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Gastrointestinal nematodes of red deer (*Cervus elaphus*) in European Russia

Dmitry N. Kuznetsov*, Natalya B. Romashova, Boris V. Romashov & Egor A. Vlasov

ABSTRACT. The species composition of gastrointestinal nematodes found during necropsies of 33 red deer from three regions of European Russia (Tver', Smolensk and Voronezh) was determined. In total, 11 species of nematodes were found, namely *Aonchotheca bovis, Ashworthius sidemi, Cooperia pectinata, Mazamastrongylus dagestanica, Nematodirus roscidus, Ostertagia leptospicularis, Spiculopteragia asymmetrica, Spiculopteragia spiculoptera*, *Trichostrongylus axei*, *Trichostrongylus colubriformis* and *Trichuris ovis.* Besides, a minor morph of *Ostertagia leptospicularis* ("*O. kolchida*"), as well as a minor morph of *Spiculopteragia asymmetrica* ("*S. quadrispiculata*"), were also detected in some of the red deer. The number of gastrointestinal nematodes found in red deer during the present study ranged from 4 to 431 individuals. Thus, the intensity of infection was rather low. *S. asymmetrica* was found in all three regions studied. This species showed the highest intensity of infection, as well as the prevalence. *O. leptospicularis* was also found in all three regions studied, but the intensity of infection and prevalence of this species was lower than that of *S. asymmetrica*. The other species of gastrointestinal nematodes were found in one or two of the three regions studied. *A. sidemi*, *S. asymmetrica*, *M. dagestanica* and *N. roscidus* were found in red deer in European Russia for the first time. A trend towards changes in the communities of nematodes parasitising red deer and the spread of parasites that are not typical for this host and this area was noted.

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Нематоды желудочно-кишечного тракта благородных оленей (*Cervus elaphus*) в европейской части России

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РЕЗЮМЕ. Определён видовой состав нематод желудочно-кишечного тракта, обнаруженных во время вскрытий 33 благородных оленей из трёх областей европейской части России (Тверской, Смоленской и Воронежской). В общей сложности были обнаружены нематоды 11 видов, а именно: *Aonchotheca bovis*, *Ashworthius sidemi*, *Cooperia pectinata*, *Mazamastrongylus dagestanica*, *Nematodirus roscidus*, *Ostertagia leptospicularis*, *Spiculopteragia asymmetrica*, *Spiculopteragia spiculoptera*, *Trichostrongylus axei*, *Trichostrongylus colubriformis* и *Trichuris ovis.* Кроме того, у некоторых из благородных оленей были отмечены минорные морфы вида *Ostertagia leptospicularis* ("*O. kolchida*"), а также вида *Spiculopteragia asymmetrica* ("*S. quadrispiculata*"). Количество нематод желудочно-кишечного тракта, найденных у благородных оленей в рамках данного исследования, варьировало от 4 до 431 экземпляра. Таким образом, интенсивность инвазии была сравнительно низкой. Вид *S. asymmetrica* был обнаружен во всех трех областях, где проводилось исследование, и показал наиболее высокую интенсивность и экстенсивность инвазии. Вид *O. leptospicularis* также был найден во всех трех областях, однако интенсивность и экстенсивность инвазии были ниже, чем у *S. asymmetrica*.

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Остальные виды нематод были найдены в одной или двух из трех исследованных областей. Виды *A. sidemi*, *S. asymmetrica*, *M. dagestanica* и *N. roscidus* обнаружены у благородных оленей в европейской части России впервые. Отмечена тенденция к изменениям в сообществах нематод, паразитирующих у благородного оленя, и к распространению паразитов, которые не типичны для этого хозяина и этих регионов.

КЛЮЧЕВЫЕ СЛОВА: дикие жвачные, пищеварительный тракт, паразитические нематоды, Россия.

Introduction

Data concerning helminths of *Cervus elaphus* Linnaeus, 1758 inhabiting the territory of Russia are very scarce and were published several decades ago (Asadov, 1960; Pryadko, 1976; Govorka *et al.*, 1988). At the same time, the number of *C. elaphus* in the European part of Russia currently tends to increase. The red deer is a very common species in game farms in European Russia. The population of red deer in protected areas such as nature reserves is also increasing. It is well known that infection with gastrointestinal nematodes can significantly impair the health of wild ruminants (Irvin *et al.*, 2006; Magdalek *et al.*, 2021). There are a number of studies on the helminth fauna of red deer in several European countries (Kutzer & Hinaidy, 1969; Bernard *et al.*, 1988; Zaffaroni *et al.*, 2000; Cisek *et al.,* 2003; Shimalov & Shimalov, 2003; Santin-Duran *et al.*, 2004; Hora *et al.*, 2017; Zvegintsova *et al.*, 2018; van Beest *et al.*, 2023). It should be noted that some studies in recent years have shown changes in the communities of nematodes parasitising *C. elaphus* and the spread of alien species of nematodes (Ferte *et al.*, 2000; Drozdz *et al.*, 2002; Kowal *et al.*, 2014; Halvarsson *et al.*, 2022; Pyziel-Serafin *et al.*, 2023). In this regard, it seems relevant to study the species composition of gastrointestinal nematodes in *C. elaphus* inhabiting the European part of Russia.

