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NEW MOLLUSCICIDES IN CONTROL OF FRESHWATER SNAILS – INTERMEDIATE HOSTS FOR CAUSATIVE AGENTS OF FASCIOLIASIS, PARAMPHISTOMATOSIS AND ORIENTOBILHARZIASIS

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Abstract. *The article presents the results of studying the new and affordable means for freshwater snail control. It was found that mineral fertilizers – ammonium sulfate at a concentration of 0.05–0.20 %, and potassium chloride at a concentration of 0.20–0.30 % cause the death of snails of the genera Lymnaea and Planorbis in 24–72 hours after application. Hydrogen peroxide at a concentration of 1:40000 and potassium permanganate at a concentration of 1:400000 also kill snails within 24–48 hours. Commonly available products also have pronounced molluscicidal action: table salt (NaCl) and baking soda ($NaHCO_3$) at concentrations of 0.30–0.50 %. Changing the pH in the habitat of snails, i.e. water in snail biotopes, towards acidity (3.8–6.2) and alkalinity (8.0–8.4) also result in the death of snails, and the optimal environment is with pH = 7.8. These means are safe for animals and the environment, as evidenced by the results of experiments carried out on sheep, which were administered with molluscicide solutions orally using a probe in an amount of 1.5 liters per animal and by ad libitum drinking for 3 days.*

Keywords: *molluscicides, sheep, freshwater snails, intermediate hosts, mineral fertilizers, water pH*

Introduction. Fascioliasis, paramphistomatosis, and orientobilharziasis occupy a special place in the pathology of domestic and wild animals, especially ruminants – sheep, goats, cattle, deer, and others. The causative agents of these helminthiases – trematodes *Fasciola hepatica* (Linnaeus 1758), *Orientobilharzia* (Dutt & Srivastava, 1955), as well as the family *Paramphistomatidae* (Fischoeder, 1901) have their preimaginal development in the body of snails – representatives of the family *Lymnaedae*, genus *Lymnae* (*Fasciola hepatica* and *Orientobilharzia*) and genus *Planorbis* (*Paramphistoma*) [7, 8]. Consequently, in the complex of control measures against fascioliasis, orientobilharziasis, and paramphistomatosis, the control of snails is important.

Analysis of recent researches and publications. It is known that the control of snails – intermediate hosts for causative agents of helminthiases is carried out by physical methods, i.e. draining the snail habitats (biotopes), by biological methods – breeding waterfowl

(ducks, geese) in the snail habitats, and by chemical methods – processing biotopes of snail by chemical means, i.e. molluscicides [8]. The last method is the most effective and reliable, it allows to clean up quickly and fully the infected areas in pastures, to neutralize the reservoirs inhabited by snails.

Gorokhov (1966, 1970) made a significant contribution to the studying and development of measures to control freshwater snails – intermediate hosts for pathogenic helminths, including the causative agents of fascioliasis, orientobilharziasis, and paramphistomatosis, he not only run a search for new molluscicides but summarized and analyzed more than 500 works of domestic and foreign authors that were devoted to the research and application of molluscicides [3, 4].

As a result of the research, methods were found and developed for the use of such means as 5,4'-Dichlorosalicylanilide and other drugs of this series, copper sulfate, which were introduced into the practice for control of freshwater snails in order to prevent trematodosis [1, 2, 5, 6]. However, these means are either inaccessible (Dichlorosalicylanilide) or highly toxic, i.e. environmentally hazardous.

Purpose. In the light of the foregoing, we set out to find and develop methods for application of available, non-toxic, environmentally friendly molluscicides [9–12]. For this purpose, we have tested and developed a method for application generally available, relatively cheap, low-toxic, and almost safe for the flora and fauna of the environment means for control of freshwater snails – intermediate hosts for causative agents of fascioliasis, paramphistomatosis and orientobilharziasis.

