



Regulatory Mechanisms in Biosystems

ISSN 2519-8521 (Print)
ISSN 2520-2588 (Online)
Regul. Mech. Biosyst.,
2023, 14(1), 70–76
doi: 10.15421/022311

Effect of disinfectants on viability of *Trichuris skrjabini* eggs

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Article info

Received 24.01.2023

Received in revised form 16.02.2023

Accepted 17.02.2023

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Yevstafieva, V., Petrenko, M., Peleno, R., Nikiforova, O., Vakulenko, V., Reshetylo, O., & Kone, M. (2023). Effect of disinfectants on viability of *Trichuris skrjabini* eggs. *Regulatory Mechanisms in Biosystems*, 14(1), 70–76. doi:10.15421/022311

The nematodes are considered the most numerous group of cosmopolitan diseases among animal and human parasitoses. The representatives of the genus *Trichuris* attract special attention as pathogens of nematodoses. Their high fecundity, resistance to the influence of environmental factors and the ability to disperse create a serious ecological hazard and the risk of new outbreaks of infestation. The aim of the research was to establish the ovicidal efficiency of modern disinfectants on the embryogenesis of eggs of *Trichuris skrjabini* nematodes isolated from sheep. In laboratory conditions, two preparations were tested, DZPT-2 (mixture of glutaraldehyde, sodium dodecyl sulfate, essential oil) and Dixclor (mixture of sodium bisulfate, sodium chlorite, sodium percarbonate) at different concentrations and times of exposure. We established that DZPT-2 disinfectant showed a high level of ovicidal efficiency (97.5–100%) against *T. skrjabini* eggs at 4.5% concentration during exposure for 6–12 h and 5.0% concentration during exposure for 3–12 h. Dixclor showed a high level of ovicidal efficiency (100%) against *Trichuris* eggs at a concentration of 0.24% for exposures of 12 and 24 hours. Decreasing the concentration of disinfectants reduced the level of their ovicidal efficiency and led to the development of a greater number of viable eggs of *T. skrjabini*. Degenerative changes in the test cultures of *T. skrjabini* eggs caused by the tested disinfectants were characterized by the appearance and accumulation of air bubbles under the egg shell, the cessation of embryonic development at the bean-like embryo stage, loosening and resorption of the embryo inside the eggs, thinning and destruction of their shell, deformation of the eggs, and swelling of the egg plugs. Such destructive changes in eggs in experimental test cultures were also confirmed by the indicators of their morphometric parameters. Under the influence of DZPT-2 and Dixclor on the 54th day of cultivation, the length of the eggs was lower by 3.9%, and their width was greater by 4.8–5.1% compared to similar indicators in the control test culture. The obtained results allow one to recommend the tested disinfectants in defined and effective concentrations and exposures for effective control and prevention of trichurosis on livestock farms.

Keywords: trichurosis; sheep; embryogenesis; chemical preparations; ovicidal effect; disinfection.

Introduction

Socio-economic and climatic changes, urbanization, reformation of the agricultural sector and many other factors cause an increase in anthropogenic load on biocenoses and contribute to the spread of parasitic diseases, especially nematodoses of the gastrointestinal tract of animals and humans (Gao et al., 2017; Cole & Viney, 2018; Fernando et al., 2021). Among the pathogens, representatives of the genus *Trichuris* attract special attention (Dunn et al., 2002; Klementowicz et al., 2012; Yevstafieva et al., 2018; Shears & Grecis, 2022). Large scale complexes and farms for the production of livestock products are gradually being replaced by small private enterprises and livestock breeding in private farms. In such conditions, the sanitary conditions of keeping animals are often violated, the deadlines for preventive and therapeutic anti-parasitic measures are not observed (Tariq, 2015; Mekonnen, 2021). Thus, some species of parasites acquire epidemic and epizootic significance on certain territories, more stable populations of parasites appear, especially in the exogenous stages of their development. At the same time, their habitat becomes increasingly contaminated with the propagative stages of helminths in numbers that significantly exceed the natural background (Mejer & Roepstorff, 2006; Blaszkowska et al., 2013; Bojar & Klapeć, 2018; Lindgren et al., 2019). Hence, a significant number of works are devoted to the study of the effect