Material and methods

Sampling

The nematodes were collected during necropsies of 33 red deer in three regions of European Russia: Tver' (55.7° N, 32.2° E), Smolensk (55.267° N, 34.483° E) and Voronezh (51.85° N, 39.67° E) (Fig. 1). Samples from Tver' and Smolensk were collected in game farms, whereas the samples from Voronezh were collected in Voronezh State Nature Biosphere Reserve. The study included red deer from the so-called Voronezh population, which comes from 10 individuals of *C. elaphus* imported from Germany at the end of the nineteenth century (Likhatsky *et al.*, 2012). Over the twentieth century, as a result of human-controlled translocations and natural migrations, red deer from the Voronezh population have spread to almost the entire European part of Russia (Likhatsky *et al.*, 2012; Kuznetsova *et al.*, 2013). Based on information provided by the staff of the game farms in Smolensk and Tver', we can state that the red deer from these game farms also have origins from the Voronezh population of *C. elaphus*.

All of the studied red deer had died owing to accidental causes, such as injuries. The age of the red deer was estimated based on their appearance, conditions of antlers, teeth and limb bones (Klevezal, 2007). The digestive tracts of red deer were dissected and examined according to helminthological methods (Ivashkin *et al.*, 1971; Kuznetsov, 2020). Besides, we have conducted the species identification of gastrointestinal nematodes from the storage of Voronezh State Nature Biosphere Reserve (the samples from 11 red deer collected in 1980–1990s).

Taxonomical identification

In most cases, the identification of the detected nematodes was based on the morphology of the males due to the lack of distinct differences in the morphology of the females. The nematodes were prepared as temporary whole mounts, cleared in glycerol solution (two parts of glycerol and eight parts of water) and then examined using light microscopy at magnification of 40 to 400. The species identification was carried out based on morphological features presented in literature (Skrjabin *et al.*, 1954; Govorka *et al.*, 1988; Drozdz, 1995; Hoberg & Khrustalev, 1996; Lehrter *et al.*, 2016). The main features used for the identification of gastrointestinal strongyles were the peculiarities of male bursa morphology and the shape of spicules. *Trichuris* nematodes were identified based on the data presented by Yevstafieva *et al.* (2018).

Descriptive statistics

To characterise host infection with gastrointestinal nematodes we provide sample prevalence and sample mean intensity with male nematodes. We use the Jeffreys credible interval, recommended for small samples (Brown *et al.*, 2001), to characterise uncertainty for prevalence. The Bias Corrected and Accelerated Interval (BCAI) is used to characterise uncertainty in mean intensity with male nematodes. For small samples (fewer than 3 infected hosts), BCAI is not available. All intervals are calculated with 90% confidence level. Sample means, prevalence and intervals were calculated in R (R Core Team, 2025) using the DescTools (Signorell, 2025) and bayestestR (Makowski *et al.*, 2019) packages.

Results

Twenty-six of the 33 examined red deer were found to be infected with gastrointestinal nematodes. Thus, the prevalence of infection with all species of detected nematodes was 78.8%. The intensity of the infection ranged from 4 to 431 individuals of nematodes (Table 1). All of the studied red deer were not emaciated and no pronounced lesions of the digestive tracts were observed.

The intensity of infection, prevalence rates and species names of the detected nematodes are presented in Tables 1, 2. In Table 1 obtained data are given in chronological order (separately for three regions of sampling). The species names of the detected nematodes are presented in alphabetical order. In total, 11 species of gastrointestinal nematodes were found in the present study. Besides, a minor morph of *Ostertagia leptospicularis* Assadov, 1953 ("*O. kolchida*"), as well as a minor morph of *Spiculopteragia asymmetrica* (Ware, 1925) ("*S. quadrispiculata*"), were also detected in some of the red deer (Table 1).

Discussion

The intensity of the infection with gastrointestinal nematodes found during the present study was low. The maximum level of the intensity of infection that we recorded was 431 individuals of nematodes in the red deer from Voronezh dissected in October 2019 (Table 1). It should be noted that Irvine *et al.* (2006) consider a level of less than 1000 nematodes to be the low intensity of infection. The studies concerning gastrointestinal nematodes of *C. elaphus* in various countries, as a rule, show a low level of the intensity of infection (Rickard *et al.,* 1993; Drozdz *et al*., 2002; Cisek *et al*., 2003; Santin-Duran *et al*., 2004; Shimalov & Shimalov, 2003; Kowal *et al*., 2014). In comparison, the intensity of infection, noted in other species of wild ruminants, such as moose or bison, looks more impressive (Demiaszkiewicz *et al*., 2009; Grandi *et al*., 2018; Filip-Hutsch *et al*., 2021). However, we must keep in mind that even a low level of the infection may impact the health of red deer (Irvine *et al*., 2006). At the same time, we detected rather big species diversity of gastrointestinal nematodes parasitising red deer in European Russia. In our study, the most commonly detected species was *S. asymmetrica* (Fig. 2). This species was found in all three regions studied, with 60.6% (46.3–73.6%) prevalence (Table 2). Based on the literature data, it can be assumed that red deer is a fairly common host for *S. asymmetrica*. This nematode was recorded in *C. elaphus* not only in several European countries, but also in other parts of the world (Kutzer & Hinaidy, 1969;

