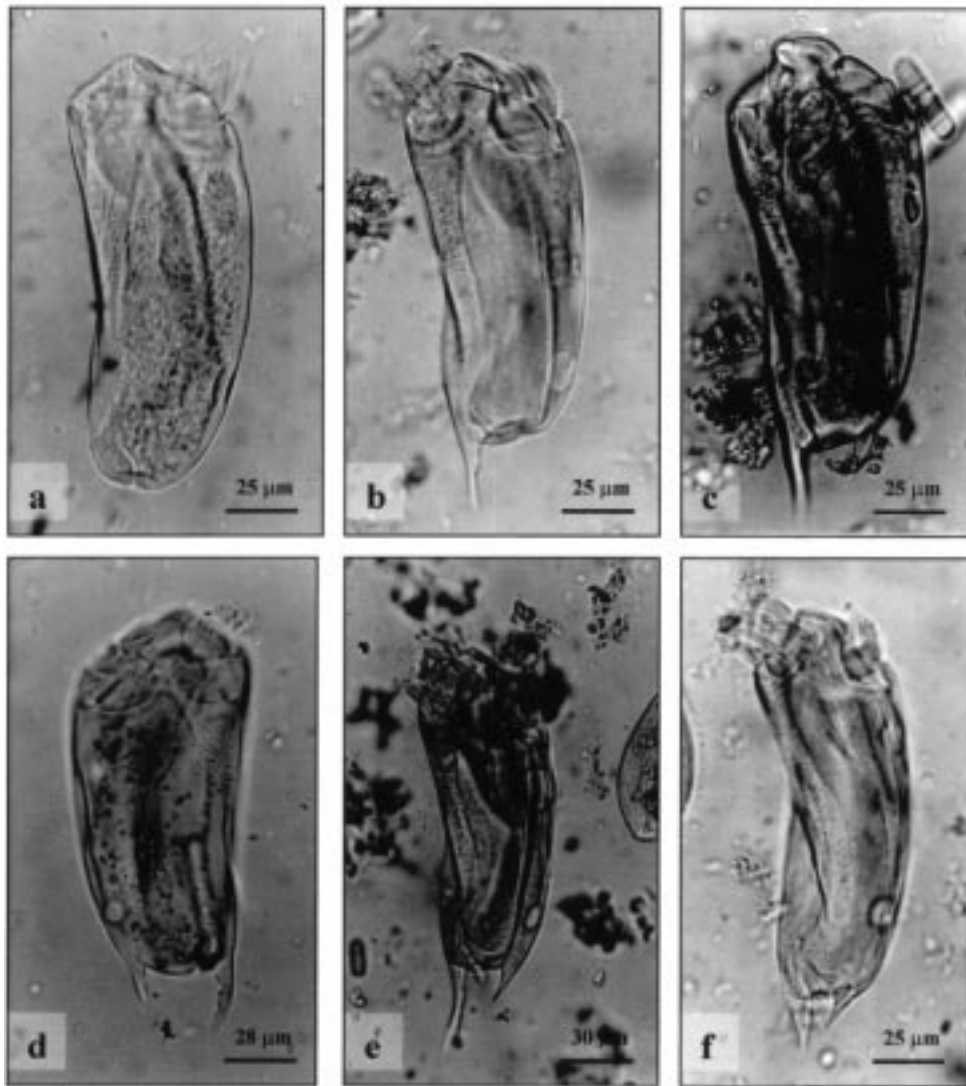


Figure 3. *Epidinium ecaudatum* f. *ecaudatum* (a, from left), *E. e. f. caudatum* (b, from left), *E. e. f. bicaudatum* (c, from left; d from right) and *E. e. f. tricaudatum* (e-f, both from left), photomicrographs of MFS applied specimens.

Table 4. Morphometrical data on *Epidinium ecaudatum* f. *ecaudatum* (sample from goat no. 3).

<i>Epidinium ecaudatum</i> f. <i>ecaudatum</i> [n=6]			
	Range	Mean	SD
L	116.50-151.45	138.63	14.49
W	44.27-60.58	54.76	7.48
MaL	65.24-83.88	74.95	7.43
MaW	9.32-16.31	11.85	2.80
L/MaL	1.72-1.97	1.85	0.09
L/W	2.42-2.70	2.54	0.10
MaL/MaW	4.57-8.75	6.63	1.66

by Dogiel (10) and Kofoid and MacLennan (42). However, the specimens obtained from our goats gave a higher value regarding the L/VSL ratio, i.e., they possess a rather short ventral spine (l).