Methods. The study on the search for new molluscicides and the development of methods for their application was carried out in laboratory conditions, i.e. in aquariums, and then directly in the external environment, in pasture areas where freshwater snails live (biotopes).

We tested both commonly available means – table salt (NaCl) and baking soda – sodium bicarbonate ($NaHCO_3$), and those used in agriculture, human and veterinary medicine – mineral fertilizers (ammonium sulfate ($(NH_4)_2SO_4$), potassium chloride (KCl), phospho-urea), hydrogen peroxide (H_2O_2), and potassium permanganate ($KMnO_4$) in different concentrations (from 0.001 to 1.0 % or more), i.e. in proportion from 1:1000 to 1:1000000.

The effect of environmental pH values (water pH) on the viability of snails was also determined by changing water pH towards acidity (pH = 3.8–6.5) and alkalinity (pH = 7.4–8.5), for which we used hydrochloric acid (HCl) and sodium hydroxide (NaOH).

The freshly collected freshwater snails from natural reservoirs (biotopes) were used in the laboratory experiments. 50–100 specimens were placed into aquariums with different substances that

were tested as molluscicides and at different concentrations. Observations, i.e. the physiological state of the snails, their mobility, the number of alive and dead animals were determined in 30, 60 minutes, and every hour until 24 hours after the snails were placed into aquariums with molluscicides and in 3, 5, 10, 15, 20, and 25 days.

Experiments on testing molluscicides in natural conditions, i.e. in biotopes of snails, were carried out in the daytime starting from 12 until 17–18 o'clock – during the period of snail activity. The tested molluscicides in certain concentrations were introduced into natural reservoirs where snails lived in the form of concentrated aqueous solutions, taking into account the achievement of the necessary concentration of molluscicides in the water of the biotope. The observations were carried out for 30, 60 minutes, and after 3, 5, 12, 24, 48, 72 hours and then, depending on the physiological state of the snails, in the morning and evening during 20–25 days. Snails, which were used as a control, were placed in separate aquariums with ordinary tap (artesian) water with pH = 7.4.

In order to determine the safety of new molluscicides for animals and the environment, special experiments have been carried out, the essence of which is to exclude animal poisoning when molluscicides are applied in biotopes of snails. For this purpose, two series of experiments were carried out. In the first series of experiments, molluscicides were given to sheep forcibly, i.e. molluscicide solutions were administered using a probe in the amount of 1.5 liters. The second series of experiments included determining the effect of molluscicides on the body of sheep by *ad libitum* drinking for 3 days. The clinical observation and hematological examination were carried out before and after the administration of molluscicide solutions using a probe or by *ad libitum* drinking.

Results. In the first series of experiments carried out under laboratory conditions, it was found that solutions of sodium chloride (NaCl) at a concentration of 0.4 %, potassium chloride (KCl) at a concentration of 0.1%, ammonium sulfate ($(NH_4)_2SO_4$) at concentrations of 0.05 and 0.1 %, as well as phospho-urea at a concentration of 0.3 % induce the death of snails within 24–48 hours. It was found that the devastating effect of ammonium sulfate and potassium chloride was more pronounced during the first hours after snail exposure, i.e. already within 1–3 hours caused the death of 60–70 % of snails and this process was completed mainly in 24 hours. Comparatively slower was the effect of table salt and phospho-urea, which induced snail death after 12–24 hours of exposure. Lower concentrations of molluscicides than the above-mentioned somewhat decelerated the snail death, and an increase in the concentration of substances accelerated the process of snail death (Table 1).

