

Main Parasitic Infestations of Wild Ungulates Used for Food

Igor Gennadievich Glamazdin, Ilya Nikolayevich Medvedev*, Denis Denisovich Kutuzov, Ilnura Ibragimovna Fayzullina, Sofia Vitalievna Nazarova, Natalya Yuryevna Sysoeva, Nikolay Evgenievich Komarov, Olga Anatolyevna Bannikova, Marina Ivanovna Gubanova, Karina Vitalevna Bakaeva, Veronika Vladimirovna Tarasova

Received: 28 February 2024 / Received in revised form: 02 May 2024, Accepted: 7 May 2024, Published online: 15 May 2024

Abstract

Various parasitic infestations are very characteristic of wild animals. The frequency of parasites and their species composition is much richer than in farm animals. At the same time, public catering, which is an important sphere of life of modern man, under the influence of fashion and the development of gastronomic culture keeps the range of dishes offered from the meat of wild animals. Available in the sphere of public catering significant demand for products from the meat of wild animals increases the risk of human infection with their parasites and makes it relevant to consider this issue. The review and analysis of available data on the main parasitic infestations of wild ungulates, the meat of which is used for food are based on information from the most popular scientific bases. As a result of the generalization of information, analysis, and synthesis of data on their basis, the factors influencing the distribution of the main parasites among wild animals, features of their life cycle, and potential threats in terms of their infection of humans were determined. The collected material will contribute to the systematic improvement of the biosafety level of food products from wild meat.

Keywords: Meat products, Wild animals, Food, Parasites, Protozoosis, Helminthiasis

Introduction

Modern animal breeding is actively developing using the results of research on different productive animals (Solovyova *et al.*, 2020; Zavalishina, 2020c). Its main goal is to provide the population with

Igor Gennadievich Glamazdin, Denis Denisovich Kutuzov, Ilnura Ibragimovna Fayzullina, Sofia Vitalievna Nazarova, Natalya Yuryevna Sysoeva, Nikolay Evgenievich Komarov, Olga Anatolyevna Bannikova, Marina Ivanovna Gubanova, Karina Vitalevna Bakaeva, Veronika Vladimirovna Tarasova

Department of Veterinary Medicine, Russian Biotechnological University, Moscow, Russia.

Ilya Nikolayevich Medvedev*

Department of Normal Anatomy, Russian State Social University, Moscow, Russia.

*E-mail: ilmedv1@yandex.ru

a sufficient volume of meat products due to the introduction of knowledge about the physiology of young animals and pregnant females, ensuring strict compliance with the necessary conditions for the vital activity of different types of productive animals, their competent treatment and diverse prevention of various pathological processes in bred and farmed animals (Tkacheva & Zavalishina, 2018a; Karpov *et al.*, 2020). For this purpose, veterinarians and zootechnicians systematically test and begin to apply various biologically active substances and preparations that reduce the pathological affection of livestock, strengthen its various organs and systems, accelerate the growth and development of young animals, and increase the productivity of adults (Usha *et al.*, 2019).

At the same time, despite the huge volumes of production of products from farm animals, consumers are still very interested in products from wild animals (Zavalishina, 2020a). In this regard, the modern catering industry increasingly offers various meat dishes from wild animals, which are considered by consumers as delicacies due to their infrequent occurrence in the menu of catering enterprises (Tkacheva & Zavalishina, 2018b). Basically, such dishes are necessary to maintain the high status of the restaurant that offers them (Kulikov *et al.*, 2020). This is due to the fact that the restaurant business is a competitive environment, where there is an active struggle for the attention of the guests and, ultimately, for increasing profits. The development strategies of catering establishments come in different forms, they are formed taking into account popular trends, as well as fashion for beautiful and tasty food (Zavalishina, 2020b). As a result, game dishes have already taken a stable position among the rich assortment of dishes offered. Under these conditions, restaurants have already appeared, which have begun to specialize to varying degrees in game dishes, combining them with non-standard "wild" vegetable ingredients (Tkacheva, 2023).

In this context, the great need for safety in the production and realization of food products from wild meat becomes clear. Of particular importance here is the high education of chefs and proper training of restaurant staff in terms of proper preparation and safe production of dishes. In this regard, a restaurant, café or canteen should choose its suppliers wisely, strictly control the quality of the raw materials received, store them properly, cut them rationally, and prepare dishes strictly from fresh raw materials (Zhang *et al.*, 2022).