*Epidinium ecaudatum* forma *quadricaudatum* (Sharp, 1914)[Figures 4a and 4b; Tables 8 and 9]

This also is a first record from goats. The longest preanal/ventral spine extends from the posteroventral tip of the cell. Lateral spines are almost of the same length. The dorsal spine is somewhat longer than the lateral ones. The positions of the lateral spines are variable; therefore, in the majority of investigated specimens, the

References	Hosts	L	W	L/W
Fiorentini (1889)	Domestic Cattle	120	44	---
Sharp (1914)	Domestic Cattle	127 (122-132)	43 (40-45)	2.9
Dogiel (1927)	Domestic Cattle	124 (98-152)	48 (38-62)	2.6
Dogiel (1925)	Reindeer	109 (90-136)	46 (36-58)	2.4
Kleyhans and Van Hoven (1976)	Giraffe	85 (52-128)	32 (24-45)	2.6
Göçmen (1996)	Domestic Cattle	81 (55-95)	30 (25-38)	2.7
Göçmen <i>et al.</i> (1999)	Domestic Sheep	113 (91-148)	53 (38-68)	2.15
Present study	Domestic Goats	139 (117-152)	55 (44-61)	2.54

Table 5. Various morphometrical data on *Epidinium ecaudatum* f. *ecaudatum*, reported by different authors from different hosts.

Table 6. A statistical summary on various characteristics of *Epidinium ecaudatum* f. *caudatum*, *Epidinium ecaudatum* f. *bicaudatum* and *E. e. f. tricaudatum* from goat no. 3.

	<i>E. e. f. caudatum</i> [n=25]			<i>E. e. f. bicaudatum</i> [n=25]			<i>E. e. f. tricaudatum</i> [n=25]		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
L	104.85-149.12	124.80	13.40	86.21-149.12	123.12	14.61	83.88-146.79	121.81	17.35
W	39.61-58.25	48.74	4.61	39.61-60.58	47.99	5.67	34.95-55.92	47.53	5.63
VSL	6.99-37.28	24.70	6.17	11.65-34.95	27.59	5.81	6.99-41.94	28.52	8.16
MaL	55.92-86.21	69.15	8.12	41.94-83.88	67.29	8.67	41.94-90.87	70.37	12.57
MaW	9.32-18.64	12.30	2.38	6.99-18.64	11.28	2.60	6.99-13.98	10.77	1.85
L/MaW	1.61-2.04	1.81	0.13	1.64-2.14	1.84	0.14	1.53-2.00	1.75	0.13
L/W	2.05-3.15	2.57	0.27	2.18-3.05	2.57	0.21	1.96-3.75	2.58	0.35
MaL/MaW	4.00-7.50	5.74	0.87	3.83-10.00	6.24	1.54	3.50-11.00	6.69	1.52
L/VSL	3.00-21.00	5.71	3.39	3.00-7.40	4.68	1.16	2.41-14.33	4.73	2.20

Table 7. Morphometrical data on *Epidinium ecaudatum* f. *tricaudatum* by different authors.

References	Countries	Hosts	L	W	L/W	L/VSL
Dogiel (1927)	Russia	<i>Bos taurus</i>	118 (98-140)	-----	-----	2.94
Kofoid and MacLennan (1933)	Ceylon	<i>Bos indicus</i>	112 (85-131)	49 (42-60)	2.31	2.00
Kleyhans and Van Hoven (1976)	S Africa	<i>Giraffa camelopardalis</i>	92 (74-102)	31 (24-38)	2.98	-----
Torun (1996)	Turkey	<i>Ovis aries</i>	109 (98-118)	48 (43-58)	2.28	3.74
Göçmen (1996)	Turkey	<i>Bos taurus</i>	105 (74-138)	47 (28-59)	2.29	4.55
Present Study	Turkey	<i>Capra hircus</i>	122 (84-147)	48 (35-56)	2.58	4.73

caudal spine model is I+II+IV+V, but in a few it is I+III+IV+V. Morphometrical data on the form are summarized in Table 8.

As is evident in Table 9, *Epidinium ecaudatum* f. *quadricaudatum* specimens from our goats are rather similar to those evaluated by Dogiel (10), Göçmen (34, 35), Torun (36) and Göçmen *et al.* (38). While the values obtained from the specimens originating from our cattle seem somewhat higher, the comparison of data

concerning various characteristics with those from our goats demonstrates CD values below 0.90, i.e., there are no significant differences.

