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Ruminal Ciliate (Ciliophora, Trichostomatia) Biota of European Roe Deer (*Capreolus capreolus*) in Kastamonu

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Abstract: This study investigated the ruminal ciliate biota of European roe deer (*Capreolus capreolus*) in Kastamonu. Only one species, *Entodinium dubardi* (Ophryoscolecidae, Trichostomatia), was identified from the ruminal contents of twelve (70.6% prevalence) of seventeen roe deers. Five of seventeen roe deer had no ciliates. *E. dubardi* was determined for the first time from the ruminal content of roe deer in Türkiye. The average ciliate concentration was 17.5 ± 27.0 × 10^4 cells mL^{-1}. Min.–max. values ranged from 0 to 87 × 10^4 cells mL^{-1}.

Keywords: Cervidae, *Entodinium dubardi*, Ophryoscolecidae, microorganism, ecosystem.

Kastamonu'daki Avrupa Karacalarının (*Capreolus capreolus*) İşkembe Siliyat (Ciliophora, Trichostomatia) Biyotası

Öz: Bu çalışmada Kastamonu'daki Avrupa karacalarının (*Capreolus capreolus*) işkembe siliyat biyotası araştırılmıştır. Tek bir tür, *Entodinium dubardi* (Ophryoscolecidae, Trichostomatia) onyedi karacanın onikisinin (%70.6 yaygınlık) işkembe içeriğinden teşhis edilmiştir. Onyedi karacanın beşinde siliyat yoktur. *E. dubardi* Türkiye'deki karacaların (*Capreolus capreolus*) işkembe içeriğinden ilk defa tespit edilmiştir. Ortalama siliyat konsantrasyonu 17.5 ± 27.0 × 10^4 hücre mL^{-1}'dir. Min.–maks. değerler 0'dan 87'ye × 10^4 hücre mL^{-1} değişmektedir.

Anahtar kelimeler: Cervidae, *Entodinium dubardi*, Ophryoscolecidae, mikroorganizma, ekosistem.

1. Introduction

Ruminants are herbivorous animals that develop a symbiotic relationship with microorganisms to acquire their energy and nutrients from plant materials. These ruminal microorganisms comprise bacteria, archaea, fungi, and ciliated protozoa. Symbiotic ciliated protozoa have an essential role in the rumen ecosystem of both wild and domesticated ruminants because their presence is assumed to be effective in the nutrition and metabolism of the host (Hungate, 1966; Dehortiy, 1986; Williams & Coleman, 1992).

The wild roe deer, *Capreolus capreolus* (Linnaeus, 1758), known as the European roe deer, is the smallest species of the family Cervidae in Türkiye and Europe and possesses a wide dispersion in Europe and Asia. They primarily exist in northern Anatolia, with small numbers in Türkiye's Mediterranean, Aegean, and Eastern Anatolian regions (Beşkardeş et al., 2008; Evcin et al., 2017; Keten, 2017). The roe deer belong to the ruminants of the browser type; thus, they are concentrate selectors and possess a highly developed food selectivity (Deutsch et al., 1998; Marinucci et al., 2005; Miltko et al., 2020). The roe deer prefer herbaceous plants, buds, green shoots of trees, young leaves, and shrubs in the summer diet and herbs, shoots of trees and shrubs, lichen, and dry grasses in the winter diet (Cornelis et al., 1999; Miltko et al., 2020).

This study investigated the ruminal biota of wild roe deer living in the city of Kastamonu that has extensive forests and unwooded field areas in the Western Black Sea Region of Türkiye. The results obtained from the present study were compared with those from different investigations in numerous locations.

