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Literature Review

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The Small Pond Snail *(Lymnaea truncatula)* and Its Role in Spreading Trematodiases. The Situation in the Kaluga Region: Literature Review

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Abstract

Introduction. The small pond snail (*Lymnaea truncatula*) acts not only as a vector for certain species of helminths but also as a universal intermediate host ensuring the circulation of a wide range of trematodes. The increased number of these parasites is a matter of significant epizootological and epidemiological concern as they are posing a threat to the health of humans and farm animals. The aim of the present review is to summarize the available ecology, parasitology, veterinary and epidemiology science data regarding *L. truncatula* and its role in spreading the trematodiases, particularly in the Kaluga Region.

Materials and Methods. The following science citation databases were used: Google Scholar, PubMed, Web of Science, CyberLeninka, Russian Index of Science Citation (RISC/РИНЦ), and others. The publications in Russian and English of the period of 2010–2023 were selected by the keywords: *L. truncatula*, trematodiases, fascioliasis, dicrocoeliasis, Kaluga Region. Articles that were not peer-reviewed and data without statistical verification were excluded. The results were presented in a PRISMA flow chart.

Results. It has been established that the small pond snail plays a key role in the transmission of fascioliasis and is also potentially involved in the spread of other trematodiases. The main factors affecting spreading the infestation include hydrothermal conditions, high soil water capacity, livestock grazing intensity, and the state of melioration system. In the Kaluga Region, the mollusk population density in floodplain biotopes reaches 60–70 specimens/m², and the infestation rate reaches 23%, which creates the stable foci of infestation. The periods of greatest epizootic danger last from June to September. For the efficient control and prevention of trematodiases in the region, a comprehensive approach is required, which combines reclamation works, the use of molluscicides, and modern monitoring systems, as well as systemic collaboration between the specialists of veterinary, agricultural and research institutions.

Discussion and Conclusion. When interpreting the results of the present review, it is necessary to remember the limitations typical for this type of research: the risk of biased evaluation of studies due to the predominance of the publications with positive or statistically significant results in the analysed citation databases; the heterogeneity of the included studies, which complicates direct data comparison; the geographical and temporal limitations of data by region, etc. The following areas of research can be of potential importance in the future: studying the influence of the mollusk microbiome on their resistance to infestation; evaluating the efficiency of new biological control methods; and studying the impact of climate changes on parasitic systems. The data obtained will enable the development of a scientifically based trematodiases control system adapted to the Kaluga Region conditions.

Keywords: literature review, small pond snail, *Lymnaea truncatula*, trematodiases, fascioliasis, dicrocoeliasis, Kaluga Region, intermediate hosts, epizootological monitoring, control measures

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Обзор научной литературы

Малый прудовик (*Lymnaea truncatula*) и его роль в распространении трематодозов. Ситуация в Калужской области. Обзор научной литературы

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Аннотация

Введение. Малый прудовик (*Lymnaea truncatula*) выступает не только как биологический переносчик отдельных видов гельминтов, но и как универсальный промежуточный хозяин, обеспечивающий циркуляцию широкого спектра трематод. Большое число этих паразитов характеризуется выраженной эпизоотологической и эпидемиологической значимостью, представляя угрозу для здоровья человека и сельскохозяйственных животных. Цель обзора — обобщить имеющиеся данные экологии, паразитологии, ветеринарии и эпидемиологии, касающиеся *L. truncatula* и его роли в распространении трематодозов, в частности, в условиях Калужской области.

Материалы и методы. Использованы базы данных Google Scholar, PubMed, Web of Science, CyberLeninka, РИНЦ и др. Отбор публикаций на русском и английском языках проводился за период 2010–2023 гг. по ключевым словам: *L. truncatula*, трематодозы, фасциолёз, дикроцелиоз, Калужская область. Исключены статьи без рецензирования и данные без статистической проверки. Результаты отбора оформлены в виде блок-схемы PRISMA.