Of course, the quality of meat or by-products begins to form already from the birth of a wild animal and is ensured by the impact of its lifestyle in environmental conditions. Slaughtering and cutting also have a great influence on the quality of the meat obtained (Vorobyeva *et al.*, 2018).

The most popular wild animals whose meat is most often used as food are deer, elk, roe deer, and wild pigs. These animals are fairly common in the wild, including in Europe and Asia as far south as Vietnam, and are beginning to spread worldwide, including in the United States and New Zealand. Under these circumstances, it is rightly predicted that the parasite burden on these animals will increase as their population densities increase, negatively affecting their health status and the quality of products from them. Given the trend in the spread of helminths among wild animals used for food, increased efforts are needed to provide the conditions for a clear understanding of their parasitic fauna (Inoue *et al.*, 2022). In this regard, it becomes necessary to summarize the previously conducted studies on helminths of wild animals going to humans for food with systematization and comprehension of already accumulated data.

Purpose of the work: to review aspects of the main parasitic infestations of wild ungulates used for food.

Materials and Methods

As sources of information in this work we used previously published articles on the topic of interest, contained in the most authoritative and respected indexing and citation databases. The methods of analysis and synthesis, induction and deduction, generalization, and statistical processing of data were used as methods of research in this work.

Results and Discussion

As a result of the performed research, several important facts were established. **Table 1** with the main parasitic diseases of wild animals whose meat is used in public catering is given below.

Table 1. Main parasitic diseases of deer, roe deer, elk, and wild boar (Bhat *et al.*, 2022; Chen *et al.*, 2022)

Type of infestation	Disease and causative agent
Protozoosis	Sarcocystosis (<i>Sarcocystis</i>)
	Anthrax (<i>Bacillus anthracis</i>)
	Tuberculosis (<i>Mycobacterium tuberculosis</i> complex)
	Necrobacteriosis (<i>Fusobacterium necrophorum</i>)
	Brucellosis (<i>Brucella</i>)
	Salmonellosis (<i>Salmonella typhimurium</i>)
	Pasteurellosis (<i>Pasteurella multocida</i>)
Helminthiasis	Plague (<i>Yersinia pestis</i>)
	Paramphistomatosis (<i>Paramphistomum ichikawai</i> , <i>Liorchis scotiae</i> , <i>Calicophoron calicophorum</i> , <i>Gastrothylax crumeniter</i>)
	Echinococcosis (<i>Echinococcus granulosus</i>)
	Cysticercosis (<i>Cysticercus cellulosae</i>)
	Moniesiosiosis (<i>M. expansa</i> , <i>M. benedeni</i> , <i>M. autumnalis</i> , <i>M. baeri</i>)

	Dictyocaulosis (<i>Dictyocaulus hadweni</i>)
	Trichocephalosis (<i>Trichuris trichiura</i>)
	Elaphostrongylosis (<i>Elaphostrongylus rangiferi</i>)
	Ascariidosis (<i>Ascaris lumbricoides</i>)
Entomosis	Subcutaneous gadflies (<i>Oestridae</i>)
	Lice (<i>H. suis</i>)
	Fleas (<i>Siphonaptera</i>)
	Gnus (<i>Culicidae</i> , <i>Simuliidae</i> , <i>Tabanidae</i>)
Arachnozoosis	Demodecosis (<i>D.phylloides</i>)
	Sarcoptosis (<i>Sarcoptes scabiei</i>)

It has become clear that a number of wild ungulates may act as reservoirs of universal parasites that can be transmitted to livestock (White *et al.*, 2018; Winter *et al.*, 2018). Additionally, there has been prior research suggesting that the systems involved in the transmission of parasites from wild to domestic animals may be impacted by climate change. For instance, the roe deer's (*Capreolus capreolus*) increased population and habitat alterations have had a significant impact. With the gradual warming of grazing seasons and as they become wetter, there has been a marked increase in the incidence of livestock infections during interactions with infected wildlife (Wang *et al.*, 2021).

It is firmly established that wild ruminants are capable of infecting livestock with their nematodes. They transmit worms carrying alleles that determine susceptibility or resistance to antihelminthic drugs (Barone *et al.*, 2020).