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2. Material and Methods

Ruminal contents were collected from 17 wild roe deer (*Capreolus capreolus*) inhabiting various state hunting areas in Kastamonu during the hunting season (June–August) from June 2016 to August 2017. After hunting, the rumen was cut open with a knife and the thoroughly mixed samples were fixed with an equal volume of 18.5% formalin as soon as possible to prevent the destruction of ciliates (Dehority, 1984). In the laboratory, an aliquot of each sample was filtrated and stained with methyl green formalin saline (MFS) (Ogimoto & Imai, 1981; Gürelli, 2016). Ciliates were counted using a Neubauer hemocytometer counting chamber and their concentrations per 1 mL volume were calculated (Gürelli & Daw, 2020).

For the description, Dogiel's (1927) orientation system was used. The side closest to the macronucleus was the dorsal side and the opposite side was the ventral side.

The specimens of *Entodinium dubardi* were prepared following the method of Imai et al. (1992) to study in detail, using a FEG 250 scanning electron microscope (SEM) (FEI-Quanta, Hillsboro, OR, USA).

The species was classified and identified based on formerly published taxonomic lists and species descriptions (Buisson, 1923; Wertheim, 1934; Sládeček, 1946; Lynn, 2008).

3. Results and Discussion

The average concentration of (± SD) ciliates in the ruminal contents from 17 European roe deer (*Capreolus capreolus*) was 17.5 (± 27.0) × 10^4 cells mL^{-1}. Min.–max. values ranged from 0 to 87 × 10^4 cells mL^{-1}. Only one species, *Entodinium dubardi* (Ophryosoclecidae, Trichostomatia), was detected. Five of seventeen European roe deer had no ciliates. In the present study, *E. dubardi* was determined for the first time from the ruminal content of roe deer (*Capreolus capreolus*) in Türkiye.

Entodinium dubardi was first described from roe deer (*Capreolus capreolus*) in France by Buisson (1923). Later, *E. dubardi* was identified from the ruminal content of roe deer (*Capreolus capreolus*) in former Yugoslavia by Wertheim (1934), in Slovakia by Sládeček (1946), and in Germany by Brüggemann et al. (1967). *E. dubardi* was also detected in Siberian roe deer (*Capreolus pygargus*) by Kornilova et al. (2004), Argunov & Stepanova (2015), and Kornilova et al. (2021).

Entodinium dubardi inhabited the rumen of European and Siberian roe deer. It is considered that it could be specific to roe deer, except for the study (Enzinger & Hartfiel, 1998) that included isotrichid, ophryoscolecid, and entodiniid spp., and the study that included isotrichid, ophryoscolecid spp., *E. dubardi*, and other *Entodinium* spp. (Kornilova et al., 2004), *E. dubardi* is only one ciliate species inhabiting the roe deer's rumen.

The body of *Entodinium dubardi* is oval and the anterior end is truncated. The dorsal side of the body is flattened or convex, whereas the ventral side is firmly convex. The greatest width is in the middle of the body. The posterodorsal end of the body is shorter than the posteroventral end. The broad, short, and funnel-shaped vestibulum directs to the dorsal side and extends posteriorly toward the contractile vacuole. The adoral ciliary zone encircles the vestibulum at the anterior end of the body and is retractible with a distinct adoral lip. The macronucleus is generally rod-shaped, nearer the anterior dorsal end of the body, and extends typically two-thirds of the body length. Sometimes, the anterior end of the macronucleus slightly directs to the ventral side and the macronucleus is slightly thinner to the posterior end. The spherical or oval micronucleus adheres to the right ventral anterior half of the macronucleus. It is nearer to the middle of the macronucleus, just below or at the level of the contractile vacuole. The contractile vacuole is at the left anterior end of the macronucleus. The long, distinct cytoproct is at the posterior end of the body and directs to the dorsal side. The longitudinal dorsal pellicular groove is distinct at the ventral side of the macronucleus and extends the entire length or three-quarters of the body. The longitudinal ventral pellicular groove exists in two-thirds or half of the body. The parallel pellicular striations extend from the anterior end of the body to the posterior end. The boundary layer between endoplasm and ectoplasm is distinct at the posterior end and the posteroventral end of the body has thicker ectoplasm (Figs. 1–2). The size of *E. dubardi* detected in the present study is consistent with the other studies from roe deer. Measurements and morphometric ratios of *E. dubardi* from wild roe deer in Türkiye and dimensions from different hosts in various locations are given in Tables 1 and 2.