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1. Results of testing table salt and some fertilizers on freshwater snails *Lymnae* and *Planorbis* in laboratory conditions (aquariums)

Tested means	Concentration, (%)	Terms of snail death	Other observations
Table salt (NaCl)	0.4–0.7 0.8–1.5	2 days 1 day	The reproduction (egg laying) of snails was observed at the lower concentrations (0.2–0.3 %)
Potassium chloride (mineral fertilizer)	0.1 0.2 0.3–0.5 0.5–1.0	6–10 days 3–5 days 1 day 2–12 hours	High concentrations (0.5–1.0 %) induce quick (2–3 hours) snail death and the release of soft tissue from the shell
Ammonium sulfate (mineral fertilizer)	0.05 0.1 1.0	2 days 24 hours 12 hours	Snail death occurs quickly, mostly during the first hours after exposure
Phospho-urea (mineral fertilizer)	0.4 0.6 0.7 1.0	– – 7 days 10 days	Only high concentrations (0.7–1.0 %) induce snail death

The molluscicidal effect of phospho-urea is much less pronounced than the effect of other mineral fertilizers – potassium chloride and ammonium sulfate. This substance, i.e. phospho-urea leads to snail death only at concentrations of 0.7–1.0 % and requires a longer (7–10 days) exposure of this substance on snails.

It was found that the water pH also affects the terms of snail death: a change in the water pH towards the acidity (pH = 3.8–6.2) induce the snail death in 30 minutes and 72 hours, and slightly alkaline water (pH = 8.0–8.4) in a significantly short time, i.e. kills snails for 2–3 hours. The most suitable, i.e. optimal for snails is a water pH of 7.8.

In experiments carried out directly in natural habitat, i.e. in biotopes of freshwater snails, we found that ammonium sulfate at a concentration of 0.05 % and potassium chloride at a concentration of 0.2 % induce the death of all (100 %) snails within 24 hours.

In natural biotopes, table salt (NaCl) at a concentration of 0.5 % induces snail death in 24 hours. Sodium hydroxide (NaOH) at a pH of 8.5 kills 98 % of snails for 24 hours.

In experiments carried out in laboratory conditions (in aquariums), it was found that the effectiveness of the studied molluscicides is quite high, as well as the previously recommended means – copper sulfate ($CuSO_4$) at a concentration of 1:5000. So, solutions of ammonium sulfate, potassium chloride, sodium chloride at concentrations of 0.1, 0.2, and 0.4 %, respectively, showed a sufficiently high molluscicidal effect, as well as copper sulfate in the mentioned above concentration. The molluscicidal effect of water with different concentrations of hydrogen ions (pH), which was created using hydrochloric acid (pH = 4.0) and sodium hydroxide

(pH = 8.5), was also similar to the effect of a copper sulfate solution in a proportion of 1:50000, i.e. these means caused the snail death for 2–2.5 hours.

The results of determining the effect of tested new molluscicides on the clinical state and hematological parameters in sheep showed that potassium chloride at a concentration of 0.3 %, ammonium sulfate at a concentration of 0.2 %, table salt at a concentration of 0.5 %, and water with a pH equal to 4.0 and 8.5 when administering to sheep through a probe in an amount of 1.5 liters and by *ad libitum* drinking of these molluscicide solutions to sheep for 3 days do not have a clinically pronounced toxic effect and do not cause any deviations from the physiological norm in hematological parameters.

Conclusion. A sufficiently high molluscicidal effect against freshwater snails of the genera *Lymnae* and *Planorbis* – intermediate hosts for the causative agents of fascioliasis (*Fasciola hepatica, F. gigantica*), orientobilharziasis (*Orientobilharzia turkestanica*), and paramphistomatosis (family *Paramphistomidae*) of several commonly available, relatively cheap means – table salt (NaCl), baking soda, i.e. sodium bicarbonate ($NaHCO_3$), as well as mineral fertilizers – ammonium sulfate ($(NH_4)_2SO_4$), potassium chloride (KCl) at concentrations of 0.1–0.5 % and widely used in human and veterinary medicine – hydrogen peroxide (H_2O_2) and potassium permanganate ($KMnO_4$) in the proportion to the water of 1:40000 and 1:400000 was established in experiments conducted in laboratory conditions (aquariums) and in natural snail habitat (biotopes).

It has also been established that a change in water pH towards acidity (3.8–6.2) and alkalinity (8.0–8.4) also has a devastative effect on these snails.

