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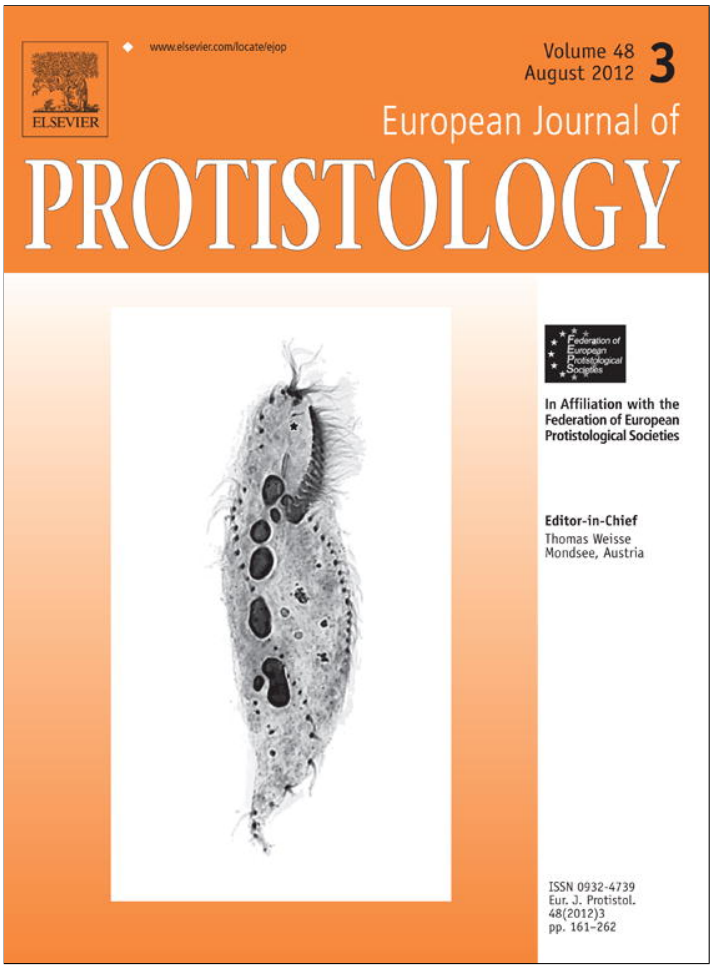

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Intestinal ciliate composition found in the feces of racing horses from Izmir, Turkey

Gözde Gürelli*, Bayram Göçmen

Ege University, Faculty of Science, Department of Biology, Zoology Section, 35100 Bornova, Izmir, Turkey

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Abstract

Species composition and distribution of intestinal ciliates were investigated in the feces from 15 racing horses living near Izmir, Turkey. Thirty-seven species belonging to 21 genera were identified. Although no new species were observed, this is the first report on intestinal ciliates in racing horses living in Turkey. The mean number of ciliates was $26.4 \pm 13.9 \times 10^4$ cells ml^{-1} of feces and the mean number of ciliate species per host was 18.8 ± 7.1. No ciliates were observed in one horse. *Bundleia* and *Polymorphella* were found to be the two dominant genera, occurring in high proportions. In contrast, *Didesmis* and *Prorodonopsis* were only observed at a low frequency. *Bundleia nana*, *Blepharoconus hemiciliatus*, *Paraisotrichopsis composita*, *Prorodonopsis coli* and *Spirodinium equi* were newly recorded from Turkey.
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Keywords: Feces; Intestinal ciliates; Racing horse; Turkey

Introduction

Many of the ciliates living in the intestine of equids can digest cellulose and starch (Dehority 1986). These ciliates are commensal and have no resistant cysts (Ike et al. 1985; Ozeki et al. 1973). The ciliates invade the host after they are ingested (coprophagy) and subsequently they become established in the host's large intestine (Ike et al. 1985). The large intestine is made up of four parts: caecum, large colon, small colon and rectum (Miyaji et al. 2008). It is well known that many different ciliates inhabit the large intestine of the horse (Adam 1951; Gassovsky 1919; Hsiung 1930; Ozeki 1977; Strelkow 1939) and that the ciliate composition in feces reflects the population in the large intestine (Gürelli and Göçmen 2010; Ike et al. 1981, 1983a,b,c; Imai et al. 1999; Ito et al. 1996; Tung 1992).

Although the composition of the intestinal ciliate community of various equids is known in general, no investigation has been conducted on the ciliate fauna of the racing horse *Equus caballus* Linnaeus, 1758, living near Izmir, Turkey.

The aims of this study were to identify and quantify the fecal ciliates from those animals living in that area and compare their fauna with Turk rahvan horses also living near Izmir. These data will also be compared with previous studies on equids from various other locations.

Material and Methods

Fecal samples were collected from 15 racing horses, *Equus caballus* Linnaeus, 1758, located in the vicinity of Izmir, Turkey. The horses were fed with oats, barley, dried clover, fodder, carrots, apples, soybean, beets, parsley, raisin, grape molasses, and a mixture of vitamins and minerals and vegetable oil. The samples were collected from January 2008 to April 2008. The fecal samples were collected immediately

*Corresponding author.
E-mail address: ggurelli@yahoo.com (G. Gürelli).

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after defecation and fixed and stained in 2 times as much methylgreen formalin saline (MFS) solution as their original volume (Gürelli and Göçmen 2010; Ogimoto and Imai 1981). This procedure was used to preserve the integrity of the cell and its internal structures. The MFS solution served as a nuclear stain and 2% Lugol's iodine was used to stain skeletal plates. Fecal samples were passed through 2.56 mm mesh gauze and kept in the dark until examination. Details of the ciliate morphology were investigated at 1000× magnification using an oil immersion objective microscope.

For detailed observation of kineties of the individual species, the protozoa were examined using the pyridinated silver carbonate impregnation technique of Fernández-Galiano (1976) and Ito and Imai (2006), and the silver nitrate impregnation technique of Ito et al. (1996).

Total cell counts were made at 400× magnification with a Neubauer hemocytometer counting chamber. The Neubauer hemocytometer counting chamber has slender grooves cut at regular intervals. The number of cells per 1 ml of intestinal contents can be calculated by the following Formula: $N = 10/4 \times a \times d$ (N: number of ciliates per 1 ml of intestinal contents, a: number of ciliates in 4 divisions on the Neubauer hemocytometer, d: sample dilution).

Differential counts of species were estimated from smear slides with a total of 400–500 cells identified for each species (Göçmen and Gürelli 2009; Gürelli and Göçmen 2010).

