Prevalence of gastrointestinal helminths in ruminants in Ukraine: a 5-year meta-analysis

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Introduction

Despite preventive measures, gastrointestinal helminthiases of ruminants are widespread. Stable parasitocenoses of helminths (gastrointestinal strongylates, fascioles, dicrocelias, cestodes and protozoa) are formed in the body of cattle. An analysis of publications over the past five years confirms the circulation of pathogens in the world (Akca et al., 2014; Jones et al., 2017; Karshima et al., 2018; Squire et al., 2018; Scala et al., 2019). Fascioliasis is the most common disease caused by trematodes of cattle, sheep and goats. Its pathogens are Fasciola hepatica L., 1758 and F. gigantica Cobbold, 1855. However, according to some researchers, in nature there are not only the above species, but also their hybrids (Amer et al., 2016; Aghayan et al., 2019). Fasciola spp., according to publications, are found on five continents of the globe, in more than 50 countries (Mehmood et al., 2017). In particular, Fasciola is common in Iran. There, the prevalence of fascioliasis did not exceed 9.1% in cattle, 4.2% in sheep and 3.1% in goats, respectively (Khademvatana et al., 2019). Another team of scientists conducted a meta-analysis of this disease, finding the incidence to be 21.0% in cattle, 2.4% in sheep and 2.0% in goats (Soosan et al., 2020). The highest rates of Fasciola spp. infection, 10.8%, is reported in slaughter animals of the province of Gilan (Ghanimatdan et al., 2019). Recent molecular genetic studies have not found any hybrid forms of Fasciola in southeastern Iran (Minaei et al., 2018).

Yuan et al. (2015) conducted research on Fasciola in China. The authors indicate that fascioliasis in goats is widespread at the level of 3.5% to 37.0%, with the average number of eggs in 1 g of feces EPG = 29.0–166.0. At the same time, the prevalence in cattle ranged from 13.3% to 46.2% with average EPG = 36.4–100.0. In Europe, including the Russian Federation, fascioliasis infection has also been reported among ruminants (Hernerra et al., 2009; Kuerpick et al., 2012; Beesley et al., 2018). A sharp decrease to 2.2% is found in the prevalence of trematodes in cattle, in particular in Tyumen region (Siben et al., 2018). Some scientific reports suggest that among cattle, Fasciola spp. are recorded less often in sheep and goats (Abdulhakim & Addis, 2012; Abdolali et al., 2016; Pinila et al., 2020). According to other studies, fascioliasis is more common in sheep and goats (Huklaeva, 2009; Gazimagomedov & Ataev, 2011; Taye et al., 2016; Pinila Lein et al., 2019). Fascioliasis has been shown to cause significant economic damage to livestock farms (Jaja et al., 2017; Arabi et al., 2018; Amin-Pacheco, 2020). Global livestock losses caused by fascioliasis are more than $3 billion per year (Rinaldi et al., 2015; Elelu & Eiser, 2017; Mehmood et al., 2017).

Numerous publications have confirmed the presence of zoonotic foci of another dangerous trematode disease in the world, namely dicroceliosis (Majidi-Rad et al., 2018; Shamsi et al., 2020). To date, three pathogens are known: Dicrocoelium dendriticum (Rudolphi, 1819), D. hoesep (Looss, 1907) and D. chinesis (Sudnikov and Ryjikov, 1951) (Maurelli et al., 2019).

Keywords: cattle; sheep; goats; Trematoda; Cestoda; Nematoda.