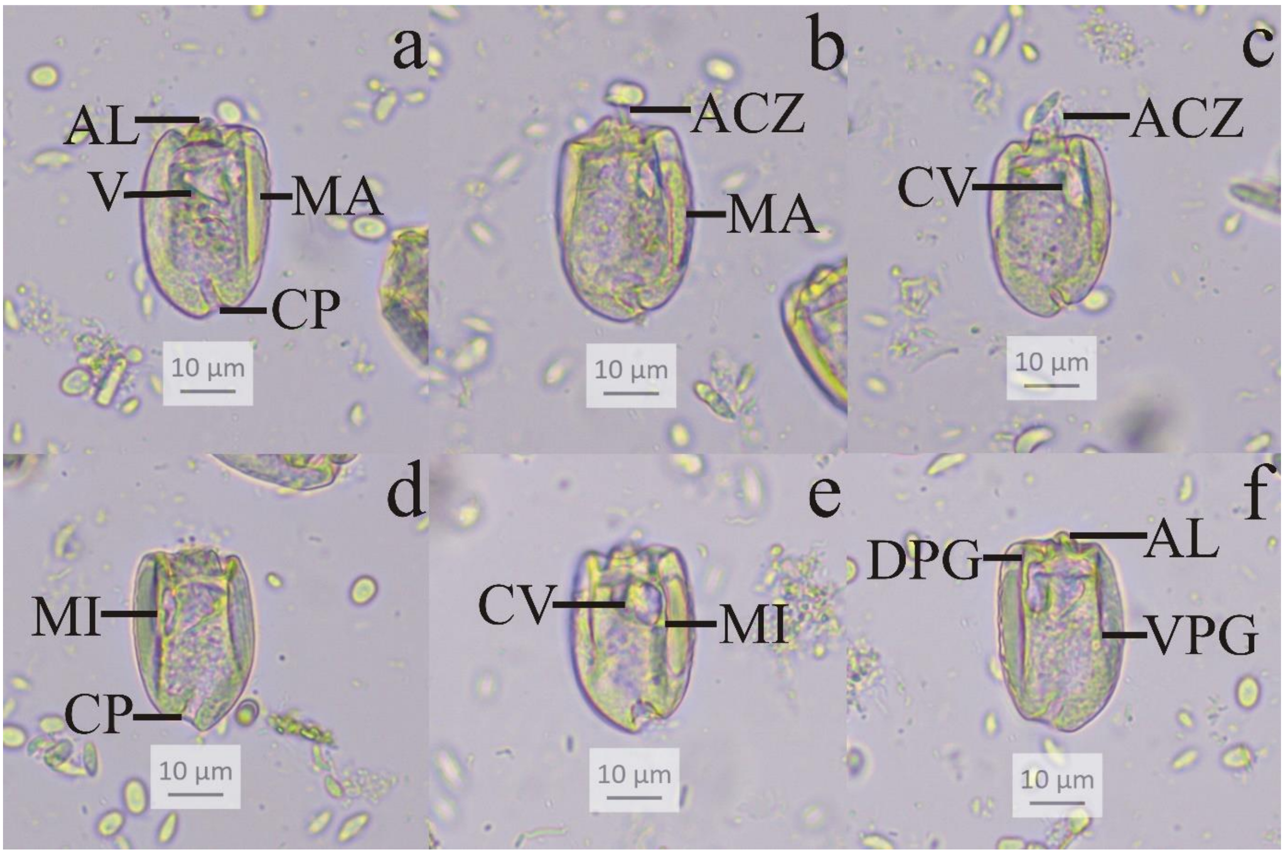

Figure 1. Photomicrographs of *Entodinium dubardi* (a, b, c, e: from the left side; d, f: from the right side) in MFS. ACZ: adoral ciliary zone, AL: adoral lip, CP: cytoproct, CV: contractile vacuole, DPG: dorsal pellicular groove, MA: macronucleus, MI: micronucleus, V: vestibulum, VPG: ventral pellicular groove.