The orientation of ciliates for description was adopted from Dogiel (1927); the side closest to the cytostome is considered as the ventral side, while the opposite side or the cell surface closest to the macronucleus is termed the dorsal side. The other two were the right and left sides.

Classification and identification of species were based on previously published species descriptions and taxonomic lists (Hsiung 1930; Kornilova 2003, 2004; Lynn 2008; Ozeki 1977; Strelkow 1939).

Results

Ciliate composition of the fecal samples

Frequency of appearance (i.e. the number of hosts in which the species was detected/number of hosts examined) and the relative composition of genera and species are shown in Table 1. We identified 37 species belonging to 21 genera. The ciliate fauna consisted of 1 genus and 2 species belonging to the family Paraisotrichidae, 10 genera and 19 species belonging to the Buetschliidae, 3 genera and 6 species belonging to the Blepharocorythidae, 1 genus and 2 species belonging to the Cycloposthiidae, 5 genera and 7 species belonging to the Spirodiniidae and 1 genus and 1 species belonging to the Allantosomatidae. For individual racing horses, the total number of species per animal ranged from 4 to 21, with an average of 18.8 ± 7.1 (SD).

One of 15 horses had no ciliates. Except for one additional horse, all other horses contained *Bundleia* and *Polymorphella*. Frequency of appearance for both *Bundleia postciliata* and *Polymorphella ampulla* was 93.3%. Of the other species, frequency of appearance of *Didesmis ovalis*, *Blepharocorys angusta* and *Prorodonopsis coli* was 6.7%, respectively. The percentage composition (i.e. the ratio of the number of each species in 400–500 cells from each of animals) was high, over 9.5%, for *Bundleia postciliata*, *Blepharocorys curvigula*, *Cycloposthium bipalmatum* (Table 1).

The average abundance of ciliates in the intestinal contents from the 15 racing horses was $26.4 \pm 15.1 \times 10^4$ cells ml^{-1}. Values ranged from 0 to 54.5×10^4 cells ml^{-1} (Table 2).

Bundleia nana, *Prorodonopsis coli*, *Paraisotrichopsis composita*, *Blepharoconus hemiciliatus* and *Spirodinium equi* are newly recorded species in Turkey (Figs. 1–5).

Strelkow (1939) classified *Cycloposthium edentatum* into four morphotypes based on its cell surface and its cell size. In this study, only one morphotype (*C. edentatum* m. edentatum) was observed. Strelkow (1939) classified *Tetratoxum parvum* in two morphotypes. Only one morphotype (*T. parvum* m. parvum) was observed in this study.

General morphology of *Bundleia nana* Strelkow, 1939 (Fam. Buetschliidae) (Fig. 1)

The average cell length was 22.5 ± 3.4 μm (22.5–37.5 μm, $n = 30$) and cell width, 28.0 ± 3.4 μm (17.5–32.5 μm, $n = 30$). It is the smallest species of the genus of *Bundleia*. Cell is flattened slightly from the sides and tapers equally toward the posterior end. The cell is widest at the anterior end. Macronucleus is globular-shaped and micronucleus is situated in the depression of the macronucleus. The position of macronucleus is not constant in the cytoplasm. Its length is 6.3 ± 1.4 μm (5.0–10.0 μm, $n = 30$) and width is 6.3 ± 1.4 μm (5.0–10.0 μm, $n = 30$). Concretion vacuole is situated at the anterior end of the cell. Cytostome is at the anterior end of the cell and is followed by a small cytopharynx. Cytoproct and anal tube are at the posterior end of the cell and directed to one side. Anterior ciliary zone is well developed and it is like a band at the anterior end. Caudal ciliary zone is very small and placed asymmetrically the posterior end.

General morphology of *Prorodonopsis coli* Gassovsky, 1919 (Fam. Buetschliidae) (Fig. 2)

The average cell length was 56.6 ± 7.3 μm (42.5–72.5 μm, $n = 30$) and cell width, 39.3 ± 5.5 μm (27.5–50.0 μm, $n = 30$). Cell is asymmetrical. It tapers toward the anterior end. Posterior end is broad and rounded. Cytostome is located at the anterior end of the cell and is slightly bent to one side. Long somatic cilia cover the cell in longitudinal rows. Somatic kineties completely encircles the cytostome and overlie longitudinal cell axis. Concretion vacuole is in front third of the cell. Macronucleus is elongated-shaped and sometimes is bean-shaped. Its position is not constant in the cytoplasm.

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Table 1. Frequency of appearance and percentage composition of intestinal ciliates in the feces of 15 racing horses.