The production of environmentally friendly livestock products is currently receiving much attention, especially in the European Union. The problem of monitoring the quality and safety of meat and milk in modern conditions is relevant not only for Ukraine but also for the world community. The scientific substantiation of the methods of research on meat for sale subject to invasive diseases is especially important, as the product may pose risks to the consumer. One of the criteria for assessing the welfare of a herd is the prevalence of helminthiases in cattle. Ruminant parasites in Ukraine have always been and remain a separate, often significant, problem for veterinary specialists. The prevalence of three species of flukes has been confirmed in ruminants: Fasciola hepatica, Dicrocoelium dendriticum and Paramphistomum cervi. Parasitization by those species negatively affects the profitability of dairy farming. Trematodes cause significant economic losses: reduced milk productivity of cows, reduced live weight gain of young animals, negative impact on reproduction. At the same time, fascioliasis is socially significant and dangerous to humans. According to the analyzed literature sources, two types of cestodes have been registered in Ukraine: Moniezia benedeni and M. expansa. The epizootic situation regarding nematodes is just as fraught. That is the most numerous group of helminths, their fauna is represented by the following species: Strongylodes papillosus, Nematodurus spathiger, Bunostomum spp., Oesophagostomum radiatum, Haemonchus contortus, Trichostrongylus colubriformis, T. ovis and T. globulosa. It is proven that in cattle parasitocenoses are recorded more often than monoinvasions. The highest rates of prevalence of infection were observed when polynionvasions included gastrointestinal strongylates, liver flukes, paramphistomas, dicrocelia. They are recorded in monoinvasions or mixed invasions. Ruminants, according to helminthological examination in different climatic zones, are constantly infested with trematodes. In Ukraine, the presence of three species of flukes has been confirmed in ruminants: Fasciola hepatica, Dicrocoelium dendriticum and Paramphistomum cervi. Parasitization by those species negatively affects the profitability of dairy farming. Trematodes cause significant economic losses: reduced milk productivity of cows, reduced live weight gain of young animals, negative impact on reproduction. At the same time, fascioliasis is socially significant and dangerous to humans. According to the analyzed literature sources, two types of cestodes have been registered in Ukraine: Moniezia benedeni and M. expansa. The epizootic situation regarding nematodes is just as fraught. That is the most numerous group of helminths, their fauna is represented by the following species: Strongylodes papillosus, Nematodurus spathiger, Bunostomum spp., Oesophagostomum radiatum, Haemonchus contortus, Trichostrongylus colubriformis, T. ovis and T. globulosa. It is proven that in cattle parasitocenoses are recorded more often than monoinvasions. The highest rates of prevalence of infection were observed when polynionvasions included gastrointestinal strongylates, liver flukes, paramphistomas, dicrocelia. They are recorded in monoinvasions or mixed invasions. Ruminants, according to helminthological examination in different climatic zones, are constantly infested with trematodes.
2007; Ottorino et al., 2007; Gorjipoor et al., 2013). There are scientific reports of the spread of Dicrocoelium spp. in cattle in Nigeria (Ehlu & Eisler, 2017) and Algeria (Choug et al., 2019). In cattle, sheep and goats on farms in Iran, Dicrocoelium infection has also been recorded (Arabhi et al., 2011; Khamjavi et al., 2014; Mohammadzeid et al., 2016; Majidi-Rad et al., 2018). Dicrocoelium dendriticum has been recorded in Saudi Arabia, for example, the prevalence was 0.5% in imported sheep (Albegnani et al., 2015). In Sardinia, D. dendriticum was found on average in 25.5% of animals on sheep farms (Scala et al., 2019). Dicroceliasis has been observed in the Russian Federation, the rate of prevalence in cattle ranging from 0.1% to 20.6% (Shmakova, 2019).

The problem of Paramphistomum infections of animals is not new and has been studied for a long time (Hanna et al., 1988, Huson et al., 2017). Scientists have identified more than 70 species from the superfamilys Paramphistomoidea in ruminants globally (Sangunia et al., 2016; Ali et al., 2018; Kahl et al., 2021). Thus, according to researchers, three species have been registered in Uttarakhand, India: Paramphistomum cervi, Gastrothyax crumenifer and Fischheiderius elongatus (Mitra et al., 2014). Also, Chaudhury et al. (2014) confirmed the parasitism of Paramphistomum cervi in sheep in the state of Gujarat, western India. Cologna et al. (2011) have described the establishment rates of prevalence in sheep 16.3% and goats 13.6% (Godara et al., 2014). Calicophorus daubneyi is found in cattle and sheep kept in Wales, Western Europe (Jones et al., 2017). In Ethiopia, bovine helminthiasis was diagnosed, on average, in 51.8% of slaughtered animals (Ayalve et al., 2016). According to researchers, 30.0% of cattle were affected by Paramphistomum spp. in Bangladesh (Ahmed et al., 2015). At the same time, quite high rates of infection were recorded in goats (~73.0%). Polynomials were made up by different species of amphistomes (Paramphistomum cervi, Cotylophorum cotylophorum and Gastrothyax crumenifer), were found in 60.0% of goats (Uddin et al., 2006). In Iran, the following species were found in cattle: Paramphistomum cervi (33.3%), Cotylophorum cotylophorum (19.5%), Gastrothyax crumenifer (5.9%) and Carmyerius spatiosus (2.7%) (Hajipour et al., 2021). The overall prevalence among domesticated animals did not exceed 9.7%. Also, cattle were found to be more prone to paramphistomosis than sheep and goats. Similar results were obtained by scientists from Ireland. According to their research, cattle have a higher risk of paramphistomosis than sheep and goats (Naranjo-Lucena et al., 2018).