*Epidinium ecaudatum* forma *parvicaudatum* (Awerinzew and Mutafówa, 1914) [Figures 4c and 4d; Table 8]

Again a first record from goats, also with a high percentage of incidence (80.00%). There are a total of

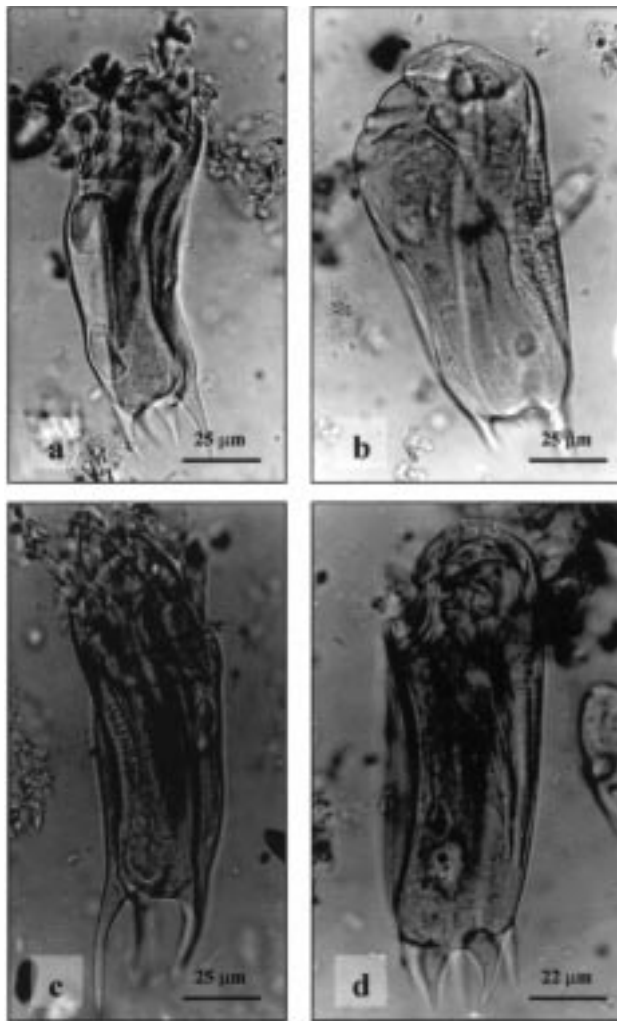


Figure 4. *Epidinium ecaudatum* f. *quadricaudatum* (a-b, both from right) and *E. e. f. parvicaudatum* (c, from left; d, from right), photomicrographs of MFS applied specimens.

five rather short and slightly inwardly curved caudal spines at the posterior end of the cell, the orientations of which are one ventral (I), two right (II and III), one dorsal (IV) and one left (V). The ventral spine is longer than the rest, almost 1/3 of the body length. A comparison of our material from goats (Table 8) with those reported from our sheep (36, 38) [U=96.34, G=43.11, U/G=2.24, IU=32.76, U/IU=2.94] shows only a single difference: regarding VSL, the form inhabiting the goats have a slightly shorter preanal (ventral) spine (CD<0.59), i.e., there is no significant difference.

*Epidinium ecaudatum forma cattanei* (Fiorentini, 1889) [Figure 5; Tables 8 and 10]

The only previous record from goats was from the domestic goat (*Capra hircus*) of India (4), ours being the second record. Of a total of five rather long caudal spines, one is ventral oriented (I), two right (II and III), one dorsal (IV) and one left (V) (Figures 1 and 5a). The ventral spine is longer than the rest. Every spine has a rather wide base but is thinner at the distal 2/3 (Figures 1 and 5). They extend roughly straight posteriorly, showing a very slight incurvation tendency. In 20.00% of the examined material, bifurcation was evident in spine V (Figure 5b), while in one specimen (4.00%) trifurcation was seen in spines I, IV and V (Figure 5d). The macronucleus is in the form of an elongated rod with acute tips, i.e., rather lenticular with a concave mid-dorsal and convex mid-ventral side.

The other formae displaying five distinct caudal spines described up to now were *E. e. f. parvicaudatum* (48), *E. e. f. rusa* (49) and *E. e. f. capricornisi* (20). These differ

Table 8. Statistical summaries on various characteristics of *Epidinium ecaudatum* f. *quadricaudatum*, *Epidinium ecaudatum* f. *parvicaudatum* and *E. e. f. cattanei* populations from our goats.