Результаты исследования. Установлено, что малый прудовик играет ключевую роль в передаче фасциолёза, а также потенциально вовлечён в циркуляцию других трематодозов. Основными факторами передачи инвазии являются гидротермический режим, высокая влагоемкость почв, интенсивность выпаса скота и состояние мелиоративных систем. В Калужской области плотность популяций моллюска в пойменных биотопах достигает 60–70 экз./м², а уровень их зараженности — 23 %, что создает устойчивые очаги инвазии. Периоды наибольшей эпизоотической опасности — июнь-сентябрь. Эффективный контроль и профилактика трематодозов в регионе требует интегрированного подхода, сочетающего мелиоративные мероприятия, применение моллюскоцидов и современных систем мониторинга, а также системного взаимодействия специалистов ветеринарных служб, аграрных предприятий и научных учреждений.

Обсуждение и заключение. При интерпретации результатов настоящего обзора необходимо учитывать ряд ограничений, характерных для работ данного типа: риск необъективной оценки исследований, связанный с тем, что в анализируемых базах данных преобладают публикации с положительными или статистически значимыми результатами; неоднородность включенных исследований, затрудняющих прямое сопоставление данных; географическую и временную ограниченность данных по региону и др. Перспективными направлениями для дальнейших исследований являются: изучение влияния микробиома моллюсков на их устойчивость к заражению; оценка эффективности новых биологических методов контроля; исследование влияния климатических изменений на паразитарные системы. Полученные данные позволят разработать научно обоснованную систему контроля трематодозов, адаптированную к условиям Калужской области.

Ключевые слова: обзор научной литературы, малый прудовик, *Lymnaea truncatula*, трематодозы, фасциолёз, дикроцелиоз, Калужская область, промежуточные хозяева, эпизоотологический мониторинг, меры борьбы

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Introduction. The small (dwarf) pond snail *(Lymnaea truncatula)* belongs to the phylum Mollusca, class Gastropoda, order Pulmonata, family Lymnaeidae [1]. The species is widespread in the temperate climatic zone of Eurasia, mainly in marshy meadows, river floodplains, wet gullies and the margins of small water bodies [2, 3]. Due to being an intermediate host for trematodes of the family Fasciolidae, the small (dwarf) pond snail represents a significant veterinary and public health problem in the regions with well-developed livestock farming [4]. For example, the Kaluga Region, with its favourable natural and climatic conditions for the development of mollusks, is considered to be an area with the persistent foci of fascioliasis [5, 6]. According to the Veterinary Department of the Kaluga Region, trematodiases refer to the cattle helminthiases most seriously affecting the economy of the region [7]. Constant monitoring, taxonomic clarification of the malacofauna, and implementation of the preventive measures are necessary in the regions of traditional livestock farming, in suburban, recreational and tourist territories [2, 8].

The present review summarizes the available scientific data on the ecological aspects in biology of *L. truncatula*, its role as an intermediate host, current trends in the incidence of fascioliasis, and modern approaches to controlling the population of intermediate hosts and reducing the risk of spreading the trematodiases. It also summarizes present-day knowledge on the role of the small (dwarf) pond snail in spreading trematodiases in agricultural animals on the example of the Kaluga Region. Particular attention is paid to identifying a set of factors that determine the formation and continuance of persistent foci of infestation within the region borders.

Materials and Methods. A search for literature was conducted in the following citation databases: Google Scholar, PubMed, Web of Science, MedLine, the Cochrane Library, EMBASE, Global.health, CyberLeninka, and Russian Index of Science Citation (RISC/РИНЦ).

Only Russian- and English-language publications published between 2010 and 2023 were included in the search. The following keywords and their combinations were used: *Lymnaea truncatula*, trematodiases, fascioliasis, dicrocoeliasis, Kaluga Region.

The criteria for including the publications in the review were: provision of original data, relevance to the topic of the study, and peer-reviewed type of the publications. Articles that were not peer-reviewed, did not present statistical data processing, and were not directly related to the species studied (the intermediate host — *L. truncatula*) were excluded from the review.