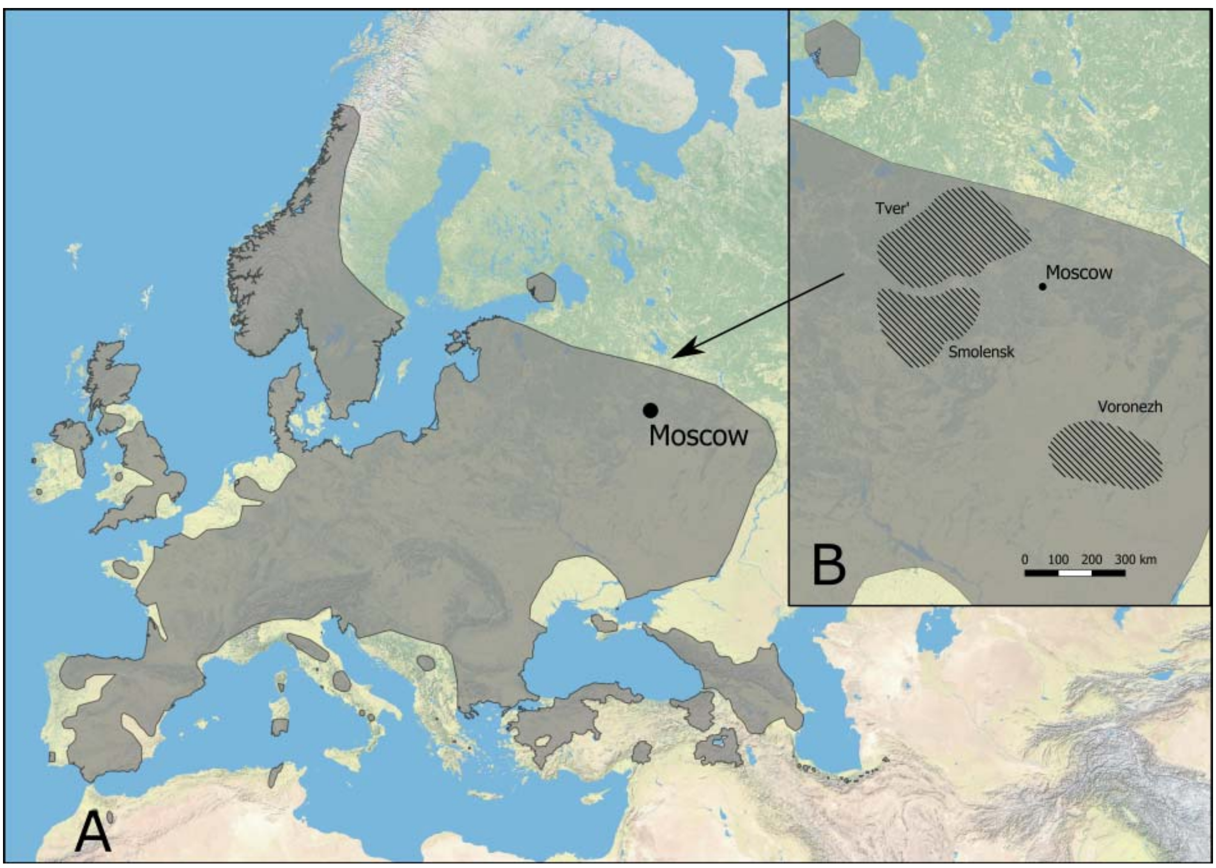

Fig. 1. The area of collection of *C. elaphus* nematodes (hatching) (B) within the distribution range of *C. elaphus* in Europe (A). The distribution range of *C. elaphus* in Europe is given according to IUCN (Lovari *et al*., 2018).

Table 1. The intensity of infection with gastrointestinal nematodes in studied individuals of *Cervus elaphus* and the list of detected species. Abbreviations: A — abomasum, SI — small intestine, LI — large intestine. Major and minor morphs are separated by slash.

Sequence number of the studied red deer	Region of sampling	Month and year of sampling	Sex and age of hosts	Number of detected nematodes			Species of detected nematodes, localization and number of males (in brackets)
				Total	Males	Females	
1	Tver’	January 2016	female, 2 years	4	1	3	*Spiculopteragia asymmetrica* (A-1)
2	Tver’	January 2016	female, 2 years	–	–	–	–
3	Tver’	March 2016	female, 2 years	–	–	–	–
4	Tver’	March 2016	male, 4 years	–	–	–	–
5	Tver’	January 2017	female, 2 years	127	46	81	*S. asymmetrica* (A-42), *Spiculopteragia spiculoptera* (A-4)
6	Tver’	January 2017	female, 3 years	–	–	–	–
7	Tver’	November 2018	male, 6 month	305	116	189	*Ostertagia leptospicularis* (A-79) / “*O. kolchida*” (A-19), *S. asymmetrica* (A-16), *Trichostrongylus colubriformis* (A-1), *Trichuris ovis* (LI-1)
8	Tver’	December 2019	female, 3 years	52	16	36	*O. leptospicularis* (A-12), *S. asymmetrica* (A-4)
9	Tver’	February 2020	female, 5 years	146	54	92	*O. leptospicularis* (A-29) / “*O. kolchida*” (A-4), *S. asymmetrica* (A-16), *S. spiculoptera* (A-2), *T. colubriformis* (A-2), *T. ovis* (LI-1)
10	Tver’	September 2021	male, 3 years	–	–	–	–
11	Tver’	January 2022	female, 6 years	129	40	89	*O. leptospicularis* (A-21), *S. asymmetrica* (A-16), *S. spiculoptera* (A-3)
12	Smolensk	September 2018	male, 1 year	212	85	127	*Ashworthius sidemi* (A-6), *O. leptospicularis* (A-13), *S. asymmetrica* (A- 65), *Trichostrongylus axei* (A-1)
13	Smolensk	March 2019	female, 5 years	–	–	–	-
14	Smolensk	December 2019	male, 4 years	270	78	192	*O. leptospicularis* (A-32), *S. asymmetrica* (A-46)
15	Smolensk	October 2020	female, 5 years	221	71	150	*O. leptospicularis* (A-32) / “*O. kolchida*” (A-3), *S. asymmetrica* (A-36)
16	Smolensk	February 2021	male, 5 years	240	56	184	*S. asymmetrica* (A-56)
17	Smolensk	April 2021	female, 2 years	–	–	–	–
18	Smolensk	November 2021	female, 4 years	131	34	97	*S. asymmetrica* (A-34)