	<i>E. e. f. quadricaudatum</i> [Goat 3, n=25]			<i>E. e. f. parvicaudatum</i> [Goat 3, n=25]			<i>E. e. f. cattanei</i> [Goat 1, n=25]		
	Ekstr.	Ort.	SD	Ekstr.	Ort.	SD	Ekstr.	Ort.	SD
L	81.55-146.79	108.95	19.47	79.22-146.79	105.97	15.21	88.54-146.79	111.28	12.80
W	32.62-58.25	44.27	7.12	32.62-67.57	44.64	7.20	41.94-76.89	57.66	8.44
VSL	11.65-39.61	26.94	7.43	16.31-44.27	25.63	7.18	44.27-83.88	60.39	12.14
MaL	37.28-88.54	59.46	13.85	41.94-83.88	59.83	10.82	46.60-83.88	62.44	9.72
MaW	6.99-13.98	10.63	2.08	9.32-16.31	11.23	1.87	6.99-13.98	10.63	1.79
L/MaL	1.54-2.25	1.86	0.20	1.50-2.29	1.79	0.19	1.47-2.10	1.80	0.18
LW	2.00-3.71	2.48	0.35	2.13-2.82	2.38	0.17	1.66-2.39	1.94	0.15
MaL/MaW	3.80-8.00	5.68	1.19	2.86-7.25	5.44	1.17	3.67-8.00	6.01	1.17
LVSL	2.59-7.80	4.30	1.24	2.21-6.14	4.35	0.93	1.42-2.32	1.88	0.25



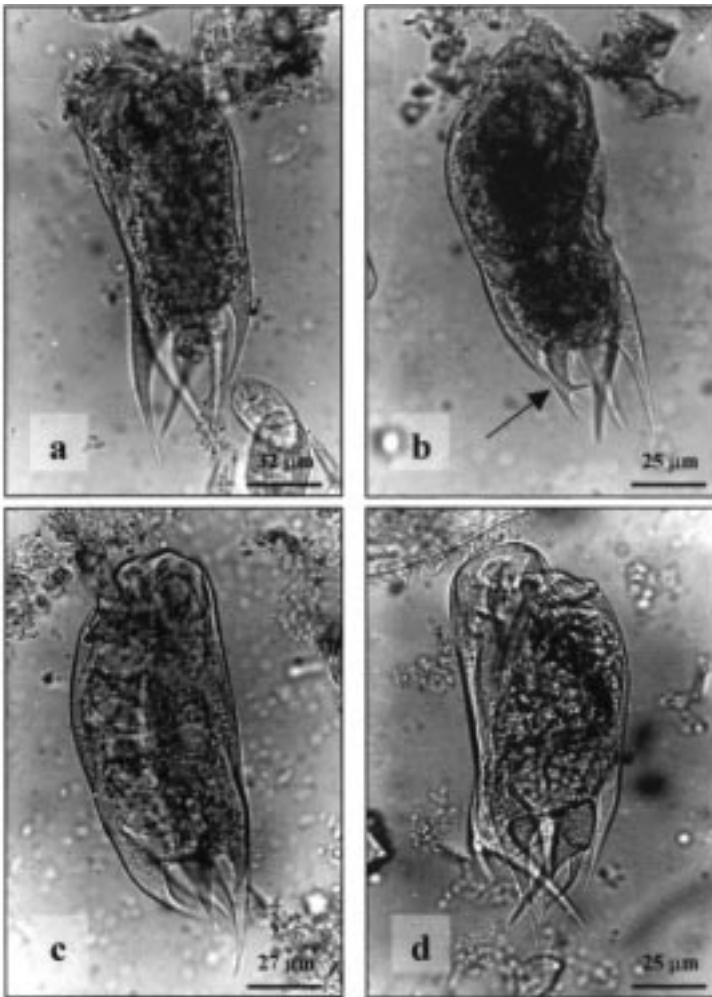


Figure 5. Photomicrographs of MFS applied *E. e. f. cattanei* specimens. a: typical form from left; b: a binary fissioning specimen with a bifurcate ( $\rightarrow$ ) spine V (from right); c: a specimen with relatively shorter caudal spines than the typical form, thus resembling *f. parvicaudatum* (from right); d: a specimen with bi- and trifurcate caudal spines, thus resembling *f. capricornisi* (from left).

Table 9. Morphometrical data on *Epidinium ecaudatum* f. *quadricaudatum* reported by different authors.