The process of literature sources' selection was documented in compliance with PRISMA guidelines. The first stage consisted of screening the titles and abstracts, and the second involved studying the full texts of potentially appropriate publications. The results of the search and step-by-step exclusion of publications are presented in the flowchart.

Research Results. A total of 146 publications were distinguished as a result of citation database search. Additionally, 3 sources were found upon manual search (monographs, methodological manuals). After removing 28 duplicate records, the total number of publications for analysis was 121. Then, after title and abstract screening, 74 publications were deemed to have a topic irrelevant to the present study and therefore were excluded. Potentially relevant full text publications (n=44) were reviewed by experts. After this step, 8 more publications were excluded (due to the low quality of statistics processing or unavailability of the full texts). Eventually, 36 highly relevant to the topic articles were selected for the review. A summary of verification process is shown in the PRISMA flowchart (Fig. 1).

Biology and ecology of *L. truncatula.* The small (dwarf) pond snail inhabits temporary water bodies, ditches, and marshy meadows, where it actively reproduces in spring and the first half of summer. This eurythermal species is capable of adapting to a wide range of hydrothermal conditions, including conditions of temperate and subboreal climates. Maximum mollusk numbers are observed in August — up to 68 specimens/m². The life cycle of *Fasciola hepatica* requires a body of an intermediate host for rediae and cercariae to form. At temperature of 15–25 °C, the evolution completes within 5–7 weeks [4]. Cercariae leave the mollusk and encyst on plants as adolescariae that can cause harm to agricultural animals while eating the grass.

Molecular genetic methods make it possible to detect hidden genetic diversity of mollusks, i.e. to distinguish between the forms that look similar but may play different roles in the transmission of parasites [4].

The period between July and September is the time of highest infestation risk for the small (dwarf) pond snail, especially in pastures with moist soil and ditches. Seasonal fluctuations in population size depend on hydrothermal conditions, competition with other species, and livestock density. By using the normalized difference vegetation index (NDVI), as well as humidity and temperature data, it is possible to construct the accurate risk charts [4].

Natural and climatic conditions of the Kaluga Region contributing to prevalence and population size of *L. truncatula.* The Kaluga Region is a unique region for studying the ecology of *L. truncatula* due to combination of favourable natural and climatic conditions [6]. The conducted analysis allows for identifying several key aspects that determine the prevalence and population size of this mollusk species in the region.

The region is characterized by the temperate continental climate with distinct seasonality. Annual mean precipitation is 550–650 mm, with approximately 70% falling in the spring and summer period, which creates optimal conditions for mollusk development. Temperature conditions are also favourable for mollusk existence: mean July temperature is +18 °C; January — approximately -10 °C. A particularly important factor is the duration of the frost-free period (approximately 140–150 days), which allows both the mollusks and the associated trematodes to complete the full life cycle [3, 6].

The hydrological network of the region includes major waterways such as the Oka, Ugra, and Zhizdra rivers. These rivers and their numerous tributaries form extensive floodplain ecosystems —the ideal habitats for *L. truncatula* [6, 9]. Of particular importance are the numerous temporary water bodies, which retain water throughout the mollusk growing season. According to hydrobiological studies, these temporary water bodies prove to have the highest mollusk population densities [2, 10].