Familia/genus/species	Frequency of appearance (%)	Percentage composition (%)	
		Mean ± SD	Range
Paraisotrichidae			
Paraisotricha	40.0	1.6 ± 4.5	0–17.6
colpoidea Fiorentini, 1890	26.7	1.4 ± 4.5	0–17.6
minuta Hsiung, 1930	20.0	0.2 ± 0.4	0–1.7
Buetschliidae			
Bundleia	93.3	26.0 ± 14.7	0–52.5
postciliata (Bundle, 1895)	93.3	11.4 ± 6.8	0–24.7
piriformis Strelkow, 1939	40.0	1.2 ± 1.9	0–6.4
nana Strelkow, 1939	40.0	1.1 ± 1.6	0–5.1
elongata Strelkow, 1939	73.3	3.5 ± 3.9	0–11.9
triangularis Strelkow, 1939	60.0	2.2 ± 4.2	0–12.4
dolichosoma Strelkow, 1939	66.7	1.6 ± 1.9	0–6.4
inflata Strelkow, 1939	73.3	4.8 ± 6.2	0–18.9
Didesmis	6.7	0.1 ± 0.3	0–1.1
ovalis Fiorentini, 1890	6.7	0.1 ± 0.3	0–1.1
Polymorphella	93.3	3.6 ± 4.2	0–10.9
ampulla (Dogiel, 1929)	93.3	3.6 ± 4.2	0–10.9
Blepharoconus	66.7	1.8 ± 2.0	0–6.1
hemiciliatus Hsiung, 1930	40.0	0.9 ± 1.2	0–3.0
benbrooki (Hsiung), 1930	73.3	1.5 ± 1.9	0–7.7
Paraisotrichopsis	53.3	1.8 ± 2.5	0–9.4
composita Gassovsky, 1919	53.3	1.8 ± 2.5	0–9.4
Holophryoides	86.7	8.3 ± 7.5	0–24.3
ovalis (Fiorentini, 1890)	80.0	2.2 ± 1.9	0–6.1
macrotricha Strelkow, 1939	73.3	4.9 ± 6.2	0–22.8
Blepharosphaera	13.3	0.1 ± 0.3	0–1.2
ellipsoidalis Hsiung, 1930	13.3	0.1 ± 0.3	0–1.2
Hemiprorodon	33.3	0.4 ± 0.8	0–3.0
gymnoposthium Strelkow, 1939	33.3	0.4 ± 0.8	0–3.0
Prorodonopsis	6.7	0.2 ± 0.8	0–3.0
coli Gassovsky, 1919	6.7	0.2 ± 0.8	0–3.0
Blepharoprosthium	80.0	4.9 ± 5.8	0–17.9
pireum Bundle, 1895	46.7	0.2 ± 0.2	0–0.6
polytrichum Strelkow, 1939	66.7	5.8 ± 6.3	0–17.8
Blepharocorythidae			
Blepharocorys	86.7	17.0 ± 15.4	0–48.3
curvigula Gassovsky, 1919	86.7	10.1 ± 10.7	0–37.3
angusta Gassovsky, 1919	6.7	0.4 ± 1.7	0–6.5
microcorys Gassovsky, 1919	46.7	6.8 ± 11.0	0–38.3
uncinata (Fiorentini, 1890)	26.7	0.4 ± 0.8	0–2.9
Ochoterenaia	33.3	0.8 ± 1.6	0–6.2
appendiculata Chavarria, 1933	33.3	0.8 ± 1.6	0–6.2
Circodinium	46.7	1.7 ± 2.2	0–6.5
minimum (Gassovsky, 1919)	46.7	1.7 ± 2.2	0–6.5
Cycloposthiidae			
Cycloposthium	66.7	7.4 ± 13.1	0–47.9
bipalmatum (Fiorentini, 1890)	66.7	9.4 ± 16.7	0–47.9
edentatum Strelkow, 1928	40.0	1.1 ± 2.6	0–10.0
Spirodiniidae			
Cochliatoxum	73.3	0.4 ± 0.4	0–1.3
periachtum Gassovsky, 1919	73.3	0.4 ± 0.4	0–1.3
Tetratoxum	80.0	2.4 ± 2.6	0–10.0
unifasciculatum (Fiorentini, 1890)	66.7	1.3 ± 1.3	0–3.6
parvum Hsiung, 1930	53.3	1.2 ± 1.8	0–6.5

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Table 1 (*Continued*)

Familia/genus/species	Frequency of appearance (%)	Percentage composition (%)	
		Mean ± SD	Range
Spirodinium	60.0	1.0 ± 1.2	0–3.3
equi Fiorentini, 1890	46.7	0.7 ± 1.0	0–3.3
confusum Hsiung, 1935	33.3	0.4 ± 0.7	0–2.6
Triadinium	80.0	5.0 ± 3.8	0–13.3
caudatum Fiorentini, 1890	80.0	5.0 ± 3.8	0–13.3
Gassovskiella	26.7	0.3 ± 0.6	0–1.5
galea (Gassovsky), 1919	26.7	0.3 ± 0.6	0–1.5
Allantosomatidae			
Allantosoma	66.7	5.1 ± 9.6	0–37.7
intestinale Gassovsky, 1919	66.7	5.1 ± 9.6	0–37.7
Total	21 genera 37 species		

Its length is 13.6 ± 4.8 μm (7.5–25.0 μm, $n = 30$), and width is 14.2 ± 5.4 μm (7.5–25.0 μm, $n = 30$). Small micronucleus is situated in the depression of the macronucleus. One contractile vacuole and cytoproct are at the posterior end of the cell.

General morphology of *Paraisotrichopsis composita* Gassovsky, 1919 (Fam. Buetschliidae) (Fig. 3)

The average cell length was 66.6 ± 9.7 μm (40.0–82.5 μm, $n = 30$), and cell width, 51.5 ± 10.2 μm (32.5–77.5 μm, $n = 30$). Cell is oval-shaped. Its anterior end and posterior end is rounded. Macronucleus is oval-shaped and micronucleus is situated in the depression of the macronucleus. The position of macronucleus is not constant in the cytoplasm. Its length is 18.6 ± 6.5 (10.0–37.5 μm, $n = 30$) and width is 17.3 ± 6.5 μm (10.0–32.5 μm, $n = 30$). Cytostome is located at the anterior end of the cell and near to the ventral side of the cell. Except within the groove, long somatic cilia cover the cell in longitudinal rows. Somatic kineties overlie longitudinal cell axis. Groove begins behind the cytostome and passes obliquely to the dorsal surface and terminates at the posterior end of the cell. Because of the groove, the cell sometimes appears to be divided into two parts. Cytoproct is situated at the ventral side of spiral groove at the end of the cell. Concretion vacuole is elongate-shaped and is at the anterior end of the cell. Small contractile vacuole is located back of the concretion vacuole.

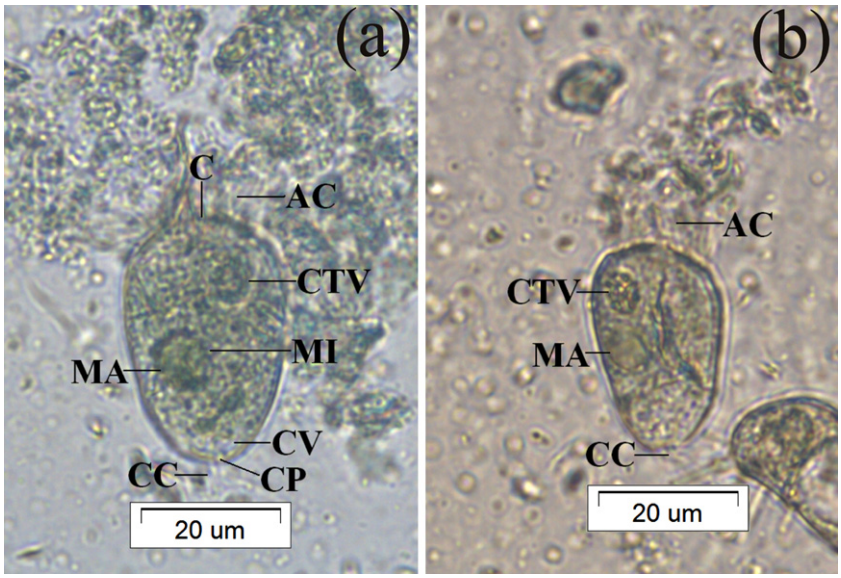

Fig. 1. Photomicrographs of *Bundleia nana* (a), (b) – in MFS. C, cytostome; MA, macronucleus; MI, micronucleus; CTV, concretion vacuole; CV, contractile vacuole; CP, cytoproct; AC, anterior ciliary zone; CC, caudal ciliary zone.