of various disinfectants on nematode eggs, since that is the stage at which pathogens persist in the environment, and is one of the links in the epizootic chain. In particular, a significant ovicidal efficiency of formalin, povidone iodide and TH4 against *Ascaridia columbae* eggs was established: the development of 80%, 85% and 98% of *Ascaris* eggs was inhibited during 12 and 15 days and exposures of 10, 20, 30 and 60 minutes. At the same time, the disinfectant Virkon-S did not have sufficient ovicidal efficiency during the experiment (Bessat & Dewair, 2019). The effectiveness of the disinfectant product based on Neopredisan® 135-1 (NP) chlorocresol on embryogenesis of *T. canis* was established *in vitro*. The agent in concentrations of 0.25%, 0.50%, 1%, 2% or 4% demonstrated a significant ovicidal effect regardless of exposure (30, 60, 90 or 120 min). Moreover, the efficiency increased depending on the concentration and exposure, with the maximum indicators of ovicidal effect (95.8%) at a concentration of 4% and an exposure of 120 min (Zhang et al., 2020). The researchers also showed a high ovicidal efficiency of ethanol against the embryogenesis of *T. canis* after a 24-day incubation period of *Toxocara* eggs. Meanwhile, sodium hypochlorite caused degeneration in 50% of eggs, and using a commercial mixture of benzalkonium chloride and formaldehyde, 25% of *T. canis* eggs developed to L₂ (Morrondo et al., 2006). There are reports of high ovicidal activity of 50% hydrogen peroxide and 3% dihydroxybenzene solution against non-invasive *T. canis*

eggs (Shalaby et al., 2011). The high ovicidal activity of 70% ethanol has also been observed. This agent caused degeneration of all *T. canis* eggs within several days and thus inhibited the development of larvae during their embryogenesis in laboratory conditions. The authors also note that sodium hypochlorite removed the outer layer of eggs, but they contained invasive larvae for two weeks, and benzalkonium chloride and formaldehyde-based disinfectants did not affect *T. canis* embryogenesis (Verocai et al., 2010). Other researchers, when determining the ovicidal effect of ethanol, methanol, and chlorhexidine at exposures of 0.5, 1, 5, 10, 30, and 60 min on the development of *A. suum* eggs, established their low efficiency. They also found that 3% cresol, 0.2% and 0.02% sodium hypochlorite delayed, but did not inactivate the embryogenesis of the studied eggs after three weeks of incubation, regardless of exposure. A test of the ovicidal efficiency of 10% povidone-iodine showed that exposure of 5 min inactivated most eggs, but did not reach 100% efficiency, even with exposure of 60 min (Oh et al., 2016).

There are reports of the ovicidal effectiveness of the chlorine-based disinfectants Brovadez-plus, Bi-dez and Dezsan against a non-invasive test culture of nematode eggs of the species *Aonchotheca bovis*. Dezsan was the most effective (91.14–100%) in 1–2% concentration, exposure 10–60 min. Bi-dez showed a high level of efficiency (92.4–100.0%) in concentrations of 1.5% (exposure for 30 and 60 min) and 2% (exposure for 10–60 min). Brovadez-plus showed high efficiency (100%) in 2% concentration for exposures from 10 to 60 min (Melnychuk & Yuskiv, 2018).

Recently, researchers have been determining the disinfection effectiveness of environmentally safe, natural agents against exogenous nematode stages in order to preserve the biocenosis and prevent environmental pollution with aggressive, chemical agents (Gortari et al., 2007; Maia Filho et al., 2013; Boyko & Brygadyrenko, 2017, 2019a, 2019b, 2021a, 2021b, 2022).