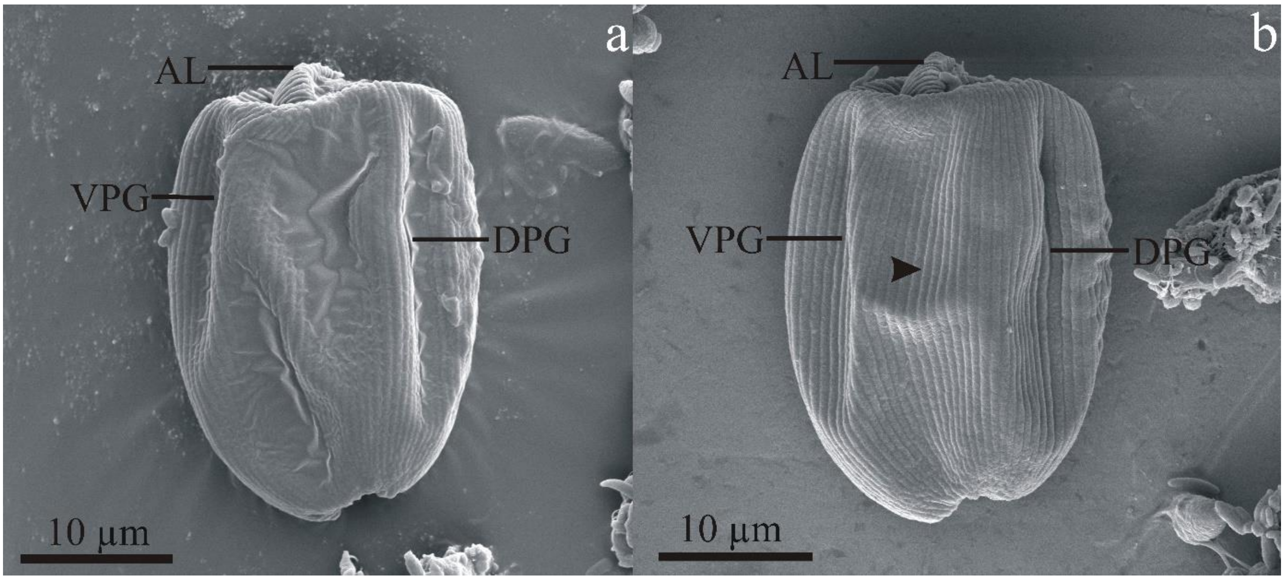

Figure 2. SEM images of *Entodinium dubardi* (a, b: from the left side). Pellicular striations (arrowhead), AL: adoral lip, DPG: dorsal pellicular groove, VPG: ventral pellicular groove.

Table 1. Measurements (µm) and morphometric ratios of *Entodinium dubardi* (n= 25).

Characters	Mean	Min.–Max. Value	SE	SD
Body length	35.4	33.0–37.6	0.2	1.2
Body width	23.6	21.3–25.0	0.2	1.0
Body length/body width	1.5	1.4–1.6	<0.1	0.1
Macronuclear length	20.6	18.0–23.6	0.3	1.5
Macronuclear width	4.9	4.1–6.0	0.1	0.5
Macronuclear length/body length	0.6	0.5–0.7	<0.1	<0.1
Distance from anterior end of the macronucleus to the micronucleus	7.0	5.7–9.1	0.2	0.9
Distance from anterior end of the macronucleus to the micronucleus/macronuclear length	0.3	0.3–0.4	<0.1	<0.1

Table 2. Comparison of *E. dubardi* dimensions (µm) from different hosts in various locations ([a]Mean ± SD not reported, [b]Min.–max. value not reported, [c]SD not reported).