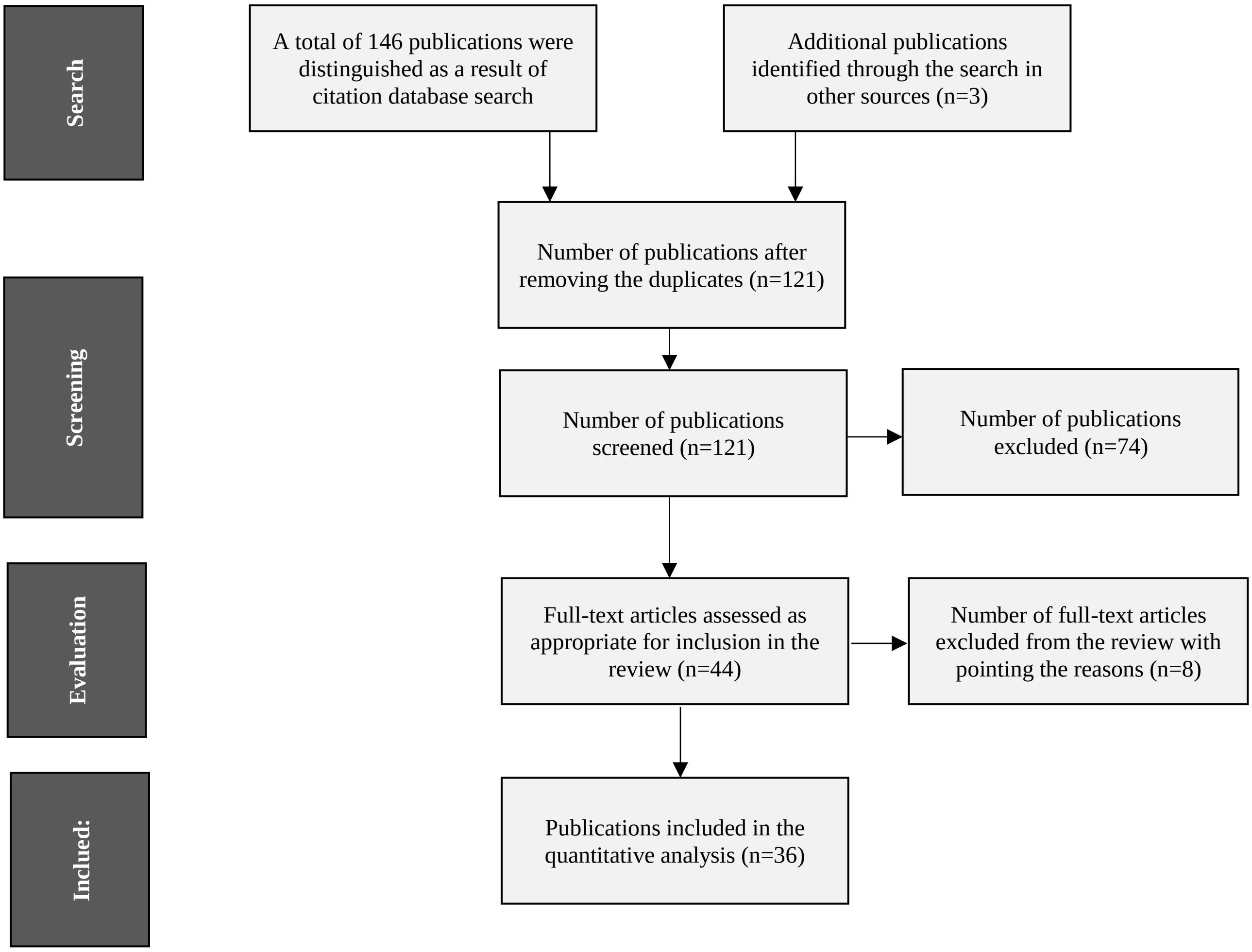

Fig. 1. PRISMA flow chart showing the results of publications' selection process

The predominance of sod-podzolic and alluvial soils in the region creates optimal conditions for the existence of mollusks. These soils are characterized by:

– high water capacity;

– abundant concentration of organic matter;

– pH neutral or slightly acidic environment;

– a well-developed capillary water system, which maintains the necessary moisture level even during short-term drying out of the water bodies [5, 6].

The main *L. truncatula* biotopes in the Kaluga Region include floodplain meadows, drainage ditches, and temporary water bodies in the pastures [6]. Population density reaches 60–70 specimens/m². Temporary water bodies play a key role in maintaining trematodiasis foci due to:

– rapid warming of water;

– abundant vegetation;

– regular circulation of trematode eggs with animal faeces;

– the absence of planktophagous fish [4, 10].

