Epizootology of nematodoses of the digestive tract of sheep

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Abstract. Systematic analysis, statistical review of literature data from domestic and foreign sources on the topic of parasitic diseases and their importance worldwide were used in the work. The search was carried out in eLibrary, Cyberleninka, PubMed, IPD immunologic database and on the ResearchGate website according to the developed strategy, taking into account the inclusion and non-inclusion criteria. The depth of the search was 53 years. The study of literature data revealed that sheep parasitoses have a wide ubiquitous distribution and are a serious problem for agriculture. According to the results of careful study of literature data it was revealed that in the territory of the Russian Federation and in other countries of the world the most widespread nematodoses of the digestive tract of sheep are haemonchosis, ostertagiosis and nematodirosis. Depending on the season of the year, geographical area and age of the animal, the intensity of infestation with haemonchosis ranges from 28,0 to 70.0 %, nematodirosis 2.2 – 48.2 %, ostertagiosis 16.0 - 82.7 %.

1 Introduction

With each new year, the population of our planet continues to grow at a rate of more than 1% per year [1]. In fact, the planet's natural resources are beginning to decrease, while the population's need for food is growing, the provision of which has become an urgent problem in almost all countries of the world. According to statistics, by 2030 it is expected that as the world population increases, the consumption of animal protein, i.e. meat, will increase by 14% compared to previous years. For example, beef production is expected to increase by almost 6% in order to meet the population's demand for meat [2].

In the world there are many factors that reduce the adequate production of mutton, beef, chicken, etc., among which parasitic infections occupy a significant place. Parasitoses lead to a decrease in total body weight, milk and milk products, digestive disorders, which causes changes in the hepatobiliary system, death of young animals, and sometimes even death of adult animals [3-4].

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Among the great variety of parasites are gastrointestinal nematodes, whose parasitism causes various changes in organs and tissues, causing significant damage to the animal organism and agriculture. This group of parasites is referred to as strongylatoses of animals. To date, many control programmes have been developed, various chemotherapeutic drugs continue to be introduced [5], animal breeds genetically resistant to parasitosis are being developed [6], and immunobiological drugs are being attempted [7]. Methods of controlling animal nematodes are changing over time. This is due to various factors: resistance of parasites to chemotherapeutic drugs; complex immunological interactions occurring during parasitisation; climatic and geographical conditions; anthropogenic influence, and others.

2 Materials and methods

Systematic analysis and statistical review of literature data from domestic and foreign sources were used. The search was carried out in eLibrary, Cyberleninka, PubMed, IPD immunological database and on the ResearchGate website according to the developed strategy, taking into account the inclusion and non-inclusion criteria. The depth of the search was 53 years. The final publication list included more than 100 studies.. Try to ensure that lines are no thinner than 0.25 point.

3 Results

Strongylatoses of animals. Strongylatoses of animals are helminthic diseases of domestic and wild animals caused by parasitisation of nematodes belonging to the suborder *Strongylata* of the *Strongylidae*. Nematodes parasitising in the digestive tract of animals consist of the families *Strongylidae*, *Trichonematidae*, *Trichostrongylidae*, *Ancylostomatidae* [8]. Diseases caused by sexually mature and larval stages of nematodes of the suborder *Strongylata* parasitising organs such as the rennet, large and small intestine, and other organs and tissues are called digestive tract strongylatoses (DTS).

DTS are geohelminths. In the external environment their development is similar. Eggs that fall with faeces into the external environment, i.e. on pastures turn into first-stage larvae, where they start feeding on bacteria from faeces, after which they undergo a double moult and transform into invasive 3rd-stage larvae, which are resistant to unfavourable environmental factors. Animals are parasitised by ingesting 3rd stage larvae with water from shallow water bodies or grass. The worms complete their development to adults in the gastrointestinal tract of the definitive host in about 3 weeks [9].

In pastures, larval development depends on ambient temperature and humidity. They are more active at high temperatures. Comfortable development occurs at a relative humidity of 100% and a temperature of 22-26°C for 7 days, and longer in cold weather. Development is slow during winter but survival is prolonged. In humid tropical areas, larvae survive for only a month. At low temperatures, larvae can survive on pasture for up to 1 year, but average 2 to 6 mo. Larvae are sensitive to high temperatures, excess moisture, and drying UV radiation. In unfavourable weather conditions, parasite larvae survive by hiding in the soil or in manure. There is another survival strategy, it is that the larvae remain inside the host as "arrested larvae" (hypobiosis). Each parasitic agent has its own optimal requirements for development and survival. Because of these differences, certain parasite species will be important in different geographic regions and at different times of the year. For example, *Haemonchus*, is a heat-loving parasite, while *Ostertagia favours* cold weather more [10].