Table 1 (*continue*)

19	Smolensk	December 2022	female, 6 years	125	38	87	*O. leptospicularis* (A-12), *S. asymmetrica* (A-26)
20	Voronezh	December 1984	female, 5 years	361	161	200	*Aonchotheca bovis* (SI-161)
21	Voronezh	December 1986	male, 7 years	373	145	228	*Cooperia pectinata* (SI-1), *Nematodirus roscidus* (SI-1), *O. leptospicularis* (A-5), *S. asymmetrica* (A-128) / "*S. quadrispiculata*" (A-10)
22	Voronezh	March 1987	male, 1 year	59	27	32	*C. pectinata* (SI-18), *N. roscidus* (SI-9)
23	Voronezh	March 1987	male, 1 year	14	4	10	*C. pectinata* (SI-2), *T. ovis* (LI -2)
24	Voronezh	March 1987	female, 1 year	49	15	34	*C. pectinata* (SI-4), *Mazamastrongylus dagestanica* (A-4), *O. leptospicularis* (A-1), *S. asymmetrica* (A-3) / "*S. quadrispiculata*" (A-1), *T. ovis* (LI -2)
25	Voronezh	February 1988	female, 4 years	54	19	35	*S. asymmetrica* (A-17) / "*S. quadrispiculata*" (A-2)
26	Voronezh	February 1989	female, 7 years	196	80	116	*S. asymmetrica* (A-71) / "*S. quadrispiculata*" (A-9)
27	Voronezh	March 1989	female, 7 years	186	60	126	*O. leptospicularis* (A-1), *S. asymmetrica* (A-57) / "*S. quadrispiculata*" (A-2)
28	Voronezh	January 1992	female, 1 year	77	25	52	*N. roscidus* (SI-25)
29	Voronezh	January 1992	female, 7 year	13	8	5	*C. pectinata* (SI-8)
30	Voronezh	January 1992	female, 7 years	6	1	5	*C. pectinata* (SI-1)
31	Voronezh	October 2019	male, 8 years	431	186	245	*A. sidemi* (A-182), *S. asymmetrica* (A-4)
32	Voronezh	November 2020	female, 8 years	183	39	144	*A. sidemi* (A-23), *S. asymmetrica* (A-16)
33	Voronezh	March 2021	female, 1 year	161	49	112	*A. sidemi* (A-44), *M. dagestanica* (A-1), *S. asymmetrica* (A-4)

Bernard *et al*., 1988; Suarez *et al*., 1991; Rickard *et al*., 1993; Mason, 1994; Santin-Duran *et al*., 2004; Youssefi *et al*., 2014; Halvarsson *et al*., 2022; Pyziel-Serafin *et al*., 2023). *Ostertagia leptospicularis* was also found in all three regions studied, but the prevalence of this species was almost twice as low as *S. asymmetrica* (Table 2). It is interesting that, according to the literature data, *O. leptospicularis* was recorded in red deer somewhat more often than *S. asymmetrica* (Kutzer & Hinaidy, 1969; Bernard *et al*., 1988; Suarez *et al*., 1991; Mason, 1994; Zaffaroni *et al*., 2000; Drozdz *et al*., 2002; Cisek *et al*., 2003; Santin-Duran *et al.,* 2004; Halvarsson *et al*., 2022; Pyziel-Serafin *et al*., 2023). *Ostertagia leptospcularis* is considered to be one of the dominant species in Cervidae, however, it is also found from time to time in Bovidae, including domestic ruminants (Zaffaroni *et al*., 2000; Wyrobisz-Papiewska *et al*., 2018).

Table 2. The prevalence and mean intensity of infection in *Cervus elaphus* (*n*=33) by the species of gastrointestinal nematodes.

Nematode species	Regions of detection	The number of infected animals	Prevalence (%) with intervals	Mean intensity of infection with intervals
Aonchotheca bovis	Voronezh	1	3.0 (0.5–11.2)	161
Ashworthius sidemi	Smolensk, Voronezh	4	12.1 (5.2–23.8)	63.8 (24.1–180.1)
Cooperia pectinata	Voronezh	6	18.2 (9.3–30.0)	5.6 (1.0–17.3)
Mazamastrongylus dagestanica	Voronezh	2	6.1 (1.8–15.8)	2.5
Nematodirus roscidus	Voronezh	3	9.1 (3.4–19.9)	11.6 (4.2–24.7)
Ostertagia leptospicularis	Tver’, Smolensk, Voronezh	11	33.3 (21.2–47.5)	23.9 (2.2–84.6)
Spiculopteragia asymmetrica	Tver’, Smolensk, Voronezh	20	60.6 (46.3–73.6)	34.1 (4.0–110.6)
Spiculopteragia spiculoptera	Tver’	3	9.1 (3.4–19.9)	3 (2.0–3.6)
Trichostrongylus axei	Smolensk	1	3.0 (0.5–11.2)	1
Trichostrongylus colubriformis	Tver’	2	6.1 (1.8–15.8)	1.5
Trichuris ovis	Tver’, Voronezh	4	12.1 (5.2–23.8)	1.5 (1.0–2.0)