Among cestodes of ruminants, one of the most common is Moniezia. The genetic diversity of Moniezia spp. was confirmed in ruminants (Dhop et al., 2015). According to Nguyen et al. (2012), M. benedeni is more common in cattle, and M. expansa in sheep and goats. The work of other scientists also proves that M. benedeni predominate in cattle (Irie et al., 2013). The rate of prevalence of anoplocephalid cestodes was 47.4% in sheep, and only 6.2% in goats. The diseases occurred not as monoinfections. At the same time, the species composition of cestodes was determined in sheep, and only 6.2% in goats. The diseases occurred not as monoinfections, they only partially reflect the subjective estimates (Hedges & Vevea, 1998). Heterogeneity within studies was evaluated using the Cochran’s Q-test while percentage variation in prevalence estimate due to heterogeneity was quantified using the formula $\hat{F} = 100 \times (Q - df) / Q$, where Q is Chi square and df is the degree of freedom which is the number of studies minus one. According to Higgins & Thompson (2002), $\hat{F}$ values of 0, 25, 50 and 75% were considered as no, low, moderate and high heterogeneities, respectively. Representation of included studies based on effect size and CI was illustrated by forest plot diagram. Confidence intervals of 95% of the distribution of gastrointestinal helminths of ruminants were calculated in Open Source Epidemiologic Statistics for Public Health, Version 3.01, updated 20130406 (www.openepi.com).

**Results**

The existing descriptive approach to the synthesis of information in veterinary medicine currently has a major drawback—the lack of systematiz tic; descriptive reviews do not use strict scientific methods, which are usually used in the presentation of research data. As a result, such publications are difficult to reproduce, they only partially reflect the subjective opinion of their authors. Thus, of the 34 studies obtained, nineteen were removed after scanning the titles, making a detailed review of the abstract and establishing the lack of a clearly defined number of positive cases or sample sizes. A total of 15 studies were included in the meta-analysis. The process of selecting research data for the included publications and the list of excluded ones is presented in Figure 2. We analyzed the materials of articles published in 2015–2020. Mostly (n = 8) the research was conducted in the Central Ukraine (Table 1). Ten publications determined the prevalence of helminthiasis in sheep only. Four publications were devoted to the study of bovine parasitosis, only three studies were conducted on goats.
A total of 19,389 positive cases were recorded from a sample of 34,060. The biological material collected during the individual studies included faeces or helminths detected during autopsy (Fig. 2). The overall prevalence of gastrointestinal helminths was 56.7% (95% CI: 56.2–57.3). Hence, among the study regions the ruminant helminthiases are most prevalent in the central Ukraine. Polyinfections dominate over monoinfections (Table 2). Estimation of prevalence and heterogeneity. The studies included in the meta-analysis were high heterogeneous, I² = 99.8% (P < 0.001). Based on Egger’s regression test, there was no significant publication bias (P = 0.534) the forest plot diagram of current meta-analysis (Fig. 3). Most of the analyzed work is devoted to animal diseases in Central Ukraine. The studies are descriptive and not generalized in systematic reviews and meta-analyses. The black boxes sizes are proportional to the study weight, with the lines indicating 95% confidence intervals (CIs).