The population of infected animals on shared pastures where they share resources affects the probability of parasite cross-transmission between various host species (Winter *et al.*, 2018). Disparities in parasite fecundity rates between various host species have been noted, and certain parasites are known to more actively infect hosts that are closely related (Laca Megyesi *et al.*, 2020).

Helminths are the most common parasites of wild ungulates, which can significantly complicate growth processes, contribute to high mortality, and impede reproduction. The effects of helminths on these processes still need to be clarified. Clarification of these issues is necessary because juveniles are often highly infected, and mortality in juveniles is an important mechanism of natural regulation of wild populations (Acerini *et al.*, 2022).

The ability of parasites to develop and survive in the free-living stages is also biologically highly significant, as this stage is key in the transmission process. In a study on the ecology of free-living stages of *Strongyloides* in cattle, it was found that at the end of the grazing season, large numbers of larvae remain in the feces, but the presence of rainfall may stimulate larvae to migrate to the pasture. As a result, parasites ingested from pasture have striking seasonal differences in infectivity and are highly sensitive to climate change and land use processes (Pryadko, 1976).

Nematodes are well adapted to their habitat conditions. The sensitivity of the free-living stages in their different species can vary greatly depending on the available temperature and humidity level of the environment. The infective larvae of *Ostertagia* spp. and *Trichostrongylus* spp. are generally adapted to cold and can overwinter on pasture if the animal does not ingest them during the

first year. At the same time, *H. contortus* is very sensitive to temperatures below 3°C, although this species is distributed throughout the subarctic region. The overwintering tactics of various parasite species influence the possibility of these nematodes spreading from domestic hosts to wildlife (Morgan *et al.*, 2004).

The study of gastrointestinal parasitic infestation of wild ungulates with helminths, conducted during the post-grazing period (from November to May) in 2018-2019 in the Hirpora Wildlife Sanctuary (HWLS) on fresh fecal samples of musk deer *Moschus* spp. and markhor *Capra falconeri*, made it possible to assess the species composition of gastrointestinal helminths and their number in these animals. The seven most common helminths were recorded: *Haemonchus* spp. (44.7%), *Nematodirus* spp. (40.0%), *Trichostrongylus* spp. (37.6%), *Strongyloides* spp. (34.1%) *Trichostrongylus* spp. (28.2) *Moniezia* spp. (23.5%) and *Fasciola* spp. (20.0%). The mean number of their eggs per gram of feces had significant differences in both species of wild ungulates. In both hosts, *Haemonchus* spp. had the highest value, and *Fasciola* spp. the lowest (Bhat *et al.*, 2022).

Wild ruminants act as reservoirs for various nematodes and play a key role in shaping the spatial distribution of nematode communities across an area. In Europe, red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) are frequent hosts of trypanosomes of elk (*Alces alces*). As thermosensitive ungulates, moose are particularly vulnerable to the effects of climate change and the associated increase in parasite pressure. Molecular analysis revealed the presence of Megatrypanum trypanosomes in almost half of the moose studied in Europe. As moose populations in Central Europe have recently been increasing, it is crucial to monitor their parasite infestation (Filip-Hutsch *et al.*, 2022).

Blastocystis sp., belonging to the Stramenopiles type, is a common unicellular intestinal parasite of wild ungulates. Generally, *Blastocystis* sp. is transmitted by the fecal-oral route, which is the primary mode of transmission. Humans have been found to be susceptible to zoonotic *Blastocystis* sp. Epidemiological studies estimate that this parasite has colonized up to two billion people worldwide. However, the pathogenicity of *Blastocystis* sp. is still uncertain, although some studies have demonstrated a possible association of the parasite with the occurrence of gastrointestinal disorders, including irritable bowel syndrome and various inflammatory bowel diseases. At the same time, other studies have shown that *Blastocystis* sp. should be considered a common commensal organism in the human intestine under conditions of increased diversity of intestinal microbiota (Ni *et al.*, 2023).

