

Original Research Paper

Reindeer Infestation with *Cysticercus Tarandi* in the Tundra of Yamalia, Russia

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Abstract: Improving the efficiency of reindeer husbandry can only be achieved by preserving the health of animals, which requires the organization of measures to protect animals from infectious and invasive pathogens. *C. tarandi* is the larval stage of *Taenia krabbei* and causes damage to muscle fibers and a decrease in the commercial qualities, energy and nutritional value of reindeer meat. The study aimed to evaluate the distribution of *C. tarandi* in the population of domesticated reindeer grazing on the tundra of the Tazovsky district of the Yamalo-Nenets Autonomous District. The infestation level was assessed upon detection of the cysticerci of *C. tarandi* in the muscle fibers and hearts during reindeer carcasses examination (n = 38,580). During the study period (2016-2018), the infestation of the reindeer with *C. tarandi* averaged 6.5%. At the slaughter unit in Tazovsky village, the infestation prevalence averaged 9.7% and in Antipayuta village was up to 5.7%. The greatest infestation rate was observed in animals belonging to the Tazovsky agricultural production cooperative and in Agrofirma Pripolarnaya limited liability company with 16.7 and 21.2%, respectively, in 2016. The lowest infestation was observed in animals belonging to private individuals (from 0 to 7.5%). On average, about 33 kg of products were not received from each reindeer carcass infected with *C. tarandi*.

Keywords: *Cysticercus tarandi*, *Taenia krabbei*, Reindeer, Yamalo-Nenets Autonomous District of Russia, Prevalence

Introduction

Taenia krabbei Moniez, 1879 is a tapeworm of the Taeniidae Ludwig, 1886 family that lives in the intestine of wild and domestic canids. Its larval stage, *Cysticercus tarandi* (synonyms: *Cysticercus tarandi* Villofc, 1883; *Cysticercus rangifer* Griiner, 1910; *Taenia rangifer* (Griiner, 1910; Meggitt, 1924), is localized in the muscle fibers and heart of reindeer, elk (Gibbs and Eaton, 1983; Lavikainen *et al.*, 2011), red deer (Flueck and Jones, 2006), roe deer (Kolár *et al.*, 1978; Al-Sabi *et al.*, 2013; Formenti *et al.*, 2018) and sheep (Priemer *et al.*, 2002). The pathogenetic effect of *C. tarandi* on the body of reindeer consists of toxic and allergic effects by the products of its metabolism, as well as damage to muscle tissue, and loss of marketable products (Jones and Pybus, 2001). In addition, the amino acid composition changes and, as a consequence of all of the above, the nutritional and energy value of the venison (Zemlyansky, 2022). The infestation of animals with *C. tarandi* is recorded mainly in the territories

of the reindeer habitat. According to Moniez, 1879 the infestation of reindeer by the larval stage of *T. krabbei* has been noted in Finland, Sweden, Norway, Greenland (Josefsen *et al.*, 2014), USA, Canada (Choquette *et al.*, 1957) and Russia (Dorzhev, 1980; Shalaeva, 2017).

In Russia, special attention is paid to the study of the parasitic fauna of reindeer due to the high social importance of breeding this animal species by the indigenous peoples of the Far North, since this occupation allows them to maintain a traditional lifestyle (Gavrichkin *et al.*, 2018). Parasitism of *Strongylida* nematodes, *Capillaria*, and *Elaphostrongylus rangiferi* genus has been noted on the territory of the Leningrad Region (Loginova and Belova, 2020) and the parasitic fauna of both domesticated and wild reindeer has been studied in Yakutia, where 31 parasitic species have been identified (Kokolova *et al.*, 2019; 2021). Parasitism of eight nematode species and three cestode species in the intestine of domesticated and wild reindeer has been detected on the territory of Taimyr, along with the absence of

representatives of trematodes in the parasitic complex of deer in this territory (Laishev *et al.*, 2008; Shalaeva, 2017).