Table 1
Summary of the main characteristics of included studies in the meta-analysis

<table>
<thead>
<tr>
<th>Source of literature</th>
<th>Region</th>
<th>Host</th>
<th>Method of diagnosis</th>
<th>Sample size</th>
<th>Cases</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ayan et al. (2019)</td>
<td>–</td>
<td>sheep</td>
<td>microscopy</td>
<td>156</td>
<td>69</td>
<td>44.2</td>
</tr>
<tr>
<td>Bohach et al. (2015)</td>
<td>South</td>
<td>sheep</td>
<td>microscopy</td>
<td>520</td>
<td>197</td>
<td>37.9</td>
</tr>
<tr>
<td>Boyko et al. (2016)</td>
<td>Central</td>
<td>sheep</td>
<td>microscopy</td>
<td>98</td>
<td>98</td>
<td>100.0</td>
</tr>
<tr>
<td>Korchan (2015)</td>
<td>Central</td>
<td>goats</td>
<td>microscopy post mortem</td>
<td>1253</td>
<td>293</td>
<td>23.4</td>
</tr>
<tr>
<td>Korchan et al. (2015)</td>
<td>Central, East South</td>
<td>goats</td>
<td>microscopy</td>
<td>2200</td>
<td>772</td>
<td>33.7</td>
</tr>
<tr>
<td>Kruchynenko et al. (2020a)</td>
<td>Central</td>
<td>cattle, sheep, goats</td>
<td>post mortem</td>
<td>832</td>
<td>222</td>
<td>26.6</td>
</tr>
<tr>
<td>Kruchynenko et al. (2020b)</td>
<td>Central</td>
<td>cattle</td>
<td>microscopy post mortem</td>
<td>6660</td>
<td>5791</td>
<td>86.9</td>
</tr>
<tr>
<td>Melnychuk &amp; Stepniuk (2016)</td>
<td>Central</td>
<td>sheep</td>
<td>post mortem</td>
<td>760</td>
<td>415</td>
<td>54.6</td>
</tr>
<tr>
<td>Melnychuk (2019)</td>
<td>South</td>
<td>sheep</td>
<td>post mortem</td>
<td>214</td>
<td>142</td>
<td>66.3</td>
</tr>
<tr>
<td>Melnychuk et al. (2019)</td>
<td>Central, South-Eastern</td>
<td>sheep</td>
<td>microscopy post mortem</td>
<td>9787</td>
<td>4494</td>
<td>45.9</td>
</tr>
<tr>
<td>Piven &amp; Bogach (2016)</td>
<td>South</td>
<td>sheep</td>
<td>microscopy</td>
<td>8151</td>
<td>5593</td>
<td>68.6</td>
</tr>
<tr>
<td>Soroka (2020)</td>
<td>North</td>
<td>sheep</td>
<td>microscopy</td>
<td>258</td>
<td>92</td>
<td>35.7</td>
</tr>
<tr>
<td>Soroka et al. (2015)</td>
<td>South</td>
<td>cattle</td>
<td>microscopy post mortem</td>
<td>1701</td>
<td>204</td>
<td>11.9</td>
</tr>
<tr>
<td>Soroka et al. (2017)</td>
<td>North</td>
<td>cattle</td>
<td>microscopy</td>
<td>770</td>
<td>442</td>
<td>57.4</td>
</tr>
<tr>
<td>Overall</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>34160</td>
<td>19389</td>
<td>56.7</td>
</tr>
</tbody>
</table>

Table 2
Pooled prevalence estimates and distribution of helminths species according to class of parasites

<table>
<thead>
<tr>
<th>Group</th>
<th>Parasite species</th>
<th>Number of studies</th>
<th>Sample size</th>
<th>Cases</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trematodes</td>
<td>Fasciola hepatica Linnaeus, 1758</td>
<td>2</td>
<td>6796</td>
<td>673</td>
<td>9.2–10.7</td>
</tr>
<tr>
<td></td>
<td>Dicrocoelium dendriticum (Rudolphi, 1819)</td>
<td>5</td>
<td>10602</td>
<td>2010</td>
<td>18.2–19.7</td>
</tr>
<tr>
<td></td>
<td>Paragonimustomum spp. (Fischschoeder, 1901)</td>
<td>1</td>
<td>6660</td>
<td>1034</td>
<td>14.7–16.4</td>
</tr>
<tr>
<td>Cestodes</td>
<td>Moniezia spp.</td>
<td>2</td>
<td>8384</td>
<td>5641</td>
<td>66.3–68.3</td>
</tr>
<tr>
<td>Nematodes</td>
<td>Strongyloides papillosus (Waid, 1856)</td>
<td>1</td>
<td>98</td>
<td>98</td>
<td>96.2–100.0</td>
</tr>
<tr>
<td></td>
<td>Strongylidae: Bunostomum, Oesophagostomum, Nematodirus, Chabertia, Cooperia, Trichostrengulus, Osterotoga, Haemonchus</td>
<td>7</td>
<td>19287</td>
<td>12047</td>
<td>61.8–63.1</td>
</tr>
<tr>
<td></td>
<td>Trichuris spp.</td>
<td>2</td>
<td>3607</td>
<td>811</td>
<td>21.1–23.9</td>
</tr>
</tbody>
</table>