Nematode parasitism in the stomach manifests as anorexia, thickening of the mucosa, decreased production of hydrochloric acid and pepsin in the rennet, dyspepsia, recession of

plasma proteins and anaemia. Parasitic gastroenteritis, a term that refers to a complex of signs caused by nematodes of the gastrointestinal (GI) tract of animals. Parasite infestation of the intestine manifests as impaired feed absorption and transport, loss of intercellular fluid and electrolyte composition, loss of plasma protein, and malabsorption. Underdeveloped epithelial tissues lack enzymes important for digestion, which causes reduced transport of vitamin components, carbohydrates and amino acids. Dyspepsia is also in turn related to the fermentation of carbohydrates in the intestine. Unabsorbed protein is broken down to amines and indoles, resulting in a specific fecal odour [11].

3.1 The most relevant strongylatoses of the digestive tract of sheep

Virtually all grazing sheep and goats are infested with GI parasites, but due to their small numbers there is no significant impact on animal health. Subclinical and clinical manifestations occur as the infestation agent increases in numbers [12-13].

It is very rare that helminthic diseases of the GI tract are caused by only one species of parasite; they are more likely to be the combined effect of a mixed infection. However, diseases caused by a single species of parasite are quite common. Below we consider the most relevant parasitic diseases of sheep both in the Russian Federation (RF) and worldwide.

3.2 Haemonchosis of sheep

This is one of the most common parasitic diseases of sheep worldwide [14-15]. The parasite causing this disease is *Haemonchus contortus*, a nematode of the family *Trichostrongylidae*. Haemonchosis of sheep leads to decreased productivity, appetite, anaemia, diarrhoea, growth retardation of young animals, sometimes even death, which causes significant economic damage to the agro-industrial complex [16-17].

According to recent literature, haemonchosis was first discovered in wild ungulates in sub-Saharan Africa and then spread worldwide for various reasons [18]. It is mainly distributed in warm and humid areas, in tropical and subtropical countries [19], but there are reports of the disease occurring in temperate regions [16].

Some sheep are known to have immune defences against the disease and this is a heritable trait, but there are breed differences in resistance to infestation [20]. For example, resistant alleles to haemonchosis have been found in the red maasai sheep breed [21].

H. contortus is widespread in the territory of the RF. In the southern part of the country, sheep haemonchosis covers large areas, so in the Republic of Dagestan (RD) the disease occurs with different intensity [22-24]. The intensity of infestation (EI) of sheep with *H. contortus* is 28,0-36,0 %, with an infestation intensity (II) of 137±3,46 exons/head. Sheep are intensively infected in autumn-winter period. Infection of lambs at an II of 250 ewes or more leads to emaciation due to prolonged diarrhoea and blood loss. Haemonchosis almost always occurs in an associative form [25]. In the Chechen Republic (CR), the incidence of sheep haemonchosis in autumn can be 72 %, 56 % in summer, and 10-30 % in spring [26]. A rich fauna of sheep parasites is found in the Orenburg region, among which sheep haemonchosis occupies a special place. As described above, haemonchosis in the Orenburg region is also always found in mixtinvasion [27]. In the Altai Mountains, sheep haemonchosis is one of the widespread diseases. EI by nematodes of *H. contortus* is 41.5 %. Higher prevalence is noted in areas with high average annual ambient temperature and more precipitation [28].

In northern Finland, *H. contortus is* becoming a potential threat to small ruminants, which requires continuous monitoring of the disease. The nematode *H. contortus* has been

shown to cause quite severe disease in sheep. Almost 90 % of rennet nematodes are diagnosed as *H. contortus* [29].

H. contortus is one of the parasites that are under constant control in the United States of America (USA). The south and southeastern part of the central United States, with hot and humid summers with a long grazing season, is well suited for *H. contortus*. In the rest of the country and southern Canada, *H. contortus* is a common and dominant parasite of the GI strongylatosis population, capable of causing substantial economic losses. In the northern part of the United States, the spread of the parasite is slow due to unfavourable climatic conditions [30].