The molluscicides that we have tested (0.2 % ammonium sulfate, 0.3 % solution of potassium chloride, 0.5 % solution of sodium chloride, and water with pH 3.4 and 8.5) do not have a pronounced negative effect on the general clinical condition and hematological parameters in sheep.

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НОВЫЕ МОЛЛЮСКОЦИДЫ В БОРЬБЕ С ПРЕСНОВОДНЫМИ МОЛЛЮСКАМИ – ПРОМЕЖУТОЧНЫМИ ХОЗЯЕВАМИ ВОЗБУДИТЕЛЕЙ ФАСЦИОЛЁЗА, ПАРАМФИСТОМАТОЗА И ОРИЕНТОБИЛЬГАРЦИОЗА

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Анотація. *В статье представлены результаты исследования новых и доступных средств борьбы с пресноводными моллюсками. Установлено, что минеральные удобрения – сульфат аммония в концентрации 0,05–0,20 % и хлорид калия в концентрации 0,20–0,30 % вызывают гибель моллюсков родов Lymnaea и Planorbis через 24–72 часа после применения. Перекись водорода в концентрации 1:40000 и перманганат калия в концентрации 1:400000 также убивают моллюсков в течение 24–48 часов. Выраженным моллюскоцидным действием обладают также общедоступные средства: поваренная соль (NaCl) и пищевая сода ($NaHCO_3$) в концентрациях 0,30–0,50 %. Изменение pH среды обитания моллюсков, то есть воды в их биотопах, в сторону кислотности (3,8–6,2) или щелочности (8,0–8,4) также приводит к гибели моллюсков, а оптимальной для их существования является среда с pH = 7,8. Эти средства являются безопасными для животных и окружающей среды, о чем свидетельствуют результаты экспериментов, проведенных на овцах, которым задавали растворы моллюскоцидов орально с помощью зонда в количестве 1,5 литра на 1 животное и путем свободного выпаивания в течении 3 суток.*

Ключевые слова: *моллюскоциды, овцы, пресноводные улитки, промежуточные хозяева, минеральные удобрения, pH воды*

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НОВІ МОЛЮСКОЦИДИ ДЛЯ БОРОТЬБИ З ПРІСНОВОДНИМИ МОЛЮСКАМИ – ПРОМІЖНИМИ ГОСПОДАРЯМИ ЗБУДНИКІВ ФАСЦІОЛЬОЗУ, ПАРАМФІСТОМАТОЗУ І ОРІЄНТОБІЛЬХАРЦІОЗУ

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Анотація. *У статті представлені результати дослідження нових та доступних засобів боротьби з прісноводними молюсками. Встановлено, що мінеральні добрива – сульфат амонію в концентрації 0,05–0,20 % та хлорид калію в концентрації 0,20–0,30 % спричинюють загибель молюсків родів Lymnaea та Planorbis через 24–72 години після застосування. Перекис водню в концентрації 1:40000 і перманганат калію в концентрації 1:400000 також вбивають молюсків впродовж 24–48 годин. Виражену молюскоцидну дію мають також загальнодоступні засоби: кухонна сіль (NaCl) і харчова сода ($NaHCO_3$) у концентраціях 0,30–0,50 %. Зміна pH середовища існування молюсків, тобто води в їхніх біотопах, у бік кислотності (3,8–6,2) чи лужності (8,0–8,4) також призводить до загибелі молюсків, а оптимальним для їхнього існування є середовище із pH = 7,8. Ці засоби є безпечними для тварин та навколишнього середовища, про що свідчать результати експериментів проведених на вівцях, яким задавали розчини молюскицидів орально за допомогою зонду в кількості 1,5 літра на 1 тварину та шляхом вільного випоювання впродовж 3 діб.*

Ключові слова: *молюскоциди, вівці, прісноводні молюски, проміжні господарі, мінеральні добрива, pH води*