References	Host	Country	Body Length (BL)	Body Width (BW)	L/W	Macronucleus Length (ML)
Buisson, 1923	*Capreolus capreolus* (European Roe Deer)	France	a (30.0–40.0)	a (18.0–29.0)	a, b	a (12.0–23.0)
Wertheim, 1934	*Capreolus capreolus* (European Roe Deer)	Former Yugoslavia	a (35.0–56.0)	a (28.0–35.0)	a, b	a, b
Sládeček, 1946	*Capreolus capreolus* (European Roe Deer)	Slovakia	34.0 ± c (28.0–48.0)	25.0 ± c (17.0–34.0)	a, b	a, b
Kornilova et al., 2021	*Capreolus pygargus* (Siberian Roe Deer)	Russia	40.1 ± 4.8 (28.8–51.8)	26.4 ± 2.4 (20.1–34.5)	a (1.4–1.6)	a, b
Present study	*Capreolus capreolus* (European Roe Deer)	Türkiye	35.4 ± 1.2 (33.0–37.6)	23.6 ± 1.0 (21.3–25.0)	1.5 ± 0.1 (1.4–1.6)	20.6 ± 1.5 (18.0–23.6)

Some authors could observe macronucleus shape and location variations in *E. dubardi* (Zielyk, 1961; Kornilova et al., 2021). The wedge-shaped macronucleus located in one-half of the body length of *E. dubardi* from white-tailed deer (Zielyk, 1961) and the sausage-shaped macronucleus located in the middle of the body of *E. dubardi* from Siberian roe deer (Kornilova et al., 2021) were reported. Seven different types or variation lines of *E. dubardi* were observed from blue duiker by Dehority (1994). It is considered that the host species could be important for the variation of the macronucleus and body shape of the ciliate because different hosts have different feeding habits. Hence, their rumen physiology is different and could affect the ciliate species' morphology.

