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Gastrointestinal nematodes of common fallow deer (*Dama dama*) in game farms in European Russia

Dmitry N. Kuznetsov

ABSTRACT. The species composition of gastrointestinal nematodes found in common fallow deer (*Dama dama*) from game farms in the territory of European Russia (Tver' and Smolensk regions) was determined. The nematodes were collected in the period from 2016 to 2022, during necropsies of 30 common fallow deer. Gastrointestinal nematodes were found in 21 of the 30 fallow deer studied, thus, the prevalence was 70.0%. The intensity of infection ranged from 20 to 98 specimens of nematodes. Six species of gastrointestinal nematodes were found: *Ashworthius sidemi*, *Cooperia pectinata*, *Mazamastrongylus dagestanica*, *Ostertagia leptospicularis*, *Spiculopteragia asymmetrica* and *Trichostrongylus capricola*. In addition, "*Spiculopteragia quadrispiculata*", a minor morph of *S. asymmetrica* was also found. Among the six nematode species detected, *S. asymmetrica* dominated in both intensity of infection and the prevalence. *Ostertagia leptospicularis* was in the second place in terms of the prevalence, but the intensity of infection with *O. leptospicularis* was significantly lower compared to *S. asymmetrica*. Nematodes of four other species were found in single specimens, in 6.7–10.0% of the fallow deer studied, and only in Smolensk region. At the same time, the species *M. dagestanica* was found in common fallow deer for the first time. The detection of Asian nematode *A. sidemi* confirms the further spread of this potentially dangerous parasite among ruminants of Europe. The detection of *O. leptospicularis* also deserves special attention, since this nematode is capable of infecting not only wild ruminants of various species, but also livestock.

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Нематоды желудочно-кишечного тракта ланей (*Dama dama*) в охотничьих хозяйствах европейской части России

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РЕЗЮМЕ. Определен видовой состав нематод желудочно-кишечного тракта, обнаруженных у ланей (*Dama dama*), содержавшихся в охотничьих хозяйствах на территории европейской части России (Тверская и Смоленская области). Нематоды были собраны в период с 2016 по 2022 гг., при патологоанатомических исследованиях 30 ланей. Нематоды обнаружены у 21 из 30 исследованных ланей, таким образом, экстенсивность инвазии составила 70.0%. Интенсивность инвазии варьировала в пределах от 20 до 98 экземпляров нематод. Обнаружены нематоды шести видов: *Ashworthius sidemi*, *Cooperia pectinata, Mazamastrongylus dagestanica, Ostertagia leptospicularis, Spiculopteragia asymmetrica* и *Trichostrongylus capricola.* Кроме того, обнаружена минорная морфа вида *S. asymmetrica* — "*Spiculopteragia quadrispiculata*". Среди шести обнаруженных видов доминировал, как по показателям интенсивности, так и экстенсивности инвазии, вид *S. asymmetrica*. Вид *O. leptospicularis* на втором месте по экстенсивности инвазии, однако значительно уступает *S. asymmetrica* по показателям интенсивности инвазии. Нематоды четырех других видов были обнаружены в единичных экземплярах, у 6.7–10.0% исследованных ланей, только в Смоленской области. При этом вид *M. dagestanica* обнаружен у ланей впервые. Обнаружение нематоды азиатского происхождения *A. sidemi* указывает на продолжающееся распространение этого потенциально опасного паразита среди жвачных Европы. Особого внимания заслуживает и обнаружение *O. leptospicularis*, так как эта нематода способна заражать не только диких жвачных различных видов, но и домашний скот.

КЛЮЧЕВЫЕ СЛОВА: дикие жвачные, *Dama dama*, пищеварительный тракт, паразитические нематоды, Европейская Россия, охотничьи хозяйства.

Introduction

Over the past two decades, quite a large number of private game farms have been established in Russia. Some of these game farms do not limit themselves to the breeding of local ungulate species, such as red deer or wild boar. Currently, common fallow deer (*Dama dama* (Linnaeus, 1758)) is becoming a fashionable species for breeding in game farms in European Russia. It is known that the introduction of wild ruminants is associated with the risk of contamination of territories with alien parasites (Vadlejch *et al.,* 2016). On the other hand, introduced ruminant species may be more vulnerable to native parasites. Infection with helminths can significantly impair the health conditions of wild ruminants (Stien *et al.,* 2002; Irvin *et al.,* 2006; Osinska *et al.,* 2010; Magdalek *et al.,* 2021). To date, data concerning helminths of common fallow deer from Russia is limited to a small number of studies. Pryadko (1976) reported on *Chabertia ovina* (Fabricius, 1788) and four species of *Trichuris* detected in common fallow deer from a zoo. Lunitsyn *et al.* (2015) studied feces of *D. dama* in one of the game farms in European Russia and noted 60.0% prevalence of strongylids. Kuznetsov (2022) reported the first detection of *Ashworthius sidemi* Schulz, 1933 in *D. dama* in Russia. The purpose of the present study was to identify gastrointestinal nematodes found during necropsies of common fallow deer from game farms in European Russia and to compare the obtained results with data from other countries.