The Kaluga Region is referred to the industrially developed regions, yet significant attention is paid to the development of ecotourism. The region has the protected natural areas, such as the Ugra National Park, Kaluzhskie Zaseki Nature Reserve, and private eco-farms "Jersey" and "Happy Farm". These areas contribute to the conservation of natural ecosystems and biotopes, which are home, to the small (dwarf) pond snail, an important intermediate host for trematodes [4].

The seasonal dynamics of the small (dwarf) pond snail population in the region exhibits a distinctly bimodal pattern, with peaks in late spring (May–June) and late summer (August–September). Minimum values are observed in October, before the mollusks leave for wintering [3, 7].

Fascioliasis and its causative agent. Fascioliasis is a helminthiasis caused by the liver fluke *Fasciola hepatica*, affecting domestic and wild ruminants, as well as humans. *L. truncatula* is the primary and obligate first-intermediate host for this parasite. The life cycle includes: egg → miracidium → sporocyst → redia → cercaria → adolescaria. Infestation occurs after ingestion of vegetation or water contaminated with adolescariae [11].

The economic damage from fascioliasis is significant: the estimated number of infested people and animals equals to millions of cases annually [9]. The expansion of *L. truncatula* habitat upon the influence of climate changes, increases the risk of emergence of new foci of infestation [12, 13]. Most vulnerable are the regions with pasture husbandry, where there is a lack of systemic monitoring of intermediate hosts.

In humans, fascioliasis is manifested by fever, pain in the right hypochondrium, eosinophilia, and liver enlargement. In agricultural animals, it is manifested by anaemia, decreased productivity, cachexia, and liver and bile duct damage [4].

Other trematodiases associated with *L. truncatula*. Dicrocoeliasis is caused by *Dicrocoelium dendriticum* that parasitizes in the liver of herbivores. The first hosts are terrestrial mollusks of the genus *Zebrina*, *L. truncatula*. Transmission occurs through infested ants (the second-intermediate hosts), which are ingested by the animals. The parasite causes chronic liver damage, bile duct fibrosis, and reduced productivity in cattle [11].

Opisthorchiasis is caused by *Opisthorchis felineus*. The first intermediate hosts are mollusks of the genus *Bithynia*. However, as noted by M.V. Vinarsky, in some cases, for example, when the ecological balance is disturbed, *L. truncatula* may be involved as a transit or atypical intermediate [2, 6]. Such cases have been recorded in river basins with high aquatic biomass density, and with introduction of new species [10]. Animals become infested through consumption of raw or insufficiently processed fish containing metacercariae. This causes hepatobiliary disorders, and bears the risk of cholangitis, and even cholangiocarcinoma [11].

Fascioliasis, caused by *Fasciola gigantica*—the giant liver fluke widely spread in southern regions, but due to global warming, its northern expansion is possible. *L. truncatula* can temporarily replace native species *Lymnaea auricularia* or *Radix spp.*, especially in hybrid zones of its habitat [9].

Echinostomatidosis (caused by *Echinostoma revolutum*) can occur in *L. truncatula* in experimental conditions. Infestation occurs through ingestion of cercariae. In humans and birds, it causes intestinal inflammation, pain, fever, and diarrhea [11].

Polyinfestations—a combination of *F. hepatica* with *Paramphistomum cervi* or other trematodes—are possible in mollusks in water bodies with high fecal contamination and temperatures above 20°C. Such polyinfestations increase the severity of the parasite load in ruminants [10].

The exotic species *Schistosoma mansoni* is not yet transmitted by *L. truncatula* and does not represent a biomedical threat so far. However, in the event of artificial introduction and global climate change, the mollusk may participate in atypical cycles in laboratory settings. This emphasises the potential danger of spreading this trematodiasis in other epidemiological chains too [13].