References	Countries	Hosts	L	W	L/W	VSL	L/VSL
Dogiel (1927)	Russia	<i>Bos taurus</i>	119 (100-140)	-	-	42 (16-70)	2.86
Kleyhan & Van Hoven (1976)	S. Africa	<i>Giraffa camelopardalis</i>	92 (76-109)	32 (24-38)	2.89	-	-
Kofoid & MacIennan (1933)	Ceylon	<i>Bos indicus</i>	116 (110-119)	51 (48-52)	2.29	26 (20-35)	1.92
Torun (1996)	Turkey	<i>Ovis aries</i>	113 (100-130)	50 (44-63)	2.27	38 (25-40)	3.77
Göçmen (1996)	Turkey	<i>Bos taurus</i>	120 (110-140)	50 (48-53)	2.40	38 (28-45)	3.22
Present study	Turkey	<i>Capra hircus</i>	109 (82-147)	44 (33-58)	2.48	27 (12-40)	4.30

Table 10. Morphometrical data on *Epidinium ecaudatum* f. *cattanei* reported by different authors.

References	Countries	Hosts	L	W	L/W	VSL	L/VSL
Dogiel (1927)	Russia	Domestic Cattle	101 (85-110)	54 (45-60)	1.83	80 (62-102)	1.26 (1.08-1.37)
Kofoid & McLennan (1933)	Ceylon	Zebu Cattle	97 (78-120)	53 (42-65)	1.84	63 (4-80)	1.17 (0.87-1.41)
Göçmen (1996; 1999)	Turkey	Domestic Cattle	92 (70-113)	42 (26-53)	2.18	67 (43-98)	1.39 (1.13-1.83)
Present Study	Turkey	Domestic Goats	111 (89-147)	58 (42-77)	1.94	60 (44-84)	1.88 (1.42-2.32)

from *E. e. f. cattanei* in (i) shorter caudal spines (*E. e. f. parvicaudatum*), or in (ii) equal length caudal spines (*E. e. f. rusa*), or in (iii) bifurcate/trifurcate caudal spines with free ends (*E. e. f. capricornisi*) (34, 35, 43).

While several authors (10, 34, 35, 39, 42, 43) have claimed that these characteristics differentiate these ciliates from the other formae of the species, as well as from each other, *E. e. f. cattanei* and *E. e. f. parvicaudatum* were first seen together by Dogiel (10) in cattle in Russia, but without any discussion given. Therefore, previously, the differentiating characteristics of *E. e. f. cattanei* from *E. e. f. parvicaudatum* were given as the longer caudal spines of the former, with the length of its preanal spine never being shorter than half its body length (Tables 8 and 10).

During the present study, especially in goats numbered 1 and 3, a ratio value of 2.81 in L/VSL, i.e., preanal spine lengths nearly 1/3 of the body length, were frequently seen, implying a similarity to *E. e. f. parvicaudatum* (Figure 5c), but being truncate at the posterior end, together with the thickness of the spine bases, and the shape of the macronucleus all point to the fact that these abundant forms were clearly *E. e. f. cattanei*. This suggests that the formerly given diagnostic characteristics for *E. e. f. cattanei* are insufficient; they should include “the posterior end of the body is truncate, the spine bases are rather thick and macronucleus is lenticular”. If among these characteristics “the posterior end of the body” and “the macronucleus shape”, which are used as species criteria among rumen ciliates, are taken into consideration, then maybe it would be more appropriate to raise the *cattanei* form to the species level. On the other hand, since *parvicaudatum* and *cattanei* were found sympatrically within the same hosts, it is not

possible to consider *cattanei* as a subspecies. From the viewpoint of *E. e. f. parvicaudatum*, this form is different from the other *E. ecaudatum* formae only in caudal spination. Thus, the “forma” status proposed (34, 35, 39) for this form seems appropriate.

A comparison of the L/W values of *E. e. f. cattanei* and *E. e. f. parvicaudatum* obtained from our goats points to a difference among them (CD=1.38), with *E. e. f. cattanei* being more stout. In 20.00% of the specimens, especially in spine V, the tip was bifurcate. In one specimen (4.00%), spines I, IV and V were trifurcate. This is a significant point, since, up to now, in formae within *E. ecaudatum*, the only form which displays a similar forkedness of spines was found in the Japanese Serow, *Capricornis crispus*, and was described as *E. e. f. capricornisi* by Imai *et al.* (20). The cell length (L) of this ciliate was 110.6 (90-130)  $\mu$ m, cell width (W) was 57.7 (50-70)  $\mu$ m, L/W was 1.93 (1.50-2.60) and spine length (VSL) was 12.6 (5-15)  $\mu$ m (Imai *et al.*, 1981). Except the caudal spine length (CD=3.38), these values are quite similar (CD<0.03) to those obtained from *E. e. f. cattanei* of our goats. An important point here is the coincidence of bi- and trifurcated spines, however, as a variation, in *cattanei* form ciliates from our goats, a characteristic which is known only from the *capricornisi* form of *Epidinium ecaudatum*, a condition which suggests a phylogenetical relation between the two formae or species (?).

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