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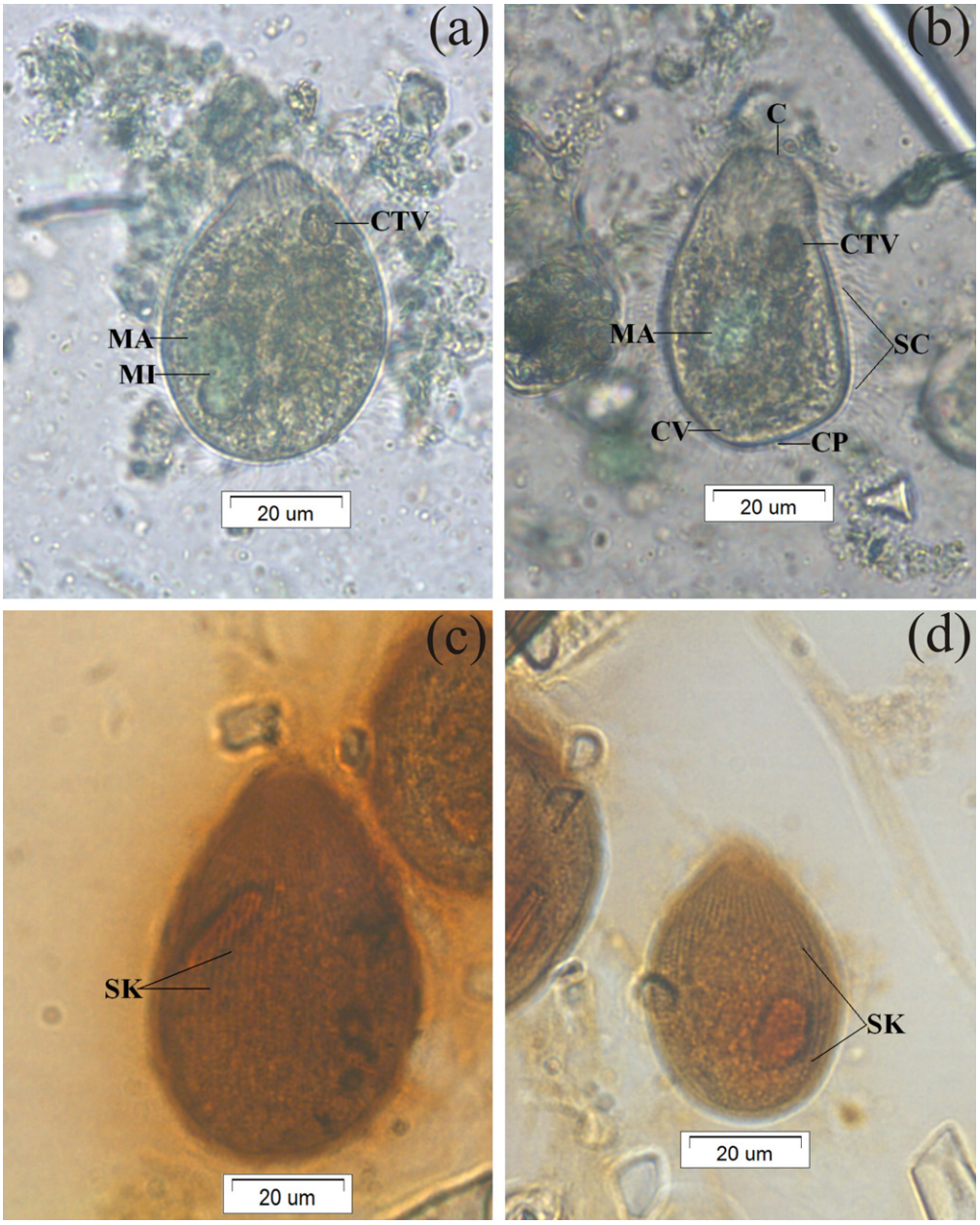

Fig. 2. Photomicrographs of *Prorodonopsis coli* (a), (b) – in MFS, (c), (d) – after silver nitrate impregnation. SC, somatic cilia; SK, somatic kineties.

General morphology of *Blepharoconus hemiciliatus* Hsiung, 1930 (Fam. Buetschliidae) (Fig. 4)

The average cell length was 69.8 ± 9.3 μm (55.0–90.0 μm, $n = 30$) and cell width, 57.3 ± 6.6 μm (47.5–70.0 μm, $n = 30$). Cell is conical to rounded and slightly tapers toward the posterior end. Macronucleus is oval-shaped and the micronucleus is situated in the depression of the macronucleus. The position of macronucleus is not constant in the cytoplasm, but it is generally found in the middle of the cell. Its length is 20.6 ± 4.4 μm (12.5–30.0 μm, $n = 30$) and width is 18.8 ± 0.7 μm (12.5–25.0 μm, $n = 30$). Concretion vacuole is elongated and situated in the anterior end of the cell, near one side. It protrudes from the cell surface. Small, rounded-shaped cytostome is at the anterior end of the cell and is followed by a cone-shaped cytopharynx. Cytopharynx reached the middle of the cell. Supporting fibrils are in cytopharynx. Lateral fold is at the anterior fourth of the cell. Anterior ciliary zone is asymmetrical, situated around the cytostome in longitudinal rows. On one side of the cell it reaches near the concretion vacuole, and on other side, it reaches the middle of the cell. Longitudinal shallow grooves closely set to each other cover the rest of the cell surface; however, they cannot be observed in fixed materials.1–3 contractile vacuoles are found in the cell and one of them lies