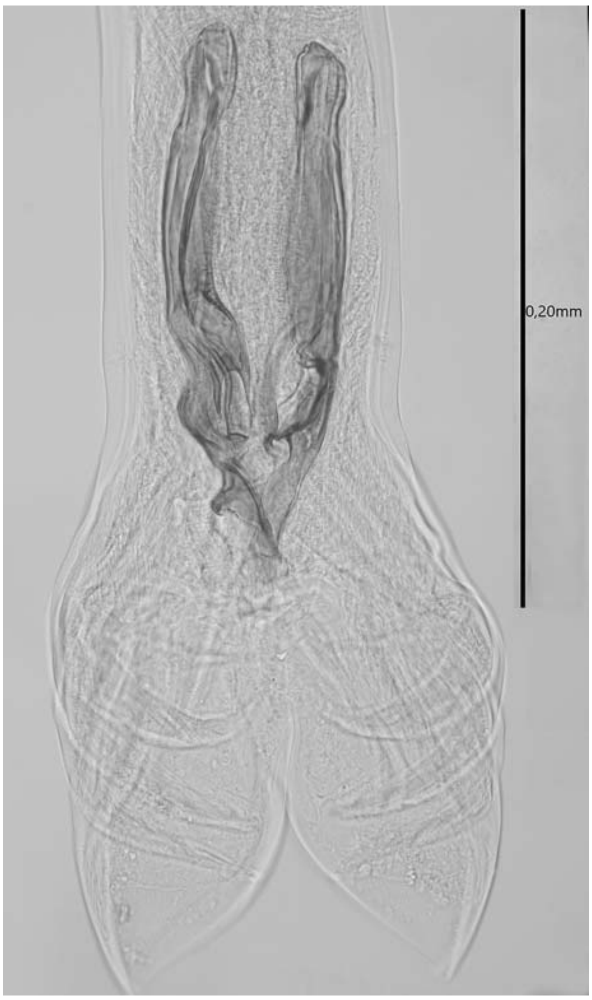

Fig. 2. *Spiculopteragia asymmetrica*, posterior end of male (bursa and spicules).

Cooperia pectinata Ransom, 1907 was found in six of the 33 red deer examined, giving 18.2% (9.3–30.0%) prevalence. However, *C. pectinata* was found only in Voronezh, in the samples collected in 1980–1990s (Tables 1, 2). Previously *C. pectinata* was reported from *C. elaphus* in Austria, Belgium, Poland and New Zealand (Kutzer & Hinaidy, 1969; Bernard *et al.,* 1988; Mason, 1994; Drozdz *et al.,* 2002; Cisek *et al.,* 2003). Recent study using a molecular analysis revealed that

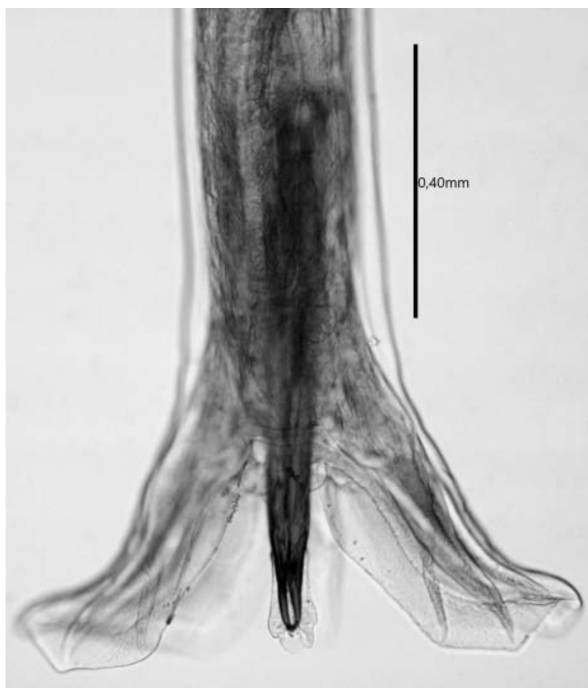

Fig. 3. *Ashworthius sidemi*, posterior end of male (bursa and spicules).