Based on analysis of the small subunit (SSU) rRNA gene of *Blastocystis* sp. at least 28 subtypes (ST1-ST17, ST21, ST23-ST32) have been confirmed in humans and various animals worldwide. Among them, ST1ST9 and ST12 are known to infect humans, while ST1ST4 accounts for more than 90% of human *Blastocystis* sp. infections. The prevalence of different subtypes appears to vary widely in many regions of the planet, and different subtypes show very different levels of pathogenicity, drug resistance, and impact on the microbiota (Chen *et al.*, 2022).

Echinococcus granulosus is a solitary that relies on a predator-prey relationship between its definitive host (wolf, *Canis lupus*) and its intermediate host (elk, *Alces alces*) to complete its life cycle. This is based on the fact that severe *E. granulosus* infection may predispose elk to generalized debilitation and increased predation risk from wolves (Bangoura & Bardsley, 2020).

Onchocerca cervipedis is a filarial worm nematode very common in North and Central America. It parasitizes and ungulates mainly under the skin of the feet from the tibia-tarsal joint to the hoof and is therefore called "footworm". Flies are intermediate hosts and transmit the larvae to ungulates by sucking their blood. The presence of *O. cervipedis* rarely causes clinical signs, but massive infection can cause swelling and damage to the legs, which increases susceptibility to predation (Côté *et al.*, 2004).

Eimeria infections are commonly observed in a variety of mammals. This genus of unicellular sporozoan parasites sometimes causes serious disease (coccidiosis) in various ungulate species in the wild. In case of contact, the parasite can be transmitted to farm animals: cattle, sheep, and goats, severely reducing their productivity (Al-Neama *et al.*, 2021; Ashraf *et al.*, 2022).

Elaphostrongylus rangiferi is a parasitic nematode specific to the reindeer (*Rangifer tarandus*), which is found in Russia in the Murmansk region, Yamalo-Nenets Autonomous Okrug, and now in the Leningrad region. The helminth's complete life cycle requires the participation of intermediate hosts, which are terrestrial or freshwater gastropod mollusks. Other wild animals, including captive and productive animals, can also become the final hosts for this parasite (Pryadko, 1976). The source of infection with the larvae of the parasite is infected animals moving freely in the territory during their capture, lease, and resale, as well as collection and sale of their manure not disinfected. Very important for the survival of the parasite is the ability of the larvae to remain viable in feces and infected shellfish for about 2 years with freeze-drying and desiccation. Its biological hazard is associated with high lethality among infected nonspecific hosts due to the development of parasitic encephalomyelitis and pneumonia due to the lack of developed specific treatment (Loginova *et al.*, 2022).

The relationship between humans, wildlife, and disease transmission can be complex and dependent on many factors, and disease dynamics can fluctuate widely. Ecological knowledge of parasite species circulating in nature, together with public health data, forms information that must be considered in epidemiological surveillance (Estavillo *et al.*, 2022). All this requires a balanced assessment of the summarized evidence and the continuation of further research based on it.

Conclusion

Parasitic diseases of wild ungulates are significant for humans, as they consume meat from a number of these animals. In addition, parasite infestation of productive animals from wild animals also significantly increases the risk of parasite infection in humans. Each type of meat especially wild animals, requires careful attention in the conditions of all stages of production, starting from

ensuring optimal living conditions for the animal, if necessary, its treatment, competent slaughter, cutting, transportation, and preparation. In this regard, it becomes necessary to summarize the previously conducted studies on helminths of wild animals, the meat of which is used by humans for food with systematization and comprehension of the accumulated data.

Acknowledgments: The team of authors thanks the administration of the Russian State Social University for the opportunity to research its basis.

Conflict of interest: None

Financial support: None

Ethics statement: The study was approved by the local ethics committee of the Russian State Social University on September 15, 2018 (protocol №11).