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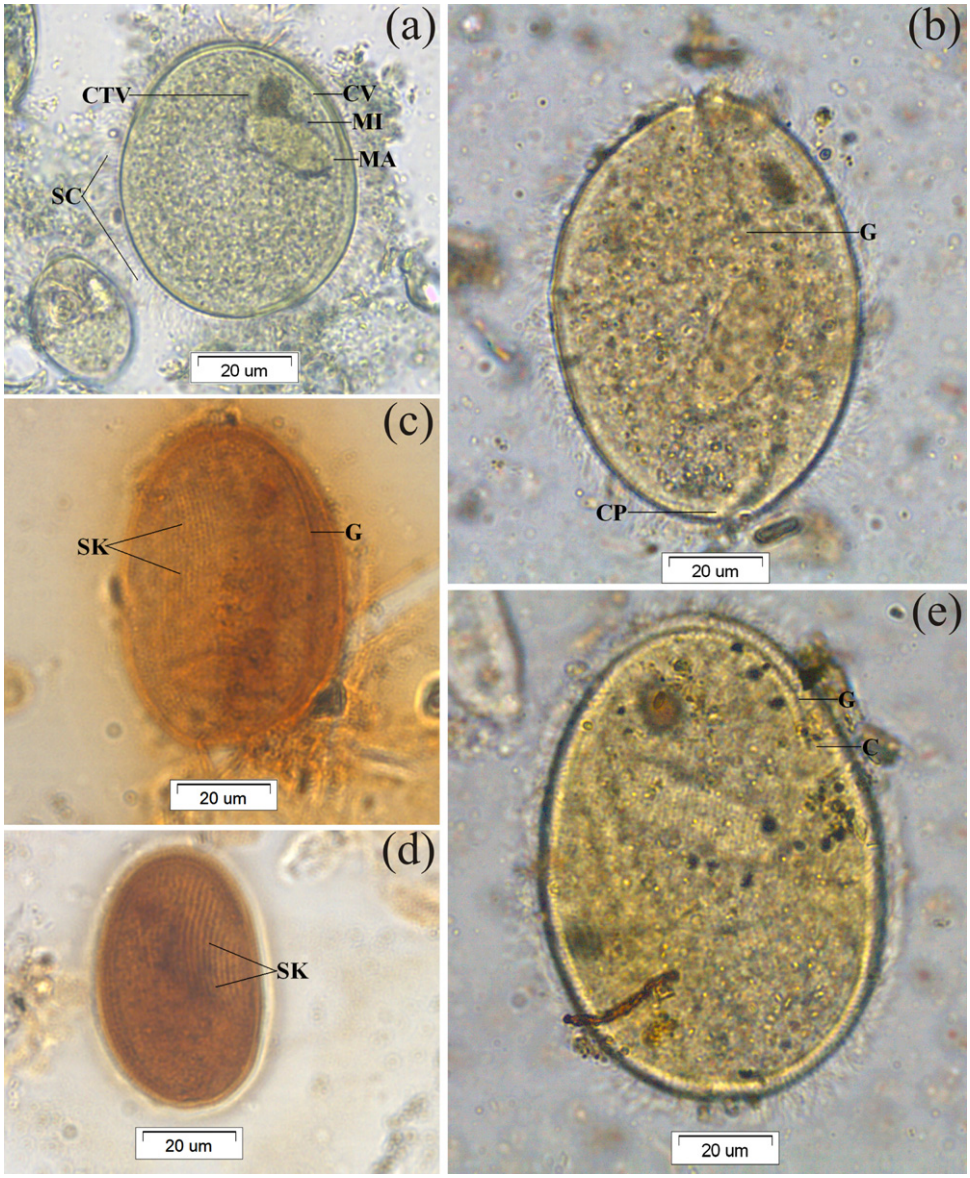

Fig. 3. Photomicrographs of *Paraisotrichopsis composita* (a) – in MFS, (b), (e) – after pyridinated silver carbonate impregnation, (c), (d) – after silver nitrate impregnation. (a), (b), (c) – from left side, (d), (e) – from right side. G, groove.

in back of the concretion vacuole. The others are located on the opposite side of the cell and cannot always be observed. Cytoproct and anal tube are at the posterior end of the cell. Small and long caudal ciliary zone are around the cytoproct.

General morphology of *Spirodinium equi* Fiorentini, 1890 (Fam. Spirodiniidae) (Fig. 5)

The average cell length was 183.0 ± 22.6 μm (137.5–217.5 μm, $n = 30$) and cell width, 66.1 ± 14.3 μm (45.0–95.0 μm, $n = 30$). Cell is elongated, cylindrical and narrowed at the ends. In its anterior part, the cell bends slightly to its ventral and left side. Its anterior end is rounded and its posterior end tapers. The cytoplasm is clearly divisible into a well defined ectoplasm and endoplasm. The ectoplasm forms a thick layer on the dorsal side of the cell, a thin layer on the ventral side and occupies the entire cell that is anterior to the anterior ciliary zone. Oral ciliary zone is located at the anterior tip of the cell. It looks like an irregular ellipse with cilia emanating from either of its borders. Anterior ciliary zone originates on the ventral surface and makes one complete spiral around the anterior region of the cell and extends a little over to the left side. The cilia in this zone are in the groove. Posterior ciliary zone is situated on the dorsal side below the middle of the cell and extends only on the left side. The cilia are in the groove. Macronucleus is situated in the dorsal region between the two zones of cilia. It is elongated and granular. Its anterior end rounded and its posterior end pointed. Its position in the cytoplasm

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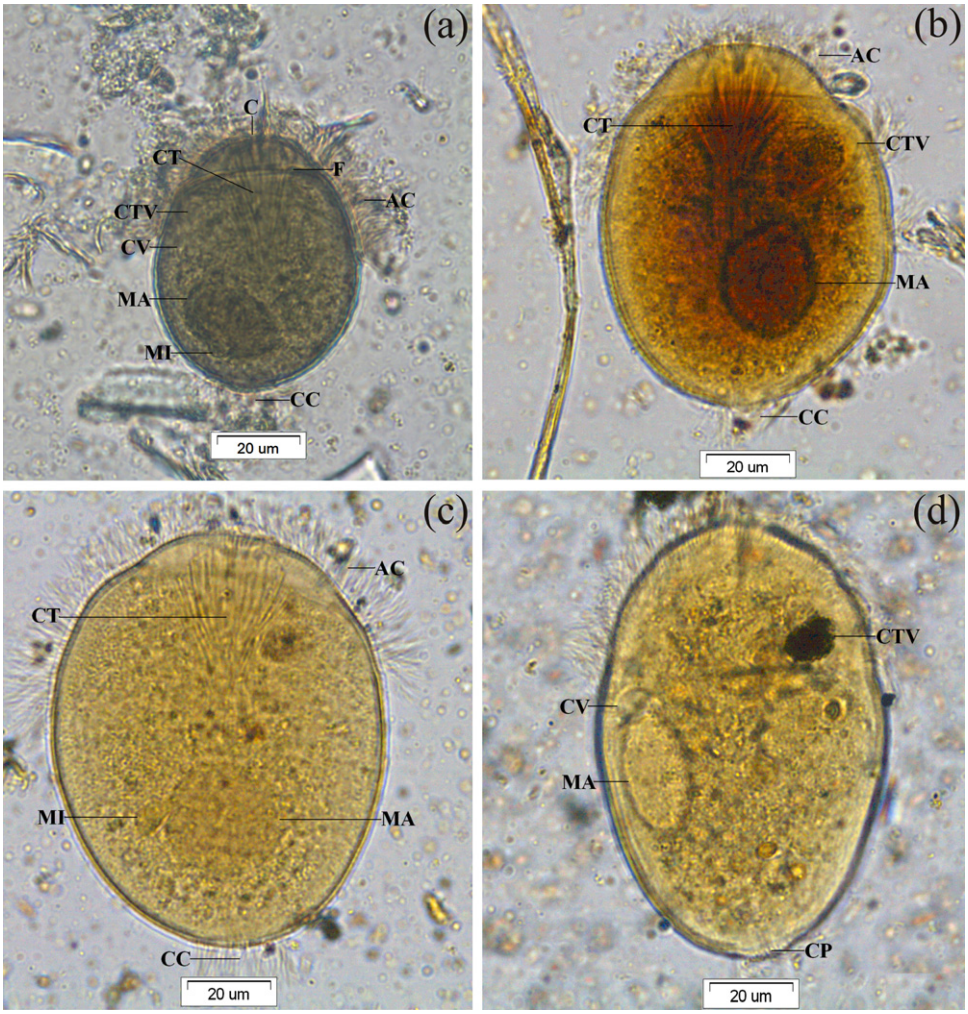