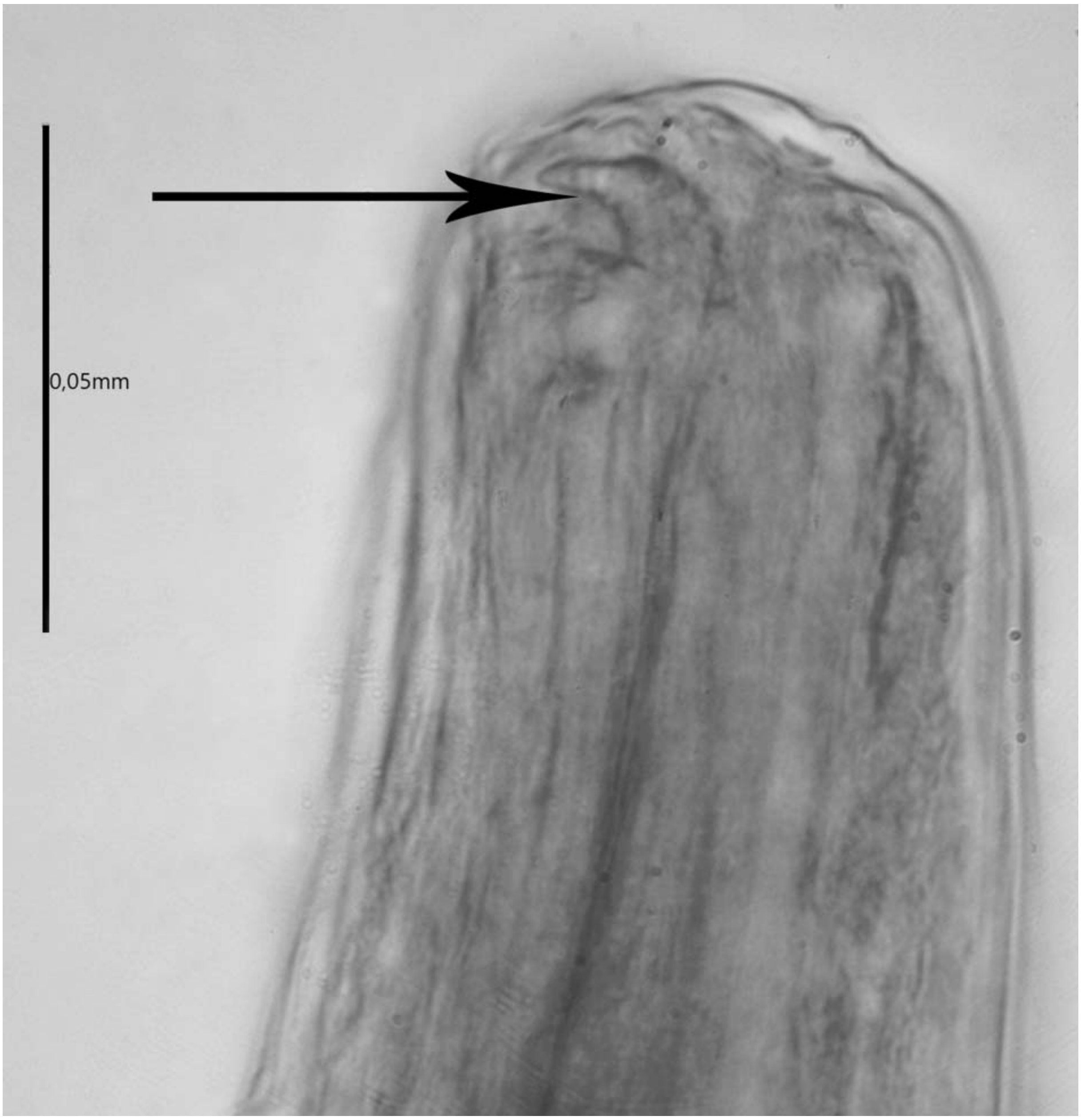

Fig. 4. *Ashworthius sidemi*, anterior end with the neodont in buccal cavity (indicated by the arrow).

Cooperia sp. parasitising Czech red deer is a separate taxon from *C. pectinata* and suggested *Cooperia ventricosa* (Rudolphi, 1809) as a typical parasite for *C. elaphus* (Albrechtova *et al*., 2024). At the same time, Albrechtova *et al.* (2024) note that the resurrection of *C. ventricosa* requires verification by collecting new nematode samples from the type host *C. elaphus* from the type locality. Therefore, we keep the name *C. pectinata* in the present study.

Trichuris ovis (Abildgaard, 1795) was observed in Tver' and Voronezh, the prevalence was 12.1% (5.2–23.8%) (Table 2). Previously *T. ovis* was found in *C. elaphus* from Belarus, Ukraine, Poland and New Zealand (Mason, 1994; Cisek *et al*., 2003; Shimalov & Shimalov, 2003; Zvegintsova *et al*., 2018). In this regard, it should be noted that many publications on nematodes of ruminants are limited to the study of abomasum and therefore do not cover nematodes harboring in the small intestine (such as *Cooperia* spp. or *Nematodirus* spp.) and in the large intestine (such as *Trichuris* spp.).

Special attention should be paid to the blood-sucking nematode *Ashworthius sidemi* Schulz, 1933, which was found in 12.1% (5.2–23.8%) of the red deer in two

Fig. 5. *Nematodirus roscidus*, posterior end of male (bursa and spicules).