Only one ciliate species, *E. dubardi*, was reported from 70.6% of the European roe deer in the present study; the other 19.4% have no ciliates. According to some studies, *E. dubardi* is the only ciliate species in the ruminal contents of roe deer (Buisson, 1923; Wertheim, 1934; Sládeček, 1946; Brüggemann et al., 1967; Kornilova et al., 2021). The compositional diversity of ruminal protozoa depends on the host species and its diet content. Roe deer have a relatively small rumen, a highly developed food selectivity, and a rapid digestive flow (Hofmann, 1989). Roe deer belong to concentrate selector ruminants and are qualified by their short ruminal retention times (Behrend et al., 2004). Concentrate selector browsers like roe deer are adopted to a faster-fermenting diet and have less efficient cellulose digestion (Hofmann, 1989; Miltko et al., 2020). The presence of protozoa in the rumen is pH-dependent. Rumen ciliates belonging to the genus *Entodinium* were developed at a pH slightly above 6.0, while other ciliates were not established until the pH reached 6.5 or above (Dehority & Orpin, 1997; Miltko et al., 2020). High concentrate diets can decrease ruminal pH and *Entodinium* is often the only genus detected (Dehority & Odenyo, 2003; Marinucci et al., 2005). The solitary nature of roe deer could explain the absence of protozoa and the lack of contact with other ruminant animals might have prevented the transfaunation and building or rebuilding of a stable ciliate population (Clauss et al., 2011). Another reason for the absence of ciliates is starvation, which causes total defaunation of the rumen, and ciliate concentration occurs in 4–6 days (Holub et al., 1969; Kamler, 1999). The ciliate concentration depends on changes in the food supply. The habitat is responsible for food availability (Cornelis et al., 1999). The ciliate concentration is strongly affected by the amounts of food taken by the host (Imai et al., 1993). Roe deer's diet was mainly based on shrubs, trees, and vegetative parts of herbaceous and woody plants (Marinucci et al., 2005). Kamler (1999) found the average concentration of ciliates in roe deer in the vegetation period was 57.2 ± 11.1 (min.= 11.8, max.= 78.5) × 10^4 cells mL^{-1} and in the winter period was 42.6 ± 20.1 (min.= 11.8, max.= 86.5) × 10^4 cells mL^{-1}. Deutsch et al. (1998) detected that the average concentration of ciliates in roe deer was 247.63 ± 5.8 × 10^4 cells mL^{-1} in April (vegetation period), 8.29 ± 1.48 × 10^4 cells mL^{-1} in March and August. Marinucci et al. (2005) found that the average concentration of ciliates in roe deer was 2.16 × 10^4 cells mL^{-1}. Miltko et al. (2020) reported the min.–max. value of ciliate concentration in roe deer was 65.0–387 × 10^4 cells mL^{-1}. The concentration of ciliates observed in the present study 17.5 (± 27.0) × 10^4 cells mL^{-1} was lower than in the studies performed by Kamler (1999), Miltko et al. (2020), and Deutsch et al. (1998) in April but higher than in the studies performed by Marinucci et al. (2005) and Deutsch et al. (1998) in March and August. The food preferences of roe deer in Kastamonu are generally soft herbs, roots, and shoots of buds and young shoots of deciduous trees (Evcin et al., 2017). The preference and amount of food according to seasonal changes affect the cellulolytic activity in the rumen of roe deer; thus, ciliate concentration increases depending on increasing cellulolytic activity. Surprisingly, ophryoscolecid, isotrichid, and other entodiniid spp. were detected in roe deer by Enzinger & Hartfiel (1998) and Kornilova et al. (2004). Close contact with other ruminants could occur and protozoa from other ruminants to roe deer could be transmitted. The ancestor of ruminant animals could have had very rich ciliate fauna. Later, the cervid hosts split up other ruminant animals in the evolution period and could have lost many ciliate species because of the food availability in the living habitat. Moreover, roe deer's solitary nature could not have allowed close contact with other ruminants. Thus, only *E. dubardi* could tolerate these conditions. The average rumen pH value recorded in roe deer was 5.7 (Marunicci et al., 2005). This pH value could be suitable for the survival of *E. dubardi*.

In conclusion, to reveal the rumen ciliate biota of wild ruminants, more hosts need to be examined; thus, the occurrence of these ciliates in different hosts may help understand the evolution of hosts.

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References

Argunov, A.V., & Stepanova, V.V. (2015). The winter diet of the Siberian roe deer (*Capreolus pygargus* Pall., 1771) in the Central Yakutia. *Vestnik KrasGAU*, 4, 138–143.

Behrend, A., Lechner-Doll, M., Streich, W.J., & Clauss, M. (2004). Seasonal faecal excretion, gut fill, liquid and particle marker retention in mouflon *Ovis ammon musimon* and a comparison with roe deer *Capreolus capreolus*. *Acta Theriologica*, 49, 503–515. https://doi.org/10.1007/BF03192594

Beşkardeş, V., Keten, A., & Arslangündoğdu, Z. (2008). The importance of roe deer (*Capreolus capreolus* L. 1758) in wildlife for Turkey. *Forestist*, 58, 15–22. https://doi.org/10.17099/jffiu.07636

Brüggemann, J., Giesecke, D., & Walser-Käst, K. (1967). Beiträge zur Wildbiologie und vergleichenden Tierphysiologie. II. Mikroorganismen im Pansen von Rothirsch (*Cervus elaphus*) und Reh (*Capreolus capreolus*). *Zeitschrift für Tierphysiologie Tierernährung und Futtermittelkunde*, 23, 143–151. https://doi.org/10.1111/j.1439-0396.1967.tb00972.x