In connection with the fact that the ecological foundations of the prevention of parasitic pollution in the conditions of an anthropogenically altered environment are aimed at achieving a favourable state of biological safety of the habitat for humans and animals, timely detection of the source of invasion and the remediation of environmental objects are relevant. Therefore, the aim of the work was to establish the ovicidal efficiency of modern disinfectants on the embryogenesis of eggs of *Trichuris skrjabini* nematodes isolated from sheep.

Materials and methods

The work was conducted in the conditions of the Laboratory of Parasitology and Veterinary and Sanitary Examination of the Poltava State Agrarian University (Ukraine) in 2022. The research protocol of the current study was approved by the Ethics Committee of the Poltava State Agrarian University (Approval number: 2022/03).

In order to determine the ovicidal efficiency of disinfectants DZPT-2 and Dixclor, test cultures of non-invasive nematode eggs of the species *Trichuris skrjabini* isolated from the gonads of female helminths were used. The collection of helminths was made during the dissection of the large intestine of sheep obtained from the slaughterhouses of the Poltava region (Ukraine).

DZPT-2 product contains the active substance glutaraldehyde (25%) and auxiliary substances: sodium dodecyl sulfate, essential oil. Dixclor contains active substances: sodium bisulfate (40%), sodium chlorite (24%), sodium percarbonate (2.5%) and auxiliary substances: sodium sulfate, magnesium sulfate, sodium chloride, sodium alginate.

In laboratory conditions, a mixture of *T. skrjabini* eggs (at least 100 specimens) was prepared in Petri dishes, to each of which disinfectants were introduced: DZPT-2 in concentrations of 3.0%, 3.5%, 4.0%, 4.5%, 5.0% under exposures for 3, 6, and 12 hours and Dixclor in concentrations of 0.0005%, 0.00010%, 0.00015%, 0.00020%, 0.24% for 12 and 24 hours. After the appropriate exposures of the test culture of *Trichuris* eggs, they were washed four times in distilled water. A control test culture of *T. skrjabini* eggs was prepared separately, and distilled water was added to it. After that, Petri dishes with egg cultures were placed in a thermostat at a temperature of 25 °C and cultivated for 54 days until motile larvae appeared in the eggs. Every day, experimental and control egg

cultures were aerated and, if necessary, moistened. The test for each disinfectant was repeated three times. On the 54th day, the ovicidal efficiency (OE, %) of disinfectants was determined according to the method (Volkov & Simonov, 1977).

The morphometric parameters of *T. skrjabini* eggs (egg length and width, n = 20) during cultivation were studied using ImageJ for Windows® software (version 2.00) in interactive mode. Microphotography was carried out using a Sigeta M3CMOS 14000 14.0 MP digital camera (China).

Statistical processing of the experimental results was carried out using Statistica 10 (StatSoft Inc., USA) software. Standard deviation (SD) and average values (\bar{x}) were calculated. Significance of difference between average values was established using one-way analysis of variance and F-test for 95% confidence level.

Results

The conducted studies established that DZPT-2 showed a high level of ovicidal efficiency against *T. skrjabini* eggs in laboratory conditions at the concentration 4.5% and exposure for 6 h (OE 97.5%) and 12 h (OE 100%), and at 5.0% and exposure 3–12 h (OE 100%, Table 1).

Table 1

The effect of the disinfectant DZPT-2 on the viability of *Trichuris skrjabini* eggs during embryogenesis ($\bar{x} \pm SD$, n = 3)