of the three regions studied (Table 2; Figs 3, 4). The detection of *A. sidemi* in red deer in the European part of Russia confirms the further spreading of this Asian nematode. Another evidence of the increasing spread of *A. sidemi* in Europe in the last two decades is the absence of nematodes of this species in the samples from Voronezh collected in 1980–1990s (Table 1). *Spiculopteragia spiculoptera* (Guschanskaja, 1931) was found in three red deer from Tver' (Table 2). *S. spiculoptera* is quite often observed in *C. elaphus*, both in Europe and in other parts of the world (Kutzer & Hinaidy, 1969; Bernard *et al*., 1988; Suarez *et al*., 1991; Rickard *et al.*, 1993; Mason, 1994; Zaffaroni *et al*., 2000; Kowal *et al*., 2014). *Nematodirus roscidus* Railliet, 1911 was found in three red deer, only in the samples collected in Voronezh in 1980-1990s (Tables 1, 2; Fig. 5). Previously *N. roscidus* was reported from *C. elaphus* in Austria and Poland (Kutzer & Hinaidy, 1969; Drozdz *et al*., 2002; Pyziel-Serafin *et al*., 2023). We believe that the reasons for these relatively rare observations of *N. roscidus* are that many studies are limited to the dissection of abomasum, as well as certain difficulties in morphological differentiation of this species from other *Nematodirus* spp. *Mazamastrongylus dagestanica* (Altaev, 1953) was detected in two red deer from

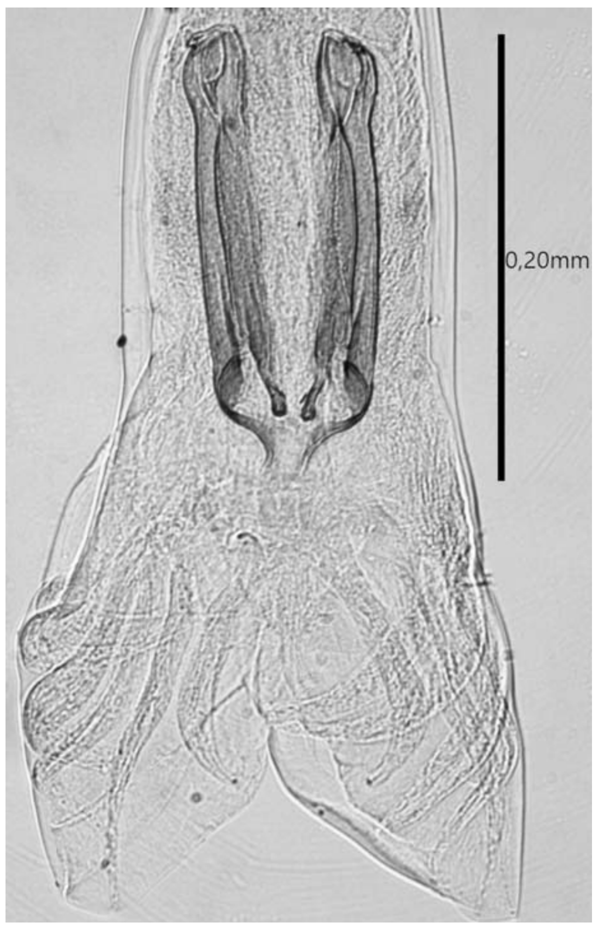

Fig. 6. *Mazamastrongylus dagestanica*, posterior end of male (bursa and spicules).

Voronezh, both in a recent sample and in a sample collected in 1987 (Table 1; Fig. 6). Interestingly, the first report on *M. dagestanica* in red deer was published only recently (Pyziel-Serafin *et al*., 2023). This species is considered to be a common parasite of moose, and it is also often found in roe deer (Kuznetsov *et al*., 2014, 2020; Wyrobisz-Papiewska *et al*., 2018). It should also be noted that *M. dagestanica* was recently found for the first time in common fallow deer (Kuznetsov, 2024).

Trichostrongylus colubriformis (Giles, 1892) was detected in two red deer from Tver' (Table 2). As for the references to this species in the literature, Govorka *et al.* (1988) list *C. elaphus* among the hosts of *T. colubriformis*, but don't specify in which country it was recorded. We found *Trichostrongylus axei* (Cobbold, 1879) in one red deer from Smolensk (Table 2). Previously *T. axei* was reported from the red deer in several European countries, as well as in New Zealand (Kutzer & Hinaidy, 1969; Mason, 1994; Zaffaroni *et al*., 2000; Santin-Duran *et al*., 2004; Zvegintsova *et al*., 2018; Halvarsson *et al*., 2022; Pyziel-Serafin *et al*., 2023). These two detected species of *Trichostrongylus* are very widespread among domestic and wild ruminants in different parts of the world (Skrjabin *et al*., 1954; Govorka *et al*., 1988; Movsesyan *et al*., 2019). Moreover, *T. colubriformis* and *T. axei* are regarded as zoonotic parasites (Skrjabin *et al.,* 1954; Mizani *et al*., 2017; Ashrafi *et al*., 2020; Bhat *et al*., 2023). *Aonchotheca bovis* (Schnyder, 1906) was observed in one sample collected in Voronezh, in 1984 (Table 1). It is noteworthy that *A. bovis* was recently found in the moose from the same place of sampling (Voronezh State Nature Biosphere Reserve) (Kuznetsov *et al*., 2022). This nematode was found earlier in several European countries in various species of wild ruminants, as well as in cattle and sheep (Govorka *et al*., 1988).