3.3 Ostertagiosis of sheep

The genus *Ostertagia* (Ransom, 1907) in sheep covers the following species; *Ostertagia* (Ostertagia) *ostertagi* (Stiles, 1892); O. (O.) *circumcincta* (Stadelman, 1894); *O.* (O.) *trifurcata* (Ransom, 1907); *O.* (Grosspiculagia) *trifida* (Guille, Marotel et Repiset, 1911); *O.* (G.) *occidentalis* (Ransom, 1907) [31]. It is mainly represented by the species *O. circumcincta* (Stadgelman, 1894). On the territory of the Kalmyk steppe the II of ostertagiosomiasis in sheep averages 58 specimens/head per year. At the same time, the peak occurs in April, with an II of 144 specimens/head [32]. This nematode is the most common invasive agent among all trichostrongylids recorded in small ruminants in Gorny Altai. The EI averages 52,4 %, the AI is 57,4 eq/head. [33]. In sheep farms of the CR ostertagiosis of sheep is widespread everywhere. The maximum EI was recorded at 16 % with an AI of 48,4±7,2 exv./head in lowland areas. The most common species in this area is *O. trifida* [34]. In the central strip of the RF, the infestation of sheep with Ostertagia increases in the period from October to November: AI 34.7 and 21,9 %. In sheep breeding complexes, ostertagiosis occurs in association with protostrongylosis + eimeriosis, on commercial farms with mulleriosis + eimeriosis [35].

In the Kursk region, ostertagiosis is the most common of all strongylatous agents of the GI tract in sheep. Parasitisation by ostertagia in the region is about 71,4 %. Young animals from 1 to 2 years old are mainly infected, EI is 82,7 % with AI of 321,2 %±55,48 eq/head. [36].

In the works of foreign colleagues it is described that some breeds of sheep have genetic resistance to *O. circumcincta* manifested in a decrease in the number of faecal eggs. Genetic loci are localised in the genome of the major histocompatibility complex. The results of studies on the genetic loci of parasitic disease resistance carried out on Texel sheep naturally infected with *O. circumcincta* showed that 21 haplotypes were found in this breed, with six of them occurring in less than five animals. Almost half of the haplotypes (7/15) were associated with reduced numbers of helminth eggs in faeces. The DRB1*1101 allele was present in two haplotypes (11a and 11b). Haplotype 11b was associated with a reduction in the number of helminth eggs in faeces, while haplotype 11a was not, but there is no complete refutation of the evidence for the effect of the latter [37]. Previously, Alsagher O.A. Ali's team identified 18 alleles in DRB1, 13 alleles in DQB1 and 16 alleles in DQB2 in a study in 235 Texel lambs. Also, 9 alleles in DQA1 and 8 alleles in DQA2 were amplified [38].

In another study on lambs of carriers and non-carriers of the DRB1*1101 allele, a significant advantage of the first group was found in experimental *O. circumcincta* infection. DRB1*1101 carrier lambs had significantly lower worm counts than non-carrier lambs ($P<0,05$) [39]. Scottish Blackface lambs with the DRB1*1101 major complex allele excrete fewer eggs in the faeces during natural and deliberate infection with the nematode *O. circumcincta*. In addition, these sheep have less invasion of the gastrointestinal tract by

the sexually mature form of the nematode than sheep with other alleles at the DRB1 locus [40].

3.4 Nematodirosis of sheep

A helminthic disease of sheep and other animals caused by nematodes of the genus *Nematodirus*, localised in the small intestine. The disease causes such signs as cachexia, decreased appetite, stunted growth and development. In sheep, the disease is caused by several species of nematodirus, among which the most common is *Nematodirus spathiger* [41].

Nematodirosis of sheep in the RF is one of the widespread diseases. The main reason for high infection is biological features of the helminth. Covered with a dense shell helminth eggs when getting into the environment allows them to withstand all negative factors (low and high temperature regimes, drying, exposure to sunlight, etc.).

Nematodirus parasitisation in sheep in the Altai Mountains occurs in all districts. The EI of *N. spathiger* infection is 21,2 %, with an EI of 15-171 specimens/head. The most widespread species in the Altai Mountains is *N. oiratianus* with an II of 21,2 %, with an II of 15-171 eq/head. oiratianus with an II of 38,1 % and an II of 16-128 specimens/head. [42].

According to the results of the data of O.M. Shvets and T.I. Mikhaleva, nematodiruses are widespread in Kursk region. Of 13 species of *strongyles*, nematodirus infestation is 44,3 %. Young animals aged 1 to 2 years are infected to a greater extent. The EI for this age group is 48,2 % with an II of 313,7±82,7 eq/head. [36].