In numerous works devoted to the study of the problems of reindeer husbandry in the adjacent territories of the Yamalo-Nenets and Khanty-Mansi Autonomous Districts, the spread of nematodes (Siben and Silivanova, 2015), trematodes (Siben *et al.*, 2018, 2019; Siben, 2021) and larval cestodes (Siben *et al.*, 2015, 2018) of animals have been shown, along with the presence of *Oedemagena tarandi* in deer (Fiodorova *et al.*, 2019; Gavrichkin *et al.*, 2019b). Clinical signs in reindeer cysticercosis are uncharacteristic and appear at a high intensity of invasion. One of the clinical signs is the depressed state of the animal due to damage to the heart muscle and the general toxic effect of the parasite on the host organism. The main diagnostic sign is the pathoanatomical changes in the carcass of the animal during slaughter. The main route of transmission of the pathogen from the intermediate host (reindeer) to the main host (dogs, wolves, etc.) is the consumption of affected animal carcasses.

However, the study of the distribution of *C. tarandi* in the domesticated reindeer population has not received sufficient attention even when studying larval cestodes (Gavrichkin *et al.*, 2018), although it is indirect (Gavrichkin *et al.*, 2019a) and factual evidence of the need for these studies. Because improving the efficiency of reindeer husbandry is impossible without preserving animal health, monitoring and control over the spread of infectious and invasive diseases in animal herds are relevant.

The purpose of our study was to analyze the spread of *Cysticercus tarandi* infestation in the reindeer grazing on the tundra of the Tazovsky district of the Yamalo-Nenets Autonomous District (YNAD).

Materials and Methods

The protocol of the study was discussed and approved at the meeting of the expert ethical commission of the All-Russian Research Institute of Veterinary Entomology and Arachnology, a branch of the Tyumen Research Center of the Siberian Branch of the Russian Academy of Sciences dated 23.09.2016, Protocol No. 3.

The study was carried out at the meat processing enterprises of the Tazovsky district of the Yamalo-Nenets Autonomous District (YNAD) and the laboratory of entomoses and helminthiasis of the All-Russian Research Institute of Veterinary Entomology and Arachnology, a branch of the Tyumen Research Center of the Siberian Branch of the Russian Academy of Sciences, using data from veterinary reports of territorial authorities in the period from 2016 to 2018.

The studies at meat processing plants were carried out in Tazovsky and Antipayuta villages. The slaughter unit at Tazovsky received reindeer which had grazed mainly on the territory from the borders of the Purovsky and

Krasnoselkupsky districts of the YNAD to the 69th parallel of northern latitude (in summer). The animals arriving at the slaughter unit in Antipayuta had grazed mainly on the territory of the Gydan peninsula (to the north of the village), with the possible entry of herds to the south in summer (during the active gnat swarming). During the study period, 7,766 reindeer carcasses were examined for the presence of *C. tarandi* at the slaughter unit in Tazovsky and 30814 in Antipayuta, with a total n = 38,580. Stunning of animals was carried out with the help of electricity and exsanguination by opening the jugular vein. Slaughter waste was decontaminated by burning in a special furnace. The slaughter of animals was carried out in compliance with the hygienic standards of the Russian Federation (Kostenko and Matveev, 2009; Dorozhkin *et al.*, 2016).

In reindeer, there are three varieties of cysticercosis that are not zoonoses: The parenchymal one, the muscular one (caused by *Cysticercus tarandi*), and mesentery cysticercosis (caused by *Cysticercus tenuicollis*). The spread of the infestation was assessed during the veterinary and sanitary examination, during the slaughter of animals at meat processing plants, and was taken into account in the planning of antiparasitic measures, in particular deworming of reindeer herding dogs.

C. tarandi is localized mainly in the striated musculature and heart and presents itself as a transparent oblong vesicle 7 to 10 mm long and 2.5 to 4.5 mm wide (Fig. 1).