Compared with the studies of gastrointestinal nematodes of moose and common fallow deer in European Russia (Kuznetsov *et al*., 2022; Kuznetsov, 2024), a higher level of the species diversity was revealed in the present study. In this regard, it should be noted that moose in general is characterized by a low level of nematode species diversity (Maklakova & Rykovsky, 2008). As for the recent study of nematodes of common fallow deer (Kuznetsov, 2024), it is considered as an initial one, suggesting further additions. However, it should be noted that in the present study, *S. asymmetrica* turned out to be the dominant species, as in the study of common fallow deer (Kuznetsov, 2024). In the study of common fallow deer, *M. dagestanica* was found for the first time for this host (Kuznetsov, 2024), and in the present study, *M. dagestanica* was found for the first time in red deer in Russia. It is important to note that *M. dagestanica* was found in red deer in Voronezh, while in fallow deer this nematode was found in Smolensk (Kuznetsov, 2024). Thus, there is a tendency for the spread of *M. dagestanica* among wild ruminants in the European part of Russia. At the same time, the present study revealed a lower level of the species diversity of nematodes than that in European roe deer (Kuznetsov *et al*., 2020). This can be explained by the fact that a significant number of the samples from red deer were collected in closed areas of the game farms, where the red deer were prevented from moving long distances and co-pasturing with other ruminants. In particular, for this reason, the red deer we studied were not at serious risk of becoming infected with the species of nematodes typical of domestic ruminants.

In comparison with the data obtained earlier in the studies of gastrointestinal nematodes of *C. elaphus* in European Russia, our data coincide with Asadov (1960) for one species only (*O. leptospicularis*). Compared with Pryadko (1976) our data coincide on seven species (*A. bovis*, *C. pectinata, O. leptospicularis, S. spiculoptera, T. axei, T. colubriformis* and *T. ovis*). Govorka *et al.* (1988) summed up the data on helminths of wild ungulates of Eastern Europe. However, Govorka *et al.* (1988) presented the data in a form that excluded the possibility of comparing the species composition of helminths in different countries of Eastern Europe. *A. sidemi*, *S. asymmetrica*, *M. dagestanica* and *N. roscidus* have not been reported from red deer in European Russia earlier. Thus, we found these four species of gastrointestinal nematodes in *C. elaphus* from European Russia for the first time.

Conclusion

The study of the species composition of gastrointestinal nematodes of red deer in three regions of European Russia detected 11 species of nematodes. The levels of the intensity of infection were relatively low. Among the detected species of nematodes, *S. asymmetrica* and *O. leptospicularis* showed the highest levels of the prevalence. A comparison with the previous data revealed four new species (*A. sidemi*, *S. asymmetrica*, *M. dagestanica* and *N. roscidus*) in the fauna of nematodes of red deer in European Russia. The first detection of Asian nematode *A. sidemi* in red deer in the European part of Russia confirms the further spreading of this alien parasite. The rather high prevalence of *S. asymmetrica* (60.6%) indicates a potential health risk for red deer. The detection of *M. dagestanica* in red deer indicates a tendency for the spread of this nematode among wild ruminants in Eastern Europe. The lack of previous reports concerning intestinal nematode *N. roscidus* in red deer may be due to the fact that many studies were limited to the dissection of abomasum, as well as difficulties in morphological differentiation among the species of *Nematodirus*.

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Appendix. R code of our calculations.

```
## R version 4.5.0 (2025-04-11)
library(DescTools) ## package version 0.99.59
library(bayestestR) ## package version 0.16.0
## general prevalence
BinomCI(x = 26, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Cooperia pectinata prevalence
BinomCI(x = 6, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Spiculopteragia spiculoptera, Nematodirus roscidus prevalence
BinomCI(x = 3, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Mazamastrongylus dagestanica, Trichostrongylus colubriformis prevalence
BinomCI(x = 2, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Trichostrongylus axei, Aonchoteca bovis prevalence
BinomCI(x = 1, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Trichuris ovis, Ashworthius sidemi prevalence
BinomCI(x = 4, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Ostertagia leptospicularis prevalence
BinomCI(x = 11, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)
## Spiculopteragia asymmetrica prevalence
BinomCI(x = 20, n = 33, conf.level = 0.9, method = "jeffreys", rand = 2025)

## Mean intensity of male nematodes and BCAI
## Cooperia pectinata
vec <- c(1, 18, 2, 4, 8, 1)
mean(vec)
bci(x = vec, ci = 0.9)
## Spiculopteragia spiculoptera
vec <- c(4, 2, 3)
mean(vec)
bci(x = vec, ci = 0.9)
## Nematodirus roscidus
vec <- c(1, 9, 25)
mean(vec)
bci(x = vec, ci = 0.9)
## Mazamastrongylus dagestanica
vec <- c(4, 1)
mean(vec)
bci(x = vec, ci = 0.9)
## Trichostrongylus colubriformis
vec <- c(1, 2)
mean(vec)
bci(x = vec, ci = 0.9)
## Trichostrongylus axei
vec <- c(1)
mean(vec)
bci(x = vec, ci = 0.9)
## Aonchoteca bovis
vec <- c(161)
mean(vec)
bci(x = vec, ci = 0.9)
## Trichuris ovis
vec <- c(1, 1, 2, 2)
mean(vec)
bci(x = vec, ci = 0.9)
## Ashworthius sidemi
vec <- c(6, 182, 23, 44)
mean(vec)
bci(x = vec, ci = 0.9)
## Ostertagia leptospicularis/kolchida
vec <- c(98, 12, 33, 21, 13, 32, 35, 12, 5, 1, 1)
mean(vec)
bci(x = vec, ci = 0.9)
## Spiculopteragia asymmetrica/quadrispiculata
vec <- c(1, 42, 16, 4, 16, 16, 65, 46, 36, 56, 34, 26, 138, 4, 19, 80, 59, 4, 16, 4)
mean(vec)
bci(x = vec, ci = 0.9)
```