Material and methods

Sample collection

Nematodes were collected during the necropsies of 30 common fallow deer from two game farms, one of which was in Tver' region and the other in Smolensk region (European part of Russia). Several individuals of the studied fallow deer were originally imported from Central Europe, but there is no exact information about the country of origin. All the studied fallow deer died due to accidental causes, such as injuries. Age of the fallow deer is given according to the information presented by the staff of the game-farms. The digestive tracts of fallow deer were dissected and examined according to helminthological methods (Ivashkin *et al.,* 1971; Kuznetsov, 2020).

Taxonomical identification

Identification of the detected nematodes based mainly on males morphology because of high similarity of the females. The detected nematodes were prepared as temporary whole mounts, cleared in glycerol solution (two parts of glycerol and eight parts of water) and then studied using light microscopy with magnification of 40 to 400. The species of detected nematodes were identified based on morphological features presented in the literature (Skrjabin *et al.,* 1954; Drozdz*,* 1965, 1995; Ivashkin *et al.,* 1989; Lehrter *et al.,* 2016). The main morphological features used for identification of the detected nematodes were the peculiarities of male reproductive system, in particular, the shape of spicules.

Results

Twenty-one of the 30 examined fallow deer were found to be infected with nematodes. Thus, the prevalence of all species of detected nematodes was 70.0%. The intensity of infection ranged from 20 to 98 individuals of nematodes. No significant lesions of the digestive tract were noted in the examined fallow deer. Rates of the intensity of infection and species names of

Table 1. The results of helminthological dissections of common fallow deer from game farms in Tver' and Smolensk regions. A — abomasum, SI — small intestine; major and minor morphs are separated by slash.

Sequence number of the studied common fallow 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	male, 2 years	29	9	20	*Ostertagia leptospicularis* (A-2), *Spiculopteragia asymmetrica* (A-7)
2	Tver'	January 2016	female, 1 year	–	–	–	–
3	Tver'	February 2016	female, 3 years	48	17	31	*S. asymmetrica* (A-15) / "*S. quadrispiculata"* (A-2)
4	Tver'	February 2016	female, 1 year	–	–	–	–
5	Tver'	December 2017	female, 3 years	36	12	24	*S. asymmetrica* (A-12)
6	Tver'	January 2018	male, 3 years	32	10	22	*O. leptospicularis* (A-2), *S. asymmetrica* (A-8)

Table 1 (*end*)

Sequence number of the studied common fallow 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	
7	Tver'	October 2018	female, 3 years	45	14	31	*O. leptospicularis* (A-3), *S. asymmetrica* (A-11)
8	Tver'	February 2019	male, 3 years	–	–	–	–
9	Tver'	November 2019	female, 3 years	55	16	39	*S. asymmetrica* (A-15) / "*S. quadrispiculata"* (A-1)
10	Tver'	January 2020	male, 3 years	98	29	69	*O. leptospicularis* (A-11), *S. asymmetrica* (A-18)
11	Tver'	March 2020	female, 3 years	–	–	–	–
12	Tver'	November 2021	female, 3 years	41	14	27	*O. leptospicularis* (A-2), *S. asymmetrica* (A-12)
13	Tver'	December 2021	male, 1 year	–	–	–	–
14	Tver'	March 2022	female, 3 years	38	11	27	*O. leptospicularis* (A-2), *S. asymmetrica* (A-9)
15	Smolensk	August 2018	female, 3 years	50	12	38	*O. leptospicularis* (A-2), *S. asymmetrica* (A-10)
16	Smolensk	September 2018	male, 2 years	54	14	40	*Ashworthius sidemi* (A-2), *Cooperia pectinata* (A-1), *O. leptospicularis* (A-3), *S. asymmetrica* (A-8)
17	Smolensk	September 2018	male, 2 years	48	18	30	*A. sidemi* (A-7), *Mazamastrongylus dagestanica* (A-1), *O. leptospicularis* (A-3), *S. asymmetrica* (A-5), *Trichostrongylus capricola* (SI-2)
18	Smolensk	March 2019	female, 3 years	41	12	29	*M. dagestanica* (A-1), *O. leptospicularis* (A-4), *S. asymmetrica* (A-7)
19	Smolensk	October 2019	female, 3 years	65	17	48	*O. leptospicularis* (A-5), *S. asymmetrica* (A-12)
20	Smolensk	October 2019	male, 2 years	79	28	51	*A. sidemi* (A-2), *C. pectinata* (A-1), *O. leptospicularis* (A-7), *S. asymmetrica* (A-18)
21	Smolensk	February 2020	female, 3 years	–	–	–	–
22	Smolensk	April 2020	male, 3 years	60	18	42	*O. leptospicularis* (A-5), *S. asymmetrica* (A-12), *T. capricola* (SI-1)
23	Smolensk	October 2020	female, 2 years	38	13	25	*O. leptospicularis* (A-5), *S. asymmetrica* (A-8)
24	Smolensk	January 2021	male, 3 years	–	–	–	–
25	Smolensk	March 2021	female, 3 years	20	8	12	*S. asymmetrica* (A-8)
26	Smolensk	September 2021	male, 2 years	29	8	21	*M. dagestanica* (A-1), *O. leptospicularis* (A-3), *S. asymmetrica* (A-4)
27	Smolensk	September 2021	female, 3 years	–	–	–	–
28	Smolensk	February 2022	female, 3 years	60	19	41	*S. asymmetrica* (A-18) / "*S. quadrispiculata"* (A-1)
29	Smolensk	April 2022	male, 2 years	–	–	–	–
30	Smolensk	November 2022	male, 2 years	40	11	29	*O. leptospicularis* (A-2), *S. asymmetrica* (A-9)

Table 2. The prevalence of gastrointestinal nematodes in studied individuals (*n*=30) of *Dama dama*.

Nematode species	Regions of detection	The number of infected animals	Prevalence (%)
Ashworthius sidemi	Smolensk	3	10.0
Cooperia pectinata	Smolensk	2	6.7
Mazamastrongylus dagestanica	Smolensk	3	10.0
Ostertagia leptospicularis	Tver', Smolensk	16	53.3
Spiculopteragia asymmetrica	Tver', Smolensk	21	70.0
Trichostrongylus capricola	Smolensk	2	6.7

the detected nematodes are presented in Tab. 1. The obtained data are presented in chronological order (separately for two examined game farms). Species names of the detected nematodes are presented in alphabetical order. In total, six species of gastrointestinal nematodes were found in the present study. All of the detected species are from the Trichostrongyloidea superfamily (following to classification by Durette-Desset *et al.,* 1999): *A. sidemi*; *Cooperia pectinata* Ransom, 1907; *Mazamastrongylus dagestanica* (Altaev, 1953); *Ostertagia leptospicularis* Assadov, 1953; *Spiculopteragia asymmetrica* (Ware, 1925) and *Trichostrongylus capricola* Ransom, 1907 (Tab. 2, Figs 1–6). Beside this, a minor morph of *S. asymmetrica* ("*S. quadrispiculata*") was also detected in two fallow deer from Tver', as well as in one fallow deer from Smolensk region (Tab. 1, Fig. 7).

Thus, the present study showed low levels of the intensity of infection as well as rather low species diversity of gastrointestinal nematodes (Tabs 1, 2). Two species of nematodes (*S. asymmetrica* and *O. leptospicularis*) dominated in examined fallow deer both in Tver' and Smolensk regions, while four other species (*A. sidemi, C. pectinata, M. dagestanica* and *T. capricola*) were found in much fewer cases (Tab. 2).

Discussion

The present study is intended to supplement the data on the helminth fauna of common fallow deer in Russia, which is so far limited to a small number of reports (Pryadko, 1976; Lunitsyn *et al.*, 2015; Kuznetsov, 2022). At the same time, it is necessary to keep in mind that small private game farms are relatively new business for Russia and their management is still imperfect. Thus, the present study can be considered mainly as the initial stage of studying parasites of common fallow deer in Russian game farms.

Spiculopteragia asymmetrica was most often found in the studied common fallow deer (Tab. 2). This species also showed the highest intensity of infection in the present study (Tab. 1). These observations agree with Wyrobisz-Papiewska *et al.* (2018), who consider *D. dama* to be the principal host of *S. asymmetrica*. Based on bibliographical references, Wyrobisz-Pa-

Fig. 1. *Ashworthius sidemi*, posterior end of male.

Fig. 2. *Cooperia pectinata*, posterior end of male.

Fig. 3. *Mazamastrongylus dagestanica*, posterior end of male.

piewska *et al*. (2018) report detection of this nematode in common fallow deer in Poland, Germany, Austria, Italy, Spain and the United Kingdom. Based on their own data, Wyrobisz-Papiewska *et al.* (2018) also report the detection of *S. asymmetrica* in European roe deer (*Capreolus capreolus* (Linnaeus, 1758)) in Poland, but with much lower rates of prevalence and intensity of infection, than in fallow deer. It is worth mentioning that mean intensity of infection with *S. asymmetrica* in fallow deer (25 specimens), noted by Wyrobisz-Papiewska *et al.* (2018), is close to those registered by us. Beside this, Govorka *et al.* (1988) mention fallow deer as the host of *S. asymmetrica* in Czechoslovakia. In Slovenia, Vengust & Bidovec (2003) found *S. asymmetrica* in 63% of necropsied fallow deer. In Sweden, *S. asymmetrica* was detected in fallow deer with 67% prevalence (Halvarsson *et al.*, 2022). Doster & Friend (1971) reported *S. asymmetrica* from *D. dama* in USA. In Australia, *S. asymmetrica* was found in 75% of studied fallow deer (Mylrea *et al.,* 1991). In Russia, *S. asymmetrica* recently was reported from *C. capreolus* and *Alces alces* Linnaeus, 1758 (Kuznetsov, 2013; Kuznetsov *et al.,* 2020, 2022).

Ostertagia leptospicularis is the second most-prevalence species found during our study (Tab. 2). The intensity of infection with *O. leptospicularis* was in all cases lower than that with *S. asymmetrica* (Tab. 1). Previously, *O. leptospicularis* was reported from *D. dama* in Poland, Germany, Austria, Czechoslovakia, Spain and the United Kingdom (Wyrobisz-Papiewska *et al.*, 2018). Halvarsson *et al*. (2022) recently detected *O. leptospicularis* in fallow deer in Sweden with 22% prevalence. In general, *O. leptospicularis* is very common in wild ruminants of various species in Europe (Wyrobisz-Papiewska *et al.*, 2018). It is also important that *O. leptospicularis* can infect livestock and has been found in domestic ruminants in various parts of the world (Saqur *et al.*, 1980; Bisset, 1994; Hoberg *et al.*, 2001; Olaifa & Ozgor, 2022).

The other four nematode species were found in only one of the regions studied, and in very small quantities

Fig. 4. *Ostertagia leptospicularis*, posterior end of male.

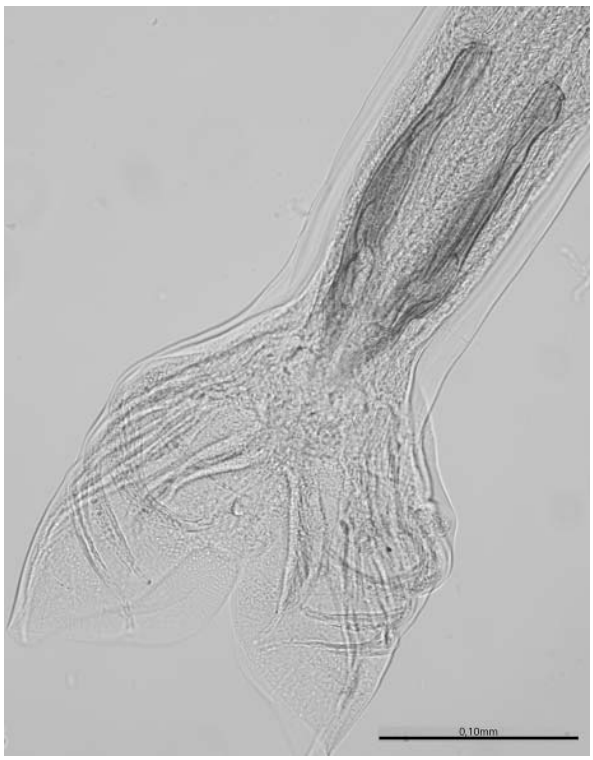

Fig. 5. *Spiculopteragia asymmetrica*, posterior end of male.

Fig. 6. *Trichostrongylus capricola*, posterior end of male.

(Tabs 1, 2). *Ashworthius sidemi* is an Asian nematode that has become increasingly widespread among ruminants in Europe in recent decades (Drozdz *et al.*, 2003; Moskwa *et al.*, 2015; Vadlejch *et al.*, 2016; Kuznetsov *et al.*, 2018). To date, *A. sidemi* has been found in *D. dama* in Sweden, Poland, France, Czechia and Russia (Hoglund *et al.*, 2007; Kowal *et al.*, 2012; Lehrter *et al.*, 2016; Magdalek *et al.,* 2021; Kuznetsov, 2022). During the present study, we found only a few specimens of *A. sidemi*, in contrast to the dominance of this nematode in *D. dama* recorded in some European

Fig. 7. "*Spiculopteragia quadrispiculata*", posterior end of male.

countries (Kowal *et al.*, 2012; Magdalek *et al.,* 2021). *Cooperia pectinata* was found in our study in 6.7% of the examined fallow deer, in single specimens. Concerning literature data on *C. pectinata*, only Govorka *et al.* (1988) mention *D. dama* as the host of this nematode, however, without specifying in which country this parasite was found in fallow deer. More recent studies report only the detection of "*Cooperia* spp." in fallow deer, and with very low rates of infection (Vengust & Bidovec, 2003; Halvarsson *et al.*, 2022). *Mazamastrongylus dagestanica* was detected in 10.0% of the studied *D. dama* from Smolensk region only (Tab. 2). Only single specimens of this nematode were found (Tab. 1). To our knowledge, this is the first detection of *M. dagestanica* in *D. dama*. We are inclined to agree with Grandi *et al.* (2018) and Wyrobisz-Papiewska *et al.* (2018), who consider moose (*A. alces*) as a principal host for *M. dagestanica*. Indeed, impressively high rates of infection with *M. dagestanica* were registered for moose (Grandi *et al.,* 2018; Filip-Hutsch *et al.,* 2021). However, *M. dagestanica* was also quite often found in European (*C. capreolus*) and Siberian (*Capreolus pygargus* (Pallas, 1771)) roe deer, although with a lower intensity of infection (Kuznetsov *et al.*, 2014, 2020). *Trichostrongylus capricola* was found in 6.7% of the studied fallow deer, in very small numbers. Fallow deer as the host of *T. capricola* is mentioned only in book by Govorka *et al.* (1988), without specifying in which country this nematode was found in *D. dama*. Interestingly, *T. capricola* has recently been reported as one of the dominant species of gastrointestinal nematodes of moose in Sweden (Grandi *et al.,* 2018). In European Russia, Lunitsyn *et al.* (2015) found *Trichostrongylus* sp. during the study of feces of *D. dama* from game farm in Tver' region.

A level of species diversity of gastrointestinal nematodes, as well as infection rates, generally close to our data was noted in some studies of *D. dama* previously conducted in Europe (Kowal *et al.,* 2012; Wyrobisz-Papiewska *et al.,* 2018). At the same time, a low level of infection with *A. sidemi* was recorded in our study, in contrast to the data presented in the literature (Kowal *et al.,* 2012; Magdalek *et al.,* 2021). However, the very fact of the detection of such a potentially dangerous parasite as *A. sidemi* indicates the need to strengthen control of gastrointestinal nematodes of wild ruminants in European Russia. *Ashworthius sidemi* was detected in *D. dama* in Russia for the first time by Kuznetsov (2022) based on the necropsies of two fallow deer conducted in 2018. In the present study we supplement the data concerning *A. sidemi* in *D. dama* in Russia with the results obtained at the same game farm after 2018, when a small number of *A. sidemi* were found in another one fallow deer (Tab. 1).

Thus, all nematode species (with the exception of *M. dagestanica*) found in the present study, have previously been reported from *D. dama* in various European countries. Beside this, all species of nematodes noted during the present study were previously found in other wild ruminants (such as roe deer or moose) inhabiting Europe.

Conclusion

An initial helminthological study of common fallow deer (*D. dama*) from game farms in European Russia revealed six species of gastrointestinal nematodes with rather low levels of the intensity of infection. Nematodes *A. sidemi*, *C. pectinata*, *M. dagestanica, O. leptospicularis, S. asymmetrica* (including a minor morph "*S. quadrispiculata*") and *T. capricola* were detected.

Spiculopteragia asymmetrica dominated in terms of intensity of infection and prevalence, which coincides with the data from studies of gastrointestinal nematodes parasitizing common fallow deer in other European countries. The detection of *A. sidemi* confirms the further spread of this Asian nematode among ruminants in Europe. Among the detected nematodes, *O. leptospicularis* also deserves special attention, since it is potentially dangerous not only for various species of wild ruminants, but also for livestock. For the first time, *M. dagestanica* was found in common fallow deer. The obtained results indicate the need for increased control of gastrointestinal nematodes on game farms.

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