To detect *C. tarandi* larvae in deer carcasses, a veterinary and sanitary examination was carried out according to the rules of veterinary inspection of slaughter animals (USSRMA, 1985; Leshchev *et al.*, 2011) in the following sequence. The head and lymph nodes located on it were examined. This was followed by tongue examination and palpation. The next step was to cut and inspect the masticatory muscles, along the entire width and parallel to their surface. The heart was examined for the presence of the parasite.



Fig. 1: *T. krabbei* larva in reindeer muscles (picture taken by the authors)

The carcasses were examined from the outside and inside, in the case of detection of cysticerci (*C. tarandi*), a more detailed examination was carried out with cuts of muscle fibers to establish the extent of the infestation. If no more than five cysticerci were detected on the carcass and internal organs on a 40² cm section and there were no pathological changes in the musculature, the organs and carcass were sent for disinfection by freezing, with further use for the manufacture of sausage products or canned minced meat. This infestation was considered insignificant. In the case of detection of more than five cysticerci on the section of muscles with an area of 40² cm or in the presence of pathological changes in the musculature, the carcass was sent for disposal and such an infestation was considered significant.

The spread of muscular cysticercosis in reindeer was estimated using the indicator of point prevalence (%). Point Prevalence (PP) was calculated using the following formula (Akbaev *et al.*, 2013):

$$PP = n / N \times 100\%$$

where,

n = The number of infected hosts

N = The number of examined hosts

The study results were processed by methods of variation statistics using the BIOSTAT software (AnalystSoft Inc., USA).

Results

The results demonstrated the infestation rates with *C. tarandi* where the Point Prevalence (PP) varied slightly and amounted in 2016 to 6.1%, 2017 to 6.5%, and 2018 to 6.9%, equaling on average 6.5% over three years (Table 1).

At the slaughter unit in Tazovsky, the infestation of the reindeer with *C. tarandi* averaged 9.7%. The infestation rate of animals with pathogens of muscular cysticercosis

was not detected in deer belonging to the Khamovskaya territorial network organization of the small indigenous people of the North (TSO KMNS), possibly due to a small sample (n = 25 and n = 44). The infestation of reindeer with *T. krabbei* larvae in the MESSO standalone subdivision limited liability company (OOO OP) and the private sector was insignificant and ranged from 1.5% (2017) to 6.0% (2018) and from 1.8% (2016) to 6.7% (2018), respectively. In the Tazovsky agricultural production cooperative (SPK) and OOO Agrofirma Pripolarnaya, the maximum prevalence in 2016 was 16.7 and 21.2%, respectively. It is worth noting that in all farms the minimum indicators of animal infestation by *T. krabbei* larvae were recorded in 2017 (Table 2).

In Antipayuta, the reindeer infestation with *C. tarandi* was 5.7%. The infestation rate in animals bred by individual reindeer herders (private sector) did not exceed 7.5% (2018) in Antipayuta and 5.0% (2017) in Gyda village. In the Siadei-Yakhinskaya Self-Regulating Organization (SRO) KMNS, the maximum infestation of reindeer with *T. krabbei* larvae was recorded in 2017 with a prevalence of 11.5%, and the minimum was recorded in 2018 with a prevalence of 3.7%. In animals belonging to the Sovkhoz Antipayutinsky Municipal Unitary enterprise (MUP), the infestation with *C. tarandi* varied slightly from 4.3% in 2018 to 5.2% in 2017 (Table 3).

According to the rules of veterinary inspection of slaughter animals (USSRMA, 1985), in case of significant muscle damage by *T. krabbei* larvae (more than five cysticerci per 40 cm²), reindeer carcasses are sent for disposal. During the study period, 81,990 tons of venison were disposed of. According to the above data, at the slaughterhouse in Tazovsky, about 27 kg of products were not received from each carcass of reindeer affected by *T. krabbei* larvae, and at the slaughterhouse in Antipayuta, the same indicator reached 39 kg, which averaged 33 kg in the district.