Note: for helminths of the order Strongylida, genera are given.
Paramphistomum infection (Piven & Bogach, 2016) is also recorded in Odesa region. Fascioliasis in sheep as a part of mixed highly heterogenous, I² = 99.9% (P < 0.001). Karshima et al. (2018) found 56.2–57.3). In our work, the studies included in the meta-analysis were conducted on the territory of Ukraine, the prevalence reached its peak. The causative agents of helmintiasis, according to the analysis of scientific publications, circulate mainly in developing countries, in particular in Africa. A review conducted in Ethiopia presents generalized data on the prevalence of gastrointestinal nematodes in small ruminants. The average prevalence of the infection was 75.8%. At the same time, high heterogeneity was established (I² = 97.8%). Recorded nematode taxa were represented by eleven genera, including Haemonchus, Trichostrongylus, Teladorsagia / Ostertagia, Strongyloides, Banostomum, Nematodirus, Chabertia, Trichuris, Cooperia, Skrjabinema and Oesophagostomum (Azmare et al., 2016). Sheep in Kumasi (Ghana, Africa) have been studied by a number of other scientists, who found that the most common among parasites were also nematodes of the gastrointestinal tract (EI 94.5%). The second place was taken by Strongyloides helminths (27.3%) (Owusu et al., 2016). The research data, collected in Burkina Faso, Africa, confirm a high level of prevalence of Strongylota spp. of the gastrointestinal tract (70.7%), with a lower rate of moniezia of sheep (5.7%). The pathogen Strongylidae spp. had the lowest rate (0.9%). The dominant species among nematodes in Kazakhstan sheep were H. contortus (90.1%), Trichostrongylus spp. (68.5%) and Ostertagia spp. (48.9%) (Yan et al., 2021). Numerous publications confirm the circulation of the causative agent of haemonchosis in China (Britton et al., 2016; Hoberg & Zarlenu, 2016).

On the island of Bali, Indonesia, the incidence in cattle was 9.3%. The following species have been identified: Paramphistomum spp., Fasciola spp., Banostomum phelbotomum, Strongyloides papillosus, Trichostrongylus axei and Trichuris ovis. According to the coproscopic studies of sheep in the autumn-grazing period, in the Poltava region the prevalence of infection of animals by pathogens of parasites reached 100.0% (Yevstafieva et al., 2020b). The prevalence of nematodes of the genus Trichuris spp. among sheep in the central and south-eastern regions of Ukraine was 65.9% (Yevstafieva et al., 2018). Three species of Trichuris were found, T. skrjabini Baskakov, 1924, T. ovis Aibirdagard, 1795 and T. globulosa Limstow, 1901. Trichuris ovis and T. skrjabini were more common (54.9% and 35.7%), whereas T. globulosa was relatively rare (9.4%).

Thus, gastrointestinal helmintiasis have a significant geographical distribution, including in Ukraine, and we need to summarize the updated data on the distribution to prevent significant economic losses in livestock farms.

Conclusions

As a result of a meta-analysis of 15 scientific papers, it was found that helmintiasis are quite common in Ukraine, the average prevalence of helmintiasis reaching 56.8% (95% CI: 56.2–57.3%). Parasitocestoses are registered more often than monoinfections, and the highest rates of infection prevalence are observed when the species composition includes gastrointestinal strongyles of the order Strongylida. Strongyloides papillosus is the most common of all represented taxa, while Fasciola hepatica has the lowest prevalence.

The application of scientifically based veterinary and sanitary prevention measures on farms of Ukraine, ensuring the effective deworming of livestock, combined with thorough veterinary inspection at meat processing plants would reduce economic losses caused by helmintiasis.

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