Buisson, J. (1923). Sur quelques infusoires nouveaux ou peu connus parasites des mammifères. *Annales de Parasitologie Humaine et Comparée*, 1, 209–246. https://doi.org/10.1051/parasite/1923013209

Clauss, M., Müller, K., Fickel, J., Streich, W.J., Hatt, J.-M., & Südekum, K.-H. (2011). Macroecology of the host determines microecology of endobionts: protozoal faunas vary with wild ruminant feding type and body mass. *Journal of Zoology*, 283, 169–185. https://doi.org/10.1111/j.1469-7998.2010.00759.x

Cornelis, J., Casaer, J., & Hermy, M. (1999). Impact of season, habitat and research techniques on diet composition of roe deer (*Capreolus capreolus*): a review. *Journal of Zoology*, 248(2), 195–207. https://doi.org/10.1111/j.1469-7998.1999.tb01196.x

Dehority, B.A. (1984). Evaluation of subsampling and fixation procedures used for counting rumen protozoa. *Applied and Environmental Microbiology*, 48(1), 182–185. https://doi.org/10.1128/aem.48.1.182-185.1984

Dehority, B.A. (1986). Protozoa of the digestive tract of herbivorous mammals. *Insect Science and Its Application*, 7, 279–296. https://doi.org/10.1017/S1742758400009346

Dehority, B.A. (1994). Rumen ciliate protozoa of the blue duiker (*Cephalophus monticola*), with observations on morphological variation lines within the species *Entodinium dubardi*. *Journal of Eukaryotic Microbiology*, 41(2), 103–111. https://doi.org/10.1111/j.1550-7408.1994.tb01481.x

Dehority, B.A., & Odenyo, A.A. (2003). Influence of diet on the rumen protozoal fauna of indigenous African wild ruminants. *The Journal of Eukaryotic Microbiology*, 50(3), 220–223. https://doi.org/10.1111/j.1550-7408.2003.tb00121.x

Dehority, B.A.& Orpin, C.G. (1997). Development of, and natural fluctuations in, rumen microbial populations. In: Hobson, P.N., & Stewart, C.S. (ed) The Rumen Microbial Ecosystem. Springer, Dordrecht, 196–245. https://doi.org/10.1007/978-94-009-1453-7_5

Deutsch, A., Lechner-Doll, M., & Wolf, G.A. (1998). Activity of cellulolytic enzymes in the contents of reticulorumen and caecocolon of roe deer (*Capreolus capreolus*). *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, 119, 925–930. https://doi.org/10.1016/s1095-6433(98)00004-x

Dogiel, V.A. (1927). Monographie der Familie Ophryoscolecidae. *Archiv für Protistenkunde*, 59, 1–288.

Enzinger, W., & Hartfiel, W. (1998). Auswirkungen gesteigerter Energie- und Proteingehalte des Futters auf Fermentationsprodukte, Fauna und Schleimhaut des Pansens von Wildwiederkäuern (Damhirsch/Reh) im Vergleich zu Hauswiederkäuern (Schaf/Ziege). *Zeitschrift für Jagdwissenschaft*, 44, 201–220. https://doi.org/10.1007/BF02242026

Evcin, Ö., Küçük, Ö., Akkuzu, E., & Ugış, A. (2017). Habitat preferences of roe deer (*Capreolus capreolus*) in Kastamonu: case study of Elekdağı wildlife development area. *International Journal of Engineering Sciences*

& Research Technology, 6(4), 225–229. https://doi.org/10.5281/zenodo.546312

Gürelli, G. (2016). Rumen ciliates of domestic cattle (*Bos taurus taurus*) in Kastamonu, Turkey with the description of a new species. *European Journal of Protistology*, 56, 51–59. https://doi.org/10.1016/j.ejop.2016.07.002

Gürelli, G., & Daw A.F.O.E. (2020) Endosymbiotic ciliates protozoan biota of dromedary camels and domestic cattle in Tunisia. *Zootaxa*, 4859(3), 409–418. https://doi.org/10.11646/zootaxa.4859.3.6

Hofmann, R.R. (1989). Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia*, 78, 443–457. https://doi.org/10.1007/BF00378733

Hungate, R.E. (1966). The Rumen and Its Microbes. New York, Academic Press., 533 pp.