| Mode of application | | Parameters, % | | OE, % |
|---------------------|--------------|------------------------------------|---------------------------------------|-------|
| concentration, % | exposure, hr | formation of motile larvae in eggs | destructive changes and death of eggs | |
| 3.0 | 3 | 70.3 ± 1.5 | 29.7 ± 1.5 | 13.5 |
| | 6 | 64.3 ± 3.5 | 35.7 ± 3.5 | 20.9 |
| | 12 | 56.3 ± 5.1 | 43.7 ± 5.1 | 30.7 |
| 3.5 | 3 | 49.3 ± 4.5 | 50.7 ± 4.5 | 39.3 |
| | 6 | 44.3 ± 5.8 | 55.7 ± 5.8 | 45.5 |
| | 12 | 36.7 ± 5.0 | 63.3 ± 5.0 | 54.9 |
| 4.0 | 3 | 32.3 ± 4.0 | 67.7 ± 4.0 | 60.2 |
| | 6 | 20.7 ± 3.5 | 79.3 ± 3.5 | 74.6 |
| | 12 | 13.7 ± 3.2 | 86.3 ± 3.2 | 83.2 |
| 4.5 | 3 | 10.3 ± 1.5 | 89.7 ± 1.5 | 87.3 |
| | 6 | 2.0 ± 1.0 | 98.0 ± 1.0 | 97.5 |
| | 12 | – | 100.0 | 100.0 |
| 5.0 | 3 | – | 100.0 | 100.0 |
| | 6 | – | 100.0 | 100.0 |
| | 12 | – | 100.0 | 100.0 |
| Control | | 81.3 ± 4.5 | 18.7 ± 4.5 | – |

Note: OE – ovicidal efficiency (%).

A satisfactory ovicidal efficiency was established when using DZPT-2 at 4.0% at exposures of 3–12 h (60.2–83.2%), as well as at 5.5% at exposure of 3 h (87.3%). The agent in 3.0% and 3.5% concentrations at exposures of 3–12 h showed an unsatisfactory level of ovicidal efficiency, the relevant indicators ranged from 13.5% to 54.9%. Under these regimes, 36.7% to 70.3% of eggs continued to develop to the stage of formation of mobile larvae.

The ovicidal effect of DZPT-2 on the viability of *T. skrjabini* eggs was characterized by specific morphological changes in nematode eggs as a stop in development at the bean-like embryo stage (Fig. 1a), accumulation of air bubbles under the egg shell (Fig. 1b), death and resorption of the embryo, as well as thinning of the shell (Fig. 1c).

Dixclor was also effective in terms of indicators of ovicidal action on the viability of *T. skrjabini* eggs. However, these indicators depended on the concentration and exposure of the disinfectant (Table 2).

A high level of ovicidal efficiency of the agent (OE 100%) was established when it was applied to test cultures of *Trichuris* eggs at a concentration of 0.24% for 12 and 24 hours. A satisfactory level of ovicidal efficiency was established when applying Dixclor at 0.0002% for 12–24 h (60.2–78.7%), as well as at 0.00015% for 24 h (73.4%). The agent in concentrations of 0.00005% (exposure 12–24 h), 0.0001% (exposure 12–24 h) and 0.00015% (exposure 12 h) showed an unsatisfactory level of ovicidal efficiency, OE ranged from 23.0% to 48.8%. Under these regimes, 41.7% to 62.7% of eggs continued to develop until the stage of formation of mobile larvae.

The ovicidal effect of Dixclor on the viability of *T. skrjabini* eggs was characterized by specific morphological changes in nematode eggs in the form of a stop in development at the bean-like embryo stage and shell deformation (Fig. 2a), loosening of the embryo (Fig. 2b), accumulation of air bubbles under the egg shell and swelling of the plugs (Fig. 2c), resorption of the embryo (Fig. 2d).



Fig. 1. Morphological changes in the eggs of *T. skrjabini* under the effect of the disinfectant DZPT-2 on the 54th day of cultivation: *a* – arrested development and accumulation of air bubbles under the shell; *b* – resorption of the embryo; *c* – thinning and destruction of the shell, resorption of the embryo

In the control test culture, on the 54 day of cultivation, 81.3 ± 4.5% of the eggs were viable with a mobile larva inside (Fig. 3).