Fig. 4. Photomicrographs of *Blepharoconus hemiciliatus* (a) – in MFS, (b), (c), (d) – after silver pyridinated silver carbonate impregnation. CT, cytopharynx; F, fold.

Table 2. Abundance of intestinal ciliates in the feces of 15 racing horses.

Horse no	Ciliate density ($\times 10^4$ cells ml^{-1})
1	13.5
2	17.5
3	0
4	7.0
5	54.5
6	43.5
7	24.5
8	45.5
9	39.0
10	38.5
11	21.5
12	20.5
13	19.5
14	25.0
15	26.5
	Mean ± SD = 26.4 ± 15.1

is constant. Its length is 69.6 ± 10.9 μm (50.0–95.0 μm, $n = 30$), width is 13.8 ± 2.1 μm (10.0–17.5 μm, $n = 30$). Ellipsoidal micronucleus is located on the dorsal side of macronucleus in the posterior half. Cytostome is a slit-like opening in the anterior tip of the cell and near the ventral side. Cytostome follows the vestibulum. Vestibulum lies ventral to the dorsal cavity. Beginning in the anterior end of the cell and extending the length of the cell, there is a longitudinal cavity in the dorsal part of the cell. There are longitudinal striations in the dorsal cavity. Cytoproct is situated at the postero-dorsal end of the cell and connected with anal tube. One large contractile vacuole is located back of the anterior ciliary zone and right side of the cell.

Discussion

In the present study, 37 ciliate species representing 21 genera were identified, but no new species were detected. This is the first report on intestinal ciliates in racing horses living in

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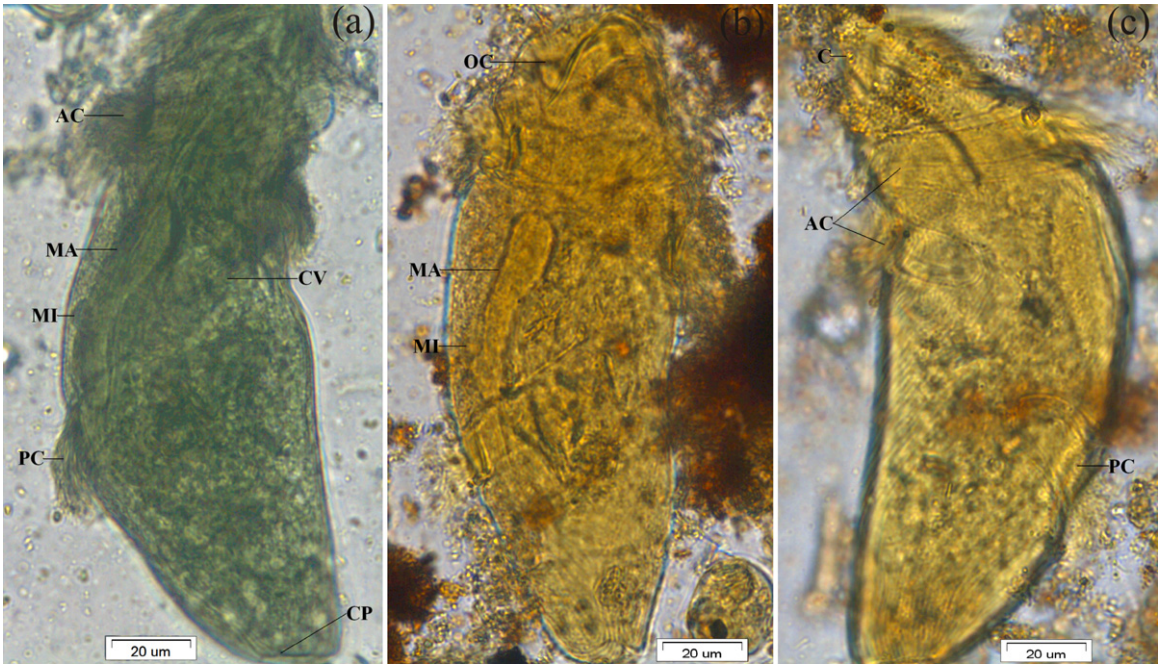

Fig. 5. Photomicrographs of *Spirodinium equi* (a) – in MFS, (b), (c) – after pyridinated silver carbonate impregnation. (a), (b) – from right side, (c) – from left side. OC, oral ciliary zone; PC, posterior ciliary zone.

Turkey. The ciliate composition of the racing horses examined in this study is similar to other reports around the world (Table 3).

When compared with ciliate surveys from other equids living in various countries, the average ciliate density in the intestine of racing horse ($26.4 \pm 15.1 \times 10^4$ cells ml^{-1}) was considerably less than that of kiso horse (Imai et al. 1999) or the riding horse (Tung 1992). On the other hand, concentrations are higher than those in the other equids examined, the light horse (Ike et al. 1981), race horse (Ike et al. 1983a), tokara pony (Ito et al. 1996), Cypriot wild donkeys (Gürelli and Göçmen 2010), Turk rahvan horse (Gürelli and Göçmen 2011) (Table 3). These variations could result from differences both in the host animals and feed. Racing horses are generally fed special foods to increase their performance (Batu 1962; Yarkın 1962; Arpacık 1996).