Table 1: The infestation rates of reindeer with *T. krabbei* larvae on the territory of the Tazovsky district of the YNAD in 2016-2018

Slaughter unit	2016			2017			2018		
	Inspected	Observed	PP %	Inspected	Observed	PP %	Inspected	Observed	PP %
Tazovsky	2,802	306	10.9	3,006	238	7.9	1,958	207	10.6
Antipayuta	8,728	395	4.5	12,038	740	6.1	10,048	623	6.2
Total	11,530	701	6.1	15,044	978	6.5	12,006	830	6.9

PP = Point prevalence.

Table 2: Reindeer infestation rates by *T. krabbei* larvae at the slaughter unit in Tazovsky with a comparison of the farms of various forms of ownership (2016-2018)

Name of the farm	2016			2017			2018		
	Inspected	Observed	PP%	Inspected	Observed	PP%	Inspected	Observed	PP%
OOO OP MESSO	351	16	4.6	130	2	1.5	100	6	6.0
SPK Tazovsky	1,399	234	16.7	2,289	220	9.6	1,423	162	11.4
OOO Agrofirma Pripolarnaya	193	41	21.2	137	2	1.5	98	18	18.4
h/s	815	15	1.8	450	14	3.1	312	21	6.7
TSO KMNS Khamovskaya	44	0	-	0	0	-	25	0	-
Total	2,802	306	10.9	3,006	238	7.9	1,958	207	10.6

PP= Point prevalence.

Table 3: Reindeer infestation rates by *T. krabbei* larvae at the slaughter unit in Antipayuta with a comparison of the farms of various forms of ownership (2016-2018)

Name of the farm	2016			2017			2018		
	Inspected	Observed	Prevalence, %	Inspected	Observed	Prevalence, %	Inspected	Observed	Prevalence, %
MUP Sovkhoz Antipayutinsky	2,310	114	4.9	2,701	139	5.2	2,840	122	4.3
SRO KMNS Syadei-Yakhinskaya	404	17	4.2	889	102	11.5	1,043	39	3.7
Antipayuta	6,014	264	4.4	7,298	441	6.0	6,165	462	7.5
Gyda	-	-	-	1,150	58	5.0	-	-	-
Total	8,728	395	4.5	12,038	740	6.1	10,048	623	6.2

PP = Point prevalence.

Discussion

Parasitism of *C. tarandi* is noted in representatives of ruminants, both wild (Flueck and Jones, 2006; Lavikainen *et al.*, 2011; Formenti *et al.*, 2018) and domesticated ones (Priemer *et al.*, 2002) but reindeer are the most affected species in all habitat territories (Dorzhiiev, 1980; Josefsen *et al.*, 2014). Numerous studies have been carried out in Russia to study the parasitic fauna of reindeer (Leshchev *et al.*, 2011; Siben and Silivanova, 2015; Shalaeva, 2017). Coproscopic studies were carried out mainly to detect pathogens of parasitic diseases, less often complete and incomplete helminthological autopsies were performed (Akbaev *et al.*, 2013). Coprologically, analysis of fecal samples are less expensive, but they do not show the presence of *C. tarandi* in the body of reindeer. The data obtained as a result of the above-mentioned surveys give a picture of the parasitological situation in the territory, which in the future may reflect the quality of the antiparasitic preventive measures carried out, but ultimately, to diagnose muscular cysticercosis, it is necessary to resort to methods of complete and incomplete helminthological autopsy or to establish the animals' infestation with *C. tarandi* during slaughter at the meat processing plant. In the course of our study, we used diagnostics of muscular cysticercosis in reindeer during slaughter at meat processing plants in Tazovsky and Antipayuta of the YNAD.