Imai, S., Tsutsumi, Y., Yumura, S., & Mulenga, A. (1992). Ciliate protozoa in the rumen of *Kafue lechwe*, *Kobus leche kafuensis*, in Zambia, with the description of four new species. *Journal of Protozoology*, 39, 564–572. https://doi.org/10.1111/j.1550-7408.1992.tb04852.x

Imai, S., Matsumoto, M., Watanabe, A., & Sato, H. (1993). Rumen ciliate protozoa in Japanese sika deer (*Cervus nippon centralis*). *Animal Science and Technology*, 64(6), 578–583.

Kamler, J. (1999). Infusorial concentration in rumen fluid of red deer, fallow deer, roe deer an moufflon. *Acta Veterinaria Brno*, 68, 247–252. https://doi.org/10.2754/avb199968040247

Keten, A. (2017). Distribution and habitat preference of roe deer (*Capreolus capreolus* L.) in Düzce Province (Turkey). *Forestist*, 67(1), 22–28. https://doi.org/10.17099/jffiu.89577

Kornilova, O.A., (2004). History of Study of Endobiotic Ciliates of Mammalia. St-Petersburg, Tessa Press., 349 pp.

Kornilova, O.A., Chistyakova, L.V., Seryodkin, I.V., & Grabarnik, I.P. (2021). Endobiotic ciliates from the rumen of the roe deer *Capreolus pygargus*. *Parazitologiya*, 55(6), 465–475. https://doi.org/10.31857/S0031184721060028

Lynn, D.H. (2008). The Ciliated Protozoa, Characterization, Classification and Guide to the Literature. New York, Springer, 605 pp.

Marinucci, M.T., Capecci, A., Riganelli, N., Acuti, G., Antonini, C., & Olivieri, O. (2005). Dietary preferences and ruminal protozoal populations in roe deer (*Capreolus capreolus*), fallow deer (*Dama dama*) and mouflon (*Ovis musimon*). *Italian Journal of Animal Science*, 4(2), 401–403. https://doi.org/10.4081/ijas.2005.2s.401

Miltko, R., Kowalik, B., Majewska, M.P., Kedzierska, A, McEwan, N.R., & Bełżecki, G. (2020). The effect of protozoa on the bacterial composition and hydrolytic activity of the roe der rumen. *Animals*, 10(467), 1–9. https://doi.org/10.3390/ani10030467

Ogimoto, K., & Imai, S. (1981). Atlas of Rumen Microbiology. Tokyo, Japan Scientific Societies Press., 231 pp.

Sládeček, F. (1946). Ophryoscolecidae from the stomach of *Cervus elaphus* L., *Dama dama* L., and *Capreolus capreolus* L. *Vestnik Ceskoslovenske Spolecnosti Zoologicke*, 10, 201–231.

Wertheim, P. (1934). Über die beschaffenheit der infusorienmagenfauna von *Capreolus capreolus* L. *Zoologischer Anzeiger*, 106, 67–70.

Williams, A.G., & Coleman, G.S. (1992). The Rumen Protozoa. New York, Springer, 442 pp. https://doi.org/10.1007/978-1-4612-2776-2

Zielyk, M.W. (1961). Ophryoscolecid fauna from the stomach of the white-tailed deer (*Odocoileus virginianus borealis*), and observations on the division of *Entodinium dubardi* Buisson 1923 (Ciliata Entodiniomorpha). *The Journal of Protozoology*, 8(1), 33–41. https://doi.org/10.1111/j.1550-7408.1961.tb01178.x