When determining the ovicidal effect of disinfectants on the viability of *T. skrjabini* eggs during embryogenesis, the morphometric parameters of eggs were determined using the most effective concentrations and

exposures of disinfectants. It was established that under the action of 5.0% DZPT-2 for 12 h on the 54th day of cultivation, the length of the eggs was lower by 3.9% ($72.0 \pm 2.0 \mu\text{m}$, $P < 0.001$), and their width was greater by 5.1% ($35.0 \pm 0.8 \mu\text{m}$, $P < 0.001$) compared to similar indicators of *Trichuris* eggs of the control test culture (74.9 ± 2.5 and $33.3 \pm 1.1 \mu\text{m}$, Fig. 4).

The harmful effect of 0.24% Dixclor for 24 hours on the 54th day of cultivation was characterized by changes in the length and width of the eggs. In particular, the length of the eggs was also lower by 3.9% ($72.0 \pm 2.0 \mu\text{m}$, $P < 0.001$), and their width was also greater by 4.8% ($34.9 \pm 0.8 \mu\text{m}$, $P < 0.001$) compared to the similar parameters of the eggs of *Trichuris* control test culture (Fig. 5).

Table 2

The effect of the disinfectant Dixclor on the viability of *Trichuris skrjabini* eggs during embryogenesis ($x \pm \text{SD}$, $n = 3$)

| concentration, % | Mode of application exposure, hr | Parameters, % | | OE, % |
|------------------|----------------------------------|------------------------------------|---------------------------------------|-------|
| | | formation of motile larvae in eggs | destructive changes and death of eggs | |
| 0.00005 | 12 | 62.7 ± 3.1 | 37.3 ± 3.1 | 23.0 |
| | 24 | 51.3 ± 2.1 | 48.7 ± 2.1 | 36.9 |
| 0.00010 | 12 | 51.0 ± 3.0 | 49.0 ± 3.0 | 37.3 |
| | 24 | 38.0 ± 2.0 | 62.0 ± 2.0 | 53.3 |
| 0.00015 | 12 | 41.7 ± 2.5 | 58.3 ± 2.5 | 48.8 |
| | 24 | 21.7 ± 2.5 | 78.3 ± 2.5 | 73.4 |
| 0.00020 | 12 | 32.3 ± 4.0 | 67.7 ± 4.0 | 60.2 |
| | 24 | 17.3 ± 2.1 | 82.7 ± 2.1 | 78.7 |
| 0.24 | 12 | – | 100.0 | 100.0 |
| | 24 | – | 100.0 | 100.0 |
| Control | | 81.3 ± 4.5 | 18.7 ± 4.5 | – |

Note: see Table 1.

In the control test culture, the embryogenesis of *T. skrjabini* was accompanied by changes in the morphometric indicators of eggs. On the 54th day of cultivation, the length of eggs had increased by 4.2% ($74.9 \pm 2.5 \mu\text{m}$, $P < 0.001$), and the width of eggs, on the contrary, had decreased by 4.9% ($33.3 \pm 1.1 \mu\text{m}$, $P < 0.001$) compared to similar indicators before cultivation (71.9 ± 2.4 and $35.0 \pm 1.4 \mu\text{m}$, Fig. 6).

Therefore, disinfectants are the most effective in the following concentrations: DZPT-2 (4.5%, exposures of 6–12 h and 5.0%, exposures of 3–12 h), and Dixclor (0.24%, exposures of 12 and 24 h) and can be used in the treatment and prevention of trichuriasis in livestock farms.

Discussion

According to scientific data, nematodes of the gastrointestinal tract of sheep cause common invasive diseases in many countries of the world. Among the representatives of the nematode fauna in ruminants, helminths of the genus *Trichuris* are often recorded. In sheep, *Trichuris* are represented by the species *T. skrjabini*, *T. ovis* and *T. globulosa* (de Souza et al., 2013; Melnychuk et al., 2020; Bhattacharjee et al., 2021). This prevalence is due to the high stability of *Trichuris* at the exogenous stages of their development in the external environment (Ghiglietti et al., 1995; Yevstafieva et al., 2018). It is also known that the eggs of *A. suum* and *T. suis* are much more resistant to environmental factors than the free-living invasive larvae of strongyloidiasis of the digestive organs (Roepstorff & Murrell, 1997).

