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Main Parasitic Infestations of Wild Ungulates Used for Food

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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 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).

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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 (Sarcocystis) Anthrax (Bacillus anthracis) Tuberculosis (Mycobacterium tuberculosis complex) Necrobacteriosis (Fusobacterium necrophorum) Brucellosis (Brucella) Salmonellosis (Salmonella typhimurium) Pasteurellosis (Pasteurella multocida) Plague (Yersinia pestis)
Helminthiasis	Paramphistomatosis (Paramphistomum ichikawai, Liorchis scotiae, Calicophoron calicophorum, Gastrothylax crumeniter) Echinococcosis (Echinococcus granulosus) Cysticercosis (Cysticercus cellulosae) Moniesiosiosis (M. expansa, M. benedeni, M. autumnalis, M. baeri) Dictyocaulosis (Dictyocaulus hadweni) Trichocephalosis (Trichuris trichiura) Elaphostrongylosis (Elaphostrongylus rang**iferi)** Ascaridosis (Ascaris lumbricoides)
Entomosis	Subcutaneous gadflies (Oestridae) Lice (H. suis) Fleas (Siphonaptera) Gnus (Culicidae, Simuliidae, Tabanidae)
Arachnozoosis	Demodecosis (D.phylloides) Sarcoptosis (Sarcoptes scabiei)

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 3ºC, 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 *Caprafalconeri*, 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%), *Trichuris* 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 solitaire that relies on a predator-prey relationship between its definitive host (wolf, *Canislupus*) and its intermediate host (elk, *Alcesalces*) 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.

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