References

- Acerini, C. I., Morris, S., Morris, A., Kenyon, F., Mc Bean, D., Pemberton, J. M., & Albury, G. F. (2022). Helminth parasites reduce the probability of survival in young red Deer. *Parasitology*, *149*(13), 1702-1708. doi:10.1017/S0031182022001111
- Al-Neama, R. T., Bown, K. J., Blake, D. P., & Birtles, R. J. (2021). Determinants of eimeria and campylobacter infection dynamics in UK domestic sheep: The role of confection. *Parasitology*, *148*(5), 623-629.
- Ashraf, A., Trambo, S. R., Maqbool, I., Allaie, I. M., Bulbul, K. H., Shahardar, R. A., Wani, Z. A., & Sheikh, F. D. (2022). Occurrence of GI parasites in ruminants of Kashmir and Ladakh. *Journal of Parasitic Diseases*, *46*(1), 196-201.
- Bangoura, B., & Bardsley, K. D. (2020). Ruminant coccidiosis. *Veterinary Clinics: Food Animal Practice*, *36*(1), 187-203.
- Barone, C. D., Wit, J., Hoberg, E. P., Gilleard, J. S., & Zarlenga, D. S. (2020). Wild ruminants as reservoirs of domestic livestock gastrointestinal nematodes. *Vet Parasitol*, *279*(10), 109041.
- Bhat, R. A., Tak, H., Bhat, B. A., Dar, J. A., & Ahmad, R. (2022). Gastrointestinal helminth parasites of wild ungulates in hirpora wildlife sanctuary, Kashmir, India. *Journal of Parasitic Diseases*, *46*(3), 804-810. doi:10.1007/s12639-022-01493-3
- Chen, S., Meng, W., Shi, X., Chai, Y., Zhou, Z., Liu, H., Zhong, Z., Fu, H., Cao, S., Ma, X., et al. (2022). Occurrence, genetic diversity and zoonotic potential of blastocystis sp. in forest musk Deer (*moschus berezovskii*) in Southwest China. *Parasite*, *29*(6 Pt B), 34.
- Côté, S. D., Rooney, T. P., Tremblay, J. P., Dussault, C., & Waller, D. M. (2004). Ecological impacts of deer overabundance. *Annual Review of Ecology, Evolution, and Systematics*, *35*, 113-147.
- Estavillo, C., Weyland, F., & Herrera, L. (2022). Zoonotic disease risk and life-history traits: Are reservoirs fast life species? *EcoHealth*, *19*(3), 390-401.
- Filip-Hutsch, K., Świsłocka, M., Karbowski, G., Myczka, A. W., Demiaszkiewicz, A. W., & Werszko, J. (2022). Molecular identification of *Trypanosoma theileri* complex in Eurasian moose *Alces alces* (L.). *International Journal for Parasitology: Parasites and Wildlife*, *19*, 317-322. doi:10.1016/j.ijppaw.2022.11.008
- Inoue, K., Shishida, K., Kawarai, S., Takeda, S., Minami, M., & Taira, K. (2022). Helminthes detected from wild Sika Deer (*Cervus nippon centralis*) in Kanto-Chubu region, Japan. *Parasitology International*, *87*, 102485. doi:10.1016/j.parint.2021.102485
- Karpov, V. Yu., Zavalishina, S. Yu., Komarov, M. N., & Koziaikov, R. V. (2020). The potential of health tourism regarding stimulation of functional capabilities of the cardiovascular system. *Bioscience Biotechnology Research Communications*, *13*(1), 156-159. doi:10.21786/bbrc/13.1/28
- Kulikov, E. V., Zavalishina, S. Y., Vatnikov, Y. A., Seleznev, S. B., Parshina, V. I., Voronina, Y. Y., Popova, I. A., Bondareva, I. V., Petrukhina, O. A., Troshina, N. I., et al. (2020). The effects of meldonium on microrheological abnormalities of erythrocytes in rats with obesity: An experimental study. *Bali Medical Journal*, *9*(2), 444-450. doi:10.15562/bmj.v9i2.1150
- Laca Megyesi, Š., Königová, A., Babják, M., Molnár, L., Rajský, M., Szestáková, E., Major, P., Soroka, J., Urda Dolinská, M., Komáromyová, M., et al. (2020). Wild ruminants as a potential risk factor for transmission of drug resistance in the abomasal nematode *haemonchus contortus*. *European Journal of Wildlife Research*, *66*, 1-6.
- Loginova, O. A., Belova, L. M., & Spiridonov, S. E. (2022). The first report on *elaphostrongylus rangiferi* (Reindeer invasive parasite) in Leningrad oblast. *Russian Journal of Biological Invasions*, *13*(2), 232-244.
- Morgan, E. R., Milner-Gulland, E. J., Torgerson, P. R., & Medley, G. F. (2004). Ruminating on complexity: macroparasites of wildlife and livestock. *Trends in Ecology & Evolution*, *19*(4), 181-188.
- Ni, F., Yu, F., Yang, X., An, Z., Ge, Y., Liu, X., & Qi, M. (2023). Identification and genetic characterization of blastocystis subtypes in Père David's deer (*elaphurus davidianus*) from Shishou, China. *Veterinary Research Communications*, *47*(1), 259-264. doi:10.1007/s11259-022-09905-8
- Pryadko, E. I. (1976). *Helminths of Deer*. Alma-Ata: Publishing House of Science of Kazakh SSR, p. 224.
- Solovyova, L. P., Kalysh, T. V., Voevodina, Y. A., & Zamuravkin, V. I. (2020). Restoring the functional state of the hemostasis system in piglets experiencing an episode of transportation. In *BIO Web of Conferences* (Vol. 17, p. 00164). EDP Sciences. doi:10.1051/bioconf/20201700164
- Tkacheva, E. (2023). Physiological features of hematological parameters of sows during suckling, kept in the ecological conditions of central Russia. In *E3S Web of Conferences* (Vol. 420, p. 02008). EDP Sciences. doi:10.1051/e3sconf/202342002008
- Tkacheva, E. S., & Zavalishina, S. Yu. (2018a). Physiological aspects of platelet aggregation in piglets of milk nutrition.

- Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 9(5), 74-80.
- Tkacheva, E. S., & Zavalishina, S. Yu. (2018b). Physiology of platelet hemostasis in piglets during the phase of newborns. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 9(5), 1912-1918.
- Usha, B. V., Zavalishina, S. Y., Vatnikov, Y. A., Kulikov, E. V., Kuznetsov, V. I., Sturov, N. V., Kochneva, M. V., Poddubsky, A. A., Petryaeva, A. V., & Glagoleva, T. I. (2019). Diagnostics of early dysfunctions of anticoagulant and fibrinolytic features of rats' vessels in the course of metabolic syndrome formation with the help of fructose model. *Bali Medical Journal*, 8(1), 201-205. doi:10.15562/bmj.v8i1.923
- Vorobyeva, N. V., Mal, G. S., Zavalishina, S. Yu., Glagoleva, T. I., & Fayzullina, I. I. (2018). Influence of physical exercise on the activity of brain processes. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 9(6), 240-244.
- Wang, T., Redman, E. M., Morosetti, A., Chen, R., Kulle, S., Morden, N., McFarland, C., Vineer, H. R., Colwell, D. D., Morgan, E. R., et al. (2021). Seasonal epidemiology of gastrointestinal nematodes of cattle in the northern continental climate zone of western Canada as revealed by internal transcribed spacer-2 ribosomal DNA nemabiome barcoding. *Parasites & Vectors*, 14(1), 1-13.
- White, L. A., Forester, J. D., & Craft, M. E. (2018). Dynamic, spatial models of parasite transmission in wildlife: Their structure, applications and remaining challenges. *Journal of Animal Ecology*, 87(3), 559-580.
- Winter, J., Rehbein, S., & Joachim, A. (2018). Transmission of helminths between species of ruminants in Austria appears more likely to occur than generally assumed. *Frontiers in Veterinary Science*, 5, 30.
- Zavalishina, S. Y. (2020a). Physiological characteristics of cattle of different ages. IOP conference series: Earth and environmental science. *Biological Technologies in Agriculture: From Molecules to Ecosystems*, 548(4), 042066.
- Zavalishina, S. Y. (2020c). Functional properties of platelets in piglets when changing methods of nutrition. In *BIO Web of Conferences* (Vol. 17, p. 00171). EDP Sciences. doi:10.1051/bioconf/20201700171
- Zavalishina, S. Yu. (2020b). Functional features of Hemostasis in weakened newborncalves treated with Aminosol. *Bioscience Biotechnology Research Communications*, 13(3), 1251-1256. doi:10.21786/bbrc/13.3/41
- Zhang, P., Zhang, Q., Han, S., Yuan, G., Bai, J., & He, H. (2022). Occurrence and genetic diversity of the zoonotic enteric protozoans and *enterocytozoon bienzeusi* in père David's deer (*elaphurus davidianus*) from Beijing, China. *Pathogens (Basel, Switzerland)*, 11(11), 1223.