Disinfestation plays an important role in the comprehensive provision of veterinary welfare for parasitic diseases, especially geohelminthiasis, in livestock farms. This is due to the fact that infested animals release parasite eggs with their feces, which contaminate the environment with propagative stages. This leads to their long-term storage in the environment and is one of the links in the epizootic chain of invasion (Sinniah, 1982; Bojar & Klapeč, 2018; Lindgren et al., 2019).

Scientists recommend different protocols for disinfestation using various disinfectants that have different ovicidal efficacy against certain causative agents of animal and human nematodosis (Oh et al., 2016; Bessat & Dewair, 2019; Zhang et al., 2020). Therefore, we evaluated the effects of DZPT-2 (a mixture of glutaraldehyde, sodium dodecyl sulfate, essential oil) and Dixclor (a mixture of sodium bisulfate, sodium chlorite, sodium percarbonate) at different concentrations and exposures on the

viability of *T. skrjabini* eggs during embryogenesis in laboratory conditions.

According to the instructions, DZPT-2 is a solution for disinfection. The active ingredient is glutaraldehyde, sodium dodecyl sulfate is a surface-active substance of an anionic nature, which gives the preparation cleansing properties, and essential oil gives the preparation deodorizing properties. The solution is safe to use, it foams, has deodorizing properties,

is easily washed off with water, has a harmful effect on mycobacteria and microscopic fungi. The other tested solution, Dixclor is presented in the form of tablets that easily dissolve in water, forming chlorine dioxide, which does not release active chlorine, and its main active substance is oxygen. That disinfectant is a highly oxidizing product, free of toxic substances, which does not change the chemical composition of water after disinfection, there is no withdrawal period.