Among all trematodiases, fascioliasis remains the most significant one, but expansion of habitat, hybridization of trematodes, global warming, and changes in the economic pattern create conditions for pond snail involvement in the new parasitic systems [4].

The following recent trends remain a pressing problem:

– expansion of the trematode species using *L. truncatula* as a host;

– increase of the infestation level in mollusks;

– the emergence of new foci of infestation,

These changes may be related to climatic changes, anthropogenic transformation of landscapes, intensification of livestock farming, and changes in the grazing system [13, 14].

Trematodiasis Transmission Factors. Factors determining the intensity of trematodiasis transmission in the Kaluga Region can be divided into three groups:

1. Natural factors:

– hydrothermal regime: optimal water temperature (15–25°C), sufficient precipitation, duration of the growing period [3, 6];

– water body characteristics: depth (shallow areas are preferred), flow velocity (stagnant or slow-moving waters), high degree of vegetation overgrowth [10];

– soil conditions: composition, water capacity, organic matter concentration [5, 6].

2. Anthropogenic factors:

– land use pattern: grazing intensity (critical threshold: 2.5 heads/ha), rotation of pasture areas, availability of watering places [4, 5];

– state of melioration systems: degree of waterlogging, drainage quality, regularity of ditch cleaning [9, 10];

– economic activity: use of fertilizers, use of pesticides, haymaking [15].

3. Climatic changes:

– Temperature increase: increased period of mollusk activity, accelerated development of trematodes, expansion of the *L. truncatula* habitat [12, 13];

– Changes in precipitation patterns: increased number of temporary water bodies, changes in the hydrological regimes, redistribution of mollusk populations [12, 13];

– Extreme events: droughts, floods, abnormally warm winters [12, 13].

The has analysis revealed the correlation between the degree of anthropogenic load on water bodies, the level of mollusk infestation, and the intensity of trematodiasis transmission.

Trematode population control and prevention of trematodiases. To reduce the incidence of trematodiases in humans and animals, it is necessary to control *L. truncatula* population size in the pastures using molluscicides (based on niclosamide) during the periods of greatest mollusk activity (late May – early August) [9, 16]. The use of biological methods, e.g., introduction of predatory aquatic insects *(Hydrophilidae, Dytiscidae)* to limit the dwarf pond snail population size is now studied in the international practice [17]. It is recommended to inspect the sanitary condition of territories, especially near water bodies for implementing a set of measures aimed at controlling the populations of intermediate hosts [9].

One of the primary preventative measures is controlling *L. truncatula* population size in natural and anthropogenic biotopes. This is particularly valid for floodplain pastures and temporary water bodies, where conditions are optimal for the mollusk and, consequently, for the transmission of infestation. It is important to consider weather and climate conditions, because high humidity and warm temperatures stimulate the reproduction of the pond snail and accelerate the development of parasites [10]. The monitoring system represents a complex process, which incorporates both biological and sanitary measures. Based on the analysis of the efficiency of various methods, the following key directions of *L. truncatula* population control and prevention of associated trematode infestations in the Kaluga Region can be distinguished:

– pasture reclamation: draining temporary water bodies, soil liming, deep ploughing of marshy areas, demolition of aquatic vegetation and weeds thickets — all this leads to a decrease in the number of intermediate hosts [9];

– for local natural foci where large-scale reclamation works are impossible (e.g., in nature reserves or ecotourism areas), a biological method can be used: the release of molluscivorous fish species *(Misgurnus fossilis, Tinca tinca)* and birds capable of regulating the population size of *L. truncatula* [17];

– deworming of cattle using fasciolicides (albendazole, triclobendazole, oxyclozanide, etc.): the frequency of treatment depends on the epizootic situation and the epidemic season phases. The most efficient time for carrying out treatment is early spring (before turning cattle out to pasture) and late autumn (before stall keeping) [16, 18]. The use of molluscicides, despite their efficacy, requires consideration of the impact on the balance of aquatic ecosystems [1, 17, 18];

– a comprehensive approach that combines: environmentally friendly methods of population control [17]; modern monitoring technologies (GIS technology, PCR diagnostics) [8, 14, 19]; scientifically based forecasting [14, 20]; adaptive management of pasture lands [9].