Although the racing horse samples were obtained in the same vicinity of Izmir as those from Turk rahvan horses, density in the racing horses was greater than in Turk rahvan horses. Presumably, the special foods (carrot, raisin, grape molasses, mixture of vitamin and mineral, vegetable oil),

Table 3. Total ciliate abundance and distribution of the total number of genera and species of the ciliates in the intestine contents of equids from various locations around the world.

Locality[a]	Total ciliates ($\times 10^4$ cells ml^{-1})	Range	Total no. of genera	Total no. of species	References[b]
China	[d]	[d]	19	30	1
Japan	3.4[d]	[d]	19	40	2
Japan	9.0[d]	0.4–113.0	22	49	3
Taiwan	38.1 ± 35.9[c]	0.2–127.0	19	38	4
Japan	1.4[d]	[d]	11	18	5
Japan	140.0[d]	[d]	23	50	6
Middle Asia	[d]	[d]	25	57	7
Cyprus	3.0 ± 2.5[c]	0.5–8.5	16	22	8
Turkey	14.2 ± 13.9[c]	0–45.5	22	36	9
Turkey	26.4 ± 15.1[c]	0–54.5	21	37	Present study

[a] Number of animals and breed: China (20 horse, donkey and mule); Japan (17 light horse); Japan (60 race horse); Taiwan (40 riding horse); Japan (20 tokara pony); Japan (18 kiso horse); Middle Asia (184 kulan); Cyprus (13 wild donkey); Turkey (15 Turk rahvan horse); Turkey (15 racing horse).

[b] (1) Hsiung 1935a,b, 1936; (2) Ike et al. 1981; (3) Ike et al. 1983a; (4) Tung 1992; (5) Ito et al. 1996; (6) Imai et al. 1999; (7) Kornilova 2003; (8) Gürelli and Göçmen 2010; (9) Gürelli and Göçmen 2011.

[c] Mean ± SD.

[d] Data not reported.

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Table 4. Distribution of species of equid intestinal ciliates at various locations around the world.

Species	Geographical location[a]						
	USA (1)	China (2)	Japan (3)	Russia and Middle Asia (4)	Taiwan (5)	Cyprus (6)	Turkey (7)
Paraisotricha colpoidea	+	–	+	+	–	–	+
P. minuta	+	+	+	+	–	–	+
P. beckeri	+	–	+	+	–	–	–
Bundleia postciliata	+	+	+	+	+	+	+
B. piriformis	–	–	–	+	–	–	+
B. nana	–	–	+	+	–	–	+
B. elongata	–	–	+	+	–	–	+
B. triangularis	–	–	–	+	–	+	+
B. dolichosoma	–	–	+	+	–	–	+
B. inflata	–	–	+	+	–	–	+
B. vorax	–	–	+	+	–	–	–
B. asymmetrica	–	–	+	+	–	–	–
Didesmis ovalis	+	+	+	+	+	–	+
D. quadrata	+	–	+	+	+	–	–
D. spiralis	+	–	+	+	+	–	–
Polymorphella ampulla	+	+	+	+	+	+	+
Blepharoconus hemiciliatus	–	–	+	+	–	–	+
B. benbrooki	+	+	+	+	+	+	+
B. cervicalis	?	–	?	–	?	–	–
Ampullacula ampulla	?	–	?	–	?	?	–
Paraisotrichopsis composita	–	+	+	+	–	–	+
Alloiozona trizona	+	–	+	+	+	–	+
Blepharozoum zonatum	–	–	+	+	–	–	–
Holophryoides ovalis	–	–	+	+	+	+	+
H. macrotricha	–	–	+	+	+	–	+
Blepharosphaera ellipsoidalis	+	+	+	+	+	–	+
B. intestinalis	+	+	+	+	–	+	–
B. citriformis	–	–	+	+	–	–	–
Hemiprorodon gymnoposthium	–	–	+	+	–	–	+
Prorodonopsis coli	–	+	+	+	–	+	+
Blepharoprosthium pireum	+	+	+	+	+	–	+
B. polytrichum	–	–	+	+	–	–	+
Sulcoarcus pellucidulus	–	+	–	+	–	–	–
Wolskana tokarensis	–	–	+	–	–	–	–
Blepharocorys curvigula	+	+	+	+	+	+	+
B. uncinata	+	+	+	+	–	–	+
B. jubata	+	–	+	+	+	–	–
B. cardionucleata	+	–	+	+	+	–	–
B. valvata	+	+	+	+	+	+	–
B. angusta	+	–	+	+	+	+	+
B. microcorys	–	–	+	+	+	+	+
Ochoterenaia appendiculata	–	–	+	+	+	–	+
Circodinium minimum	+	+	+	+	+	+	+
Charonina equi	+	+	+	+	+	+	–
Cycloposthium bipalmatum	+	+	+	+	+	–	+
C. edentatum	+	+	+	+	+	+	+
C. scutigerum	+	–	+	+	+	–	–
C. corrugatum	+	–	+	+	–	–	–
C. piscicauda	–	–	–	+	–	–	–
C. dentiferum	+	–	+	+	+	–	–
C. affine	+	–	+	+	–	–	–
C. plicatocaudatum	–	–	–	+	–	–	–
C. ponomarevi	–	–	–	+	–	–	–
C. hemioni	–	–	–	+	–	–	–

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Table 4 (*Continued*)

Species	Geographical location[a]						
	USA (1)	China (2)	Japan (3)	Russia and Middle Asia (4)	Taiwan (5)	Cyprus (6)	Turkey (7)
T. dogieli	+	−	+	+	+	−	+
Ditoxum funinucleum	+	−	+	+	−	−	+
Ditoxum brevinucleatum	−	+	+	+	−	+	−
Cochliatoxum periachtum	+	+	+	+	+	−	+
Tetratoxum unifasciculatum	+	+	+	+	+	+	+
T. excavatum	+	−	+	+	+	+	+
T. parvum	+	+	+	+	+	−	+
Spirodinium equi	+	+	+	+	+	−	−
S. confusum	−	+	+	+	−	+	+
S. nanum	−	−	+	−	−	−	+
S. uncinucleatum	−	+	−	+	−	+	−
S. magnum	−	−	+	+	−	−	−
Triadinium caudatum	+	+	+	+	+	+	+
Triadinium magnum	−	+	−	+	−	−	−
Gassovskiella galea	+	+	+	+	+	−	+
Allantosoma intestinale	+	−	+	+	+	+	+
A. cucumis	−	−	+	+	−	−	−
A. biseriale	−	−	+	+	−	−	−
A. dicorniger	+	−	+	+	+	−	−
A. brevicorniger	+	−	+	+	+	−	−
A. japonensis	−	−	+	+	−	−	−
A. lineare	−	−	+	+	−	−	−
Strelkowella urunbasiensis	−	−	−	+	−	−	−

[a]References: (1) Hsiung 1930; (2) Hsiung 1935a,b, 1936; (3) Ike et al. 1981, 1983a,b,c, 1985; Imai et al. 1999; Ito et al. 1996; Ozeki et al. 1973; (4) Gassovsky 1919; Kornilova 2003, 2006; Strelkow 1939; (5) Tung 1992; (6) Gürelli and Göçmen 2010; (7) Gürelli and Göçmen 2011, Present study.

and feeding frequency contributed to the increased density of ciliates.