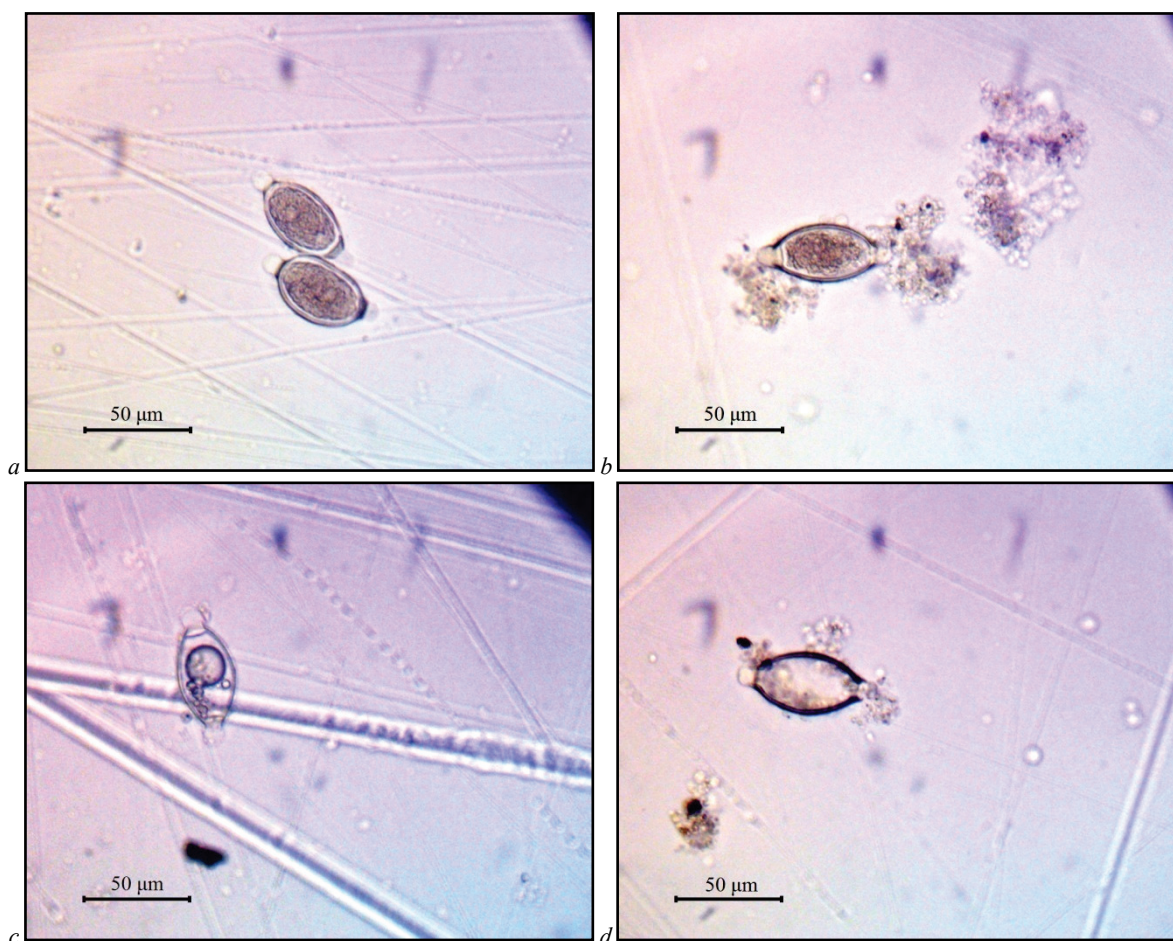


Fig. 2. Morphological changes in the eggs of *T. skrjabini* under the effect of the disinfectant Dixclor on the 54th day of cultivation: *a* – arrested development at the stage of the bean-like embryo and deformation of the shell; *b* – loosening of the embryo; *c* – accumulation of air bubbles under the shell and swelling of plugs; *d* – resorption of the embryo



Fig. 3. The formation of motile larvae in *T. skrjabini* eggs in the control test culture on the 54 day of cultivation

The conducted studies established a high level of ovicidal efficiency of DZPT-2 against *T. skrjabini* eggs in concentrations of 4.5% at exposures of 6 and 12 h (97.5% and 100%, respectively) and 5.0% at exposures of 3–12 h (100%). A satisfactory level of ovicidal efficiency was

established when the agent was used in lower concentrations: 4.0% at exposures of 3–12 hours (60.2–83.2%) and 5.5% at exposures of 3 hours (87.3%). An unsatisfactory level of ovicidal efficiency was found when the product was exposed to *Trichuris* eggs at the lowest concen-

trations of 3.0% and 3.5% during exposures of 3–12 h (13.5–54.9%). In the case of Dixclor, its ovicidal efficiency against the viability of *T. skrjabini* eggs, was high at the 0.24% concentration at exposures of 12 and 24 hours (100%). A satisfactory level of ovicidal efficiency was established when using the agent in concentrations of 0.0002% at exposures of 12–24 hours (60.2–78.7%), 0.00015% at exposures of 24 hours (73.4%). An unsatisfactory level of ovicidal efficiency was found when *Trichuris* eggs were treated with Dixclor in concentrations of 0.00005% and 0.00010% at exposure of 12–24 h (23.0–53.3), 0.00015% at exposure of 12 h (48.8%).

The high level of ovicidal efficiency of disinfectants based on glutaraldehyde is evidenced by other studies. For example, the efficiency indicators relative to test cultures of *Toxocara canis* eggs at a concentration of 2.0–4.0% and exposure of 3–24 h ranged from 90.6% to 99.7% (Paliy et al., 2020). Also, high ovicidal efficiency is noted for Dezsan (91.1–100%), which includes glutaraldehyde, in 1–2% concentration after exposure for 10–60 min (Melnychuk & Yuskiv, 2018). In other studies, 0.20% and 0.02% sodium hypochlorite delayed, but did not inactivate, embryogenesis of *A. suum* eggs after three weeks of incubation, regardless of exposure. As for *T. canis* eggs, sodium hypochlorite caused degeneration in only 50% of eggs after a 24-day incubation period (Morrono et al., 2006; Oh et al., 2016).