In the work of Vasilevich F.I. et al. it is described that the prevalence of sheep nematodirosis is low in Kaluga region, with an EI of 2,2 %. There are no data on seasonality in this work [43].

Sheep are infected with nematodirosis in the plain zone of RD by 28,0 %, in the foothill zone by 26,4 %, in the mountain zone by 23,3 % and in the highland zone by 20,9 %. The lowest infestation is found in the mountainous zone. This establishes that nematodirosis as well as other strongylatoses in the region are distributed along the vertical belt [44].

In the foothill zone of Tajikistan, the infestation of sheep with *N. spathiger* is 38,6 % out of 300 heads examined, with an II of 60,0±6,2 eq/head [45].

In West Kazakhstan oblast, the distribution of nematodirosis varies significantly depending on the season of the year. Increase of infestation occurs from the beginning of autumn, the peak is in September, where EI is 53,7 %, in October 42,4 % and in November 34,7 %. On average, the eI is 43,6 per cent. In September, the II is up to 82,4 eq/head. [46].

3.5 Other nematodoses of the digestive tract

Helminthic diseases of the digestive tract of sheep are clearly widespread. In this case, mixed infestation is the predominant form in the intestine of sheep regardless of the season of the year. It is established that up to 20 helminths can coexist in the small and large intestine of sheep, which contributes to the development of various pathological processes in the body.

In a study conducted at a meat processing plant in the Moscow region, it was found that about 830 helminths were detected in the digestive tract of 270 sheep during slaughter, among which *H. contortus* – 46 %, *O. circumcincta* – 33 %, *T. coludriformis* – 16 % and *N. filicollis* – 15 % were predominant [47].

Strongyloides sp. (EI 80%), *Trichostrongylus sp.* (EI 40-100%), *Ostertagia ostertagi* (EI 20-100%) are among the common parasites causing GI strongylatosis in sheep in different districts of Perm krai [48].

Bunostomosis is another prominent representative of sheep gastrointestinal strongyles. Bunostomosis is practically widespread in the Caucasus. Thus, in the CR, the EI of sheep with bunostomiasis in different age groups is 13,3-20 % with an II of 46,9-192 eq/head [49]. In RD, the dominant nematode diseases of the gastrointestinal tract of sheep are haberthiasis, bunostomiasis, trichostrongylosis, haemonchosis and nematodirosis with an EI of 11,2-18,7 % with an II of 25-2540 eq/head [50]. It was found that pasture grass in different rayon territories of RD was infested with bunostome larvae from 0,8 to 5,3 %. Larval infestation of grass stands is mainly observed on unimproved lands [51].

In the steppe zone of Transbaikalia, nematodes of the *Strongylata* order are the most widespread, including *Ostertagia*, *Trichocephalus* and *Cooperia*. *Butostomum, Esophagostomum* and *Habertia* are the least widespread [52].

In studies conducted at slaughterhouses in the western region of Azerbaijan, it was found that *esophagostomum*, *bunostomum* and *nematodirus* are frequent parasites of the digestive tract of sheep in this country. According to the results of sheep autopsies, up to 56 bunostomes, 80 esophagostomes and 106 nematodiruses were found [53].

4 Discussion

In the process of studying the prevalence of strongylatoses of the gastrointestinal tract of small ruminants it was revealed that such diseases as haemonchosis, ostertagiosis and nematodirosis of sheep are especially relevant among them. Sheep haemonchosis is considered to be the most widespread and economically significant among them. Practically all strongylatoses of sheep prefer warm climatic conditions, except for ostertagiosis, which can develop in cold conditions. The widespread distribution of strongylatosis in sheep is associated with climatic and geographical peculiarities, biology of the pathogen, resistance of the organism, anthropogenic factor, resistance of parasites to chemotherapeutic drugs and complex immunological links between the parasite and the host.

5 Conclusion

The wide spread of sheep parasitoses remains an urgent problem for agriculture. Development and improvement of methods of their control remains an open question. Research in breeding of sheep breeds resistant to parasitosis is gaining broad momentum. The study of allelofond on different loci of the gene of the main histocompatibility complex will allow to define genetic features of sheep. The knowledge of these indicators will further allow to determine the resistance of different breeds to unfavourable environmental factors. Therefore, carrying out selection work to obtain sheep resistant to parasitosis is a promising direction.

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