The comprehensive approach proves to be the most future-oriented method enabling achievement of a sustainable effect with minimal impact on the ecosystems and maximum economic efficiency [9, 17].

Research Limitations. When interpreting the results of the present review, it is necessary to consider a number of limitations typical of this type of work. Firstly, there is a risk of bias evaluation of studies due to the predominance of publications with positive or statistically significant results in the analysed citation databases. Studies that failed to find a correlation between *L. truncatula* and prevalence of trematodiases or showing negative results might not have been published, which potentially could distort the overall picture.

Secondly, the heterogeneity of the included studies complicates direct comparison of data: differences in the methods of field data collection, mollusk infestation diagnostic criteria, seasonal timing of research, and statistical data processing techniques could have influenced the variability of the presented indicators (e.g., population densities from 9 to 70 specimens/m²).

Thirdly, the presented data are limited by their geography and time: a significant portion of the sources discovered for the Kaluga Region refer to the period 2016–2022, which may not fully reflect the current epizootic situation, especially in the context of rapid climate changes in the recent years. Furthermore, data for a number of biotopes in the region are fragmented or absent.

Fourthly, uncertainty remains in the taxonomic identification of mollusks in early-dated studies. Before the widespread implementation of molecular genetic methods, *L. truncatula* was identified solely by morphological characteristics, which could lead to the erroneous attribution of the closely related species to this taxon and, consequently, to inaccuracies in assessing its actual role in the transmission of infestations [10, 14].

Finally, language limitations (inclusion of only Russian- and English-language publications) could have led to the exclusion of relevant studies published in other languages.

Taking into account the above limitations, it is possible to have a more balanced approach to the interpretation of the findings and defining directions for further research.

Discussion and Conclusion. Based on the results of the review of the scientific literature, the following conclusions can be drawn:

1. The small (dwarf) pond snail *L. truncatula* plays a key role in the transmission of several species of trematodes, primarily *Fasciola hepatica*.

2. The Kaluga Region has a unique combination of natural and climatic conditions favourable for development of persistent *L. truncatula* populations. These are: temperate continental climate, a well-developed hydrological network, and the predominance of sod-podzolic soils [5, 6].

3. The level of trematode infestation in mollusks in various biotopes of the region reaches 23%, creating a constant threat of infestation foci emergence [6, 10]. The formation of trematode foci is induced by a combination of interrelated natural and anthropogenic factors, including hydrothermal conditions, grazing intensity, and the state of melioration systems [5, 7, 9].

4. The ecological condition of the Kaluga Region is complicated by the anthropogenic load: pollution of air and water bodies, accumulation of wastes, and erosion of soils [6, 15]. These factors affect the stability of wetland ecosystems, which are home to mollusks—the intermediate hosts of parasites [10, 19].

5. The most efficient strategy for controlling the mollusk population size is implementation of a comprehensive approach that combines reclamation measures, the use of molluscicides, biological methods, and modern monitoring systems [9, 17, 18].

6. Prophylaxis should be adaptive, taking into account natural and climatic fluctuations, as well as the features of certain landscapes [7, 12, 13, 20, 21].

Efficient control of trematodiasis natural foci is impossible without systemic collaboration between the specialists of veterinary services, agricultural enterprises, environmental protection agencies and scientific institutions [5, 6, 9, 22, 23, 24].

The potential areas for further research include:

— studying the influence of mollusks' microbiome on their resistance to infestation;

— evaluating the efficiency of new biological control methods;

— studying the impact of climate changes on parasitic systems.

Research in these areas will enable the development of a scientifically based system of controlling trematodiases adapted to the Kaluga Region conditions and taking into account current environmental changes.

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