Strelkow (1939) and Kornilova (2003, 2006) divided the intestinal ciliates into four groups according to the feeding habits. The first group of ciliates feed upon plant particles. They were *Blepharocorys microcorys*, *Tetratoxum parvum*, *Cycloposthium edentatum*, *Ditoxum funinucleum*, *Triadinium caudatum*, *Gassovskiella galea*, *Cochliatoxum periachtum*, *Bundleia triangularis*, *Bundleia piriformis*. The second group of ciliates feed upon starch. They were *Spirodinium* spp., *Alloiozona trizona*, *Blepharoprosthium pireum*, *Holophryoides ovalis*, *Paraisotricha* spp., *Blepharocorys* spp., *Didesmis* spp. *Blepharoconus* spp. The third group feed upon bacteria. They were *Paraisotricha colpoidea*, *Paraisotricha minuta*, *Paraisotrichopsis composita*, *Polymorphella ampulla*, *Holophryoides macrotricha*, *Bundleia postciliata*, *Bundleia nana*, *Bundleia elongata*, *Bundleia inflata*, *Blepharocorys angusta*, *Blepharocorys curvigula*, *Blepharocorys cardionucleata*, *Circodinium minimum*, *Didesmis quadrata*. The fourth group are predators. Obligatory predators were *Allantosoma* spp. Facultative (not obligatory, optional) predators were *Blepharoprosthium pireum*, *Blepharoprosthium polytrichum*, *Bundleia vorax*.

In the present study and a recent previous study (Gürelli and Göçmen 2010), we observed *Ditoxum*, *Tetratoxum*, *Triadinium*, *Cycloposthium*, *Tripalmaria* and *Cochliatoxum* spp. in the horses that were fed with clover, meadow and grass. We observed *Blepharoconus*, *Alloiozona*, *Spirodinium*, *Blepharoprosthium*, *Paraisotricha*, *Paraisotrichopsis*, *Holophryoides*, *Bundleia*, *Didesmis*, *Blepharocorys*, *Circodinium*, *Hemiprorodon* spp. in the horses that were fed with barley and oats. We conclude that if the feeding condition of the horses is known, the ciliate composition in the intestine can be estimated. Similarly, the health condition of host animals can be inferred.

Newly recorded species (*P. composita*, *B. hemiciliatus*, *S. equi*, *B. nana*, *P. coli*) from racing horses were not observed in Turk rahvan horses. However, *Ditoxum funinucleum*, *Tripalmaria dogieli*, *Tetratoxum excavatum*, *Alloiozona trizona* that had been in Turk rahvan horses (Gürelli and Göçmen 2011) were not observed in racing horses living in Turkey.

Tables 3 and 4 report the abundance and occurrence of intestinal ciliates from seven different geographical locations around the world.

Bundleia nana and *Blepharoconus hemiciliatus* observed in this study, were previously reported from equids in Japan, Russia and Middle Asia, but were not recorded from China and Taiwan. *Paraisotrichopsis composita* was recorded from China, Japan, Russia and Middle Asia and Turkey. *Prorodonopsis coli* and *Spirodinium confusum* were recorded

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from China, Japan, Russia and Middle Asia, Cyprus and Turkey (Table 4). No species which were newly determined in this examination were observed in Taiwan horses. It is perplexing, because Turkey, Russia and Middle Asia, China, Japan, Taiwan and Cyprus are located on the Eurasian continent and are connected. Based on the present and previous studies, we conclude that the geographical distribution and the feeding condition of the host animals are important for evaluating the diversity of ciliate fauna in their intestines.

Bundleia nana, *P. coli*, *P. composita*, *B. hemiciliatus* and *S. equi* belong to the order Entodiniomorphida. The order Entodiniomorphida splits into three suborders (Archistomatina, Blepharocorythina and Entodiniomorphina). The suborder Archistomatina includes many ciliates which belong to the Family Buetschliidae (Lynn 2008). Ciliates in this family have a concretion vacuole. The concretion vacuole consists of small granules which are composed of calcium salts. It is the equilibrium-sense organ of the cell (Grain 1966). In this family, cilia cover all over the cell or it is the small zone at anterior and posterior end. Contractile vacuoles can be one or more (Lynn 2008). *B. nana*, *P. coli*, *P. composita* and *B. hemiciliatus* belong to the family Buetschliidae, they are ovoid to pyriform shaped and sizes are small. All of them have concretion vacuoles near the anterior end of the cell. They have one contractile vacuole, but *P. composita* can posses more. Differing from the other Buetschliid ciliates, *P. composita* has a groove which passes obliquely the entire cell. Buetschliid ciliates have non-ciliated tubular passageways.

Spirodinium equi belongs to the suborder Entodiniomorphina and the family Spirodiniidae. This suborder is characterized by somatic ciliature that is arranged in bands or tufts. The members of Spirodiniidae are medium sized, elongated, laterally flattened and somatic ciliates are as bands spiralling around the cell at the different levels (Lynn 2008). *S. equi* have three spiralling bands and vestibulum (ciliated depression). Based on our observations and knowledge, cilia are reduced in evolutionary developed species, so we suggest that other ciliates in Entodiniomorphida could be derived from Buetschliid ciliates. In Buetschliidae, morphological features of some species are less complex than in others. For example *P. coli* and *P. composita* differ from *B. nana* and *B. hemiciliatus*, species in which cilia cover the entire cell. *S. equi* has unique features different from other ciliates. This is the most developed species of all ciliates observed in this study.

Although only some researchers indicated that these ciliates cause tissue destruction (French et al. 1996; Gregory et al. 1986; Kirkpatrik and Saik 1988), they digest the cellulose and starch, so they are useful for equids. If absent, the equids will continue to live, but the protozoa will not survive outside. We conclude that there is a commensal relationship between the ciliates and equids. In addition to this, these ciliates graze on bacteria, preventing an increase or overgrowth of bacteria. According to Gassovsky (1919) the ciliates act as medical regulators in the intestine of the equids.

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