In connection with the above, the available research works on the spread of parasitic infestations of reindeer in Russia contain mainly information on the spread of intestinal parasites. However, there are several works in which parasitization of *C. tarandi* in reindeer has been noted. Thus, according to Kokolova *et al.* (2019), muscular cysticercosis has been recorded on the territory of Yakutia with a prevalence of 5.1% and according to more recent data, it has reached 13.3% (Kokolova *et al.*, 2021). According to Shalaeva (2017), the infestation rate of reindeer with cysticerci was 61.5% on the territory of Taimyr, but the prevalence of the parasites was not specified, including the prevalence of *C. tarandi*. In the Magadan region, according to Dorzhiiev (1980), the infestation of reindeer with *C. tarandi* varied from 0.1 to 9.5%. The results of our studies are consistent with the data from the aforementioned surveys.

On the territory of the YNAD, studies were conducted to study the spread of cysticerci in reindeer (Gavrishkin *et al.*, 2018), but with an emphasis on the pathogens of anthroponosis, namely *Echinococcus granulosus*. Thus, a detailed study of the distribution of *C. tarandi* in the region of our study has not been carried out.

The intensity of the epizootic process for muscular cysticercosis in reindeer in the territory of the Tazovsky district of the YNAD was assessed by the detection of *T. krabbei* larvae, with the determination of its prevalence. On average, during the study period, the prevalence was 6.5%. At the slaughter unit in Tazovsky, the prevalence averaged 9.7%, and in Antipayuta 5.7%. These indicators are lower than in the territory of Yakutia (Kokolova *et al.*, 2019; 2021) and are comparable to the infestation rate in the Magadan region (Dorzhiiev, 1980). That is, the infestation rate of reindeer, in recent years, by the causative agent of muscular cysticercosis varies from 6.5% in the Tazovsky district of the YNAD to 13.3% in Yakutia (in some years 5.1%), which indicates a comparable level of veterinary measures aimed at preventing this invasion. In the 1920s, according to D.D. Dorzhiiev (1980) in the Magadan region of Russia, the prevalence of *C. tarandi* infestation reached 9.5% and in Svalbard (Norway) it equaled 38% (Josefsen *et al.*, 2014). These indicators point to insufficient work on the prevention of muscular cysticercosis in reindeer in Svalbard but can be explained by the severe climatic conditions in this area and the presence of a large number of wild predatory mammals (the main hosts of the parasite), including polar bears that are unlikely or impossible to be subject to disease prevention measures.

During the observation period, an estimate was made of the number of lost products caused by the disposal of animal carcasses due to the infestation with the cysticerci and it averaged 33 kg per 1 carcass. This indicator points to significant economic losses for reindeer owners, even with low prevalence indicators and the need to control the spread of *T. krabbei* primarily in the population of the main hosts. These measures should include monitoring studies, the organization and the provision of timely deworming of reindeer herding dogs, as well as the organization of disposal of slaughterhouse waste and animal corpses at animal burial sites, to prevent the spread of the infestation onset.

Conclusion

During the study period (2016-2018) in the territory of the Tazovsky district of the YNAD, the infestation rate of the reindeer with *C. tarandi* averaged 6.5%. The greatest infestation rate was observed in animals belonging to the SPK Tazovsky and in OOO Agrofirma Pripolarnaya with 16.7 and 21.2%, respectively, in 2016. The lowest infestation rate was observed in animals belonging to private individuals (from 0 to 7.5%). On average, about 33 kg of products were not received from each reindeer carcass infected with *C. tarandi* in the study area. To prevent economic losses due to the infestation of reindeer by muscular cysticercosis, it is necessary to carry out some biosecurity and preventive measures including timely deworming of dogs and the organization of animal burial sites to prevent infestation of dogs. Monitoring studies of the parasite fauna of wild animals, primarily wild reindeer and carnivores (wolves, wolverines, and arctic foxes) are also needed.

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Author's Contributions

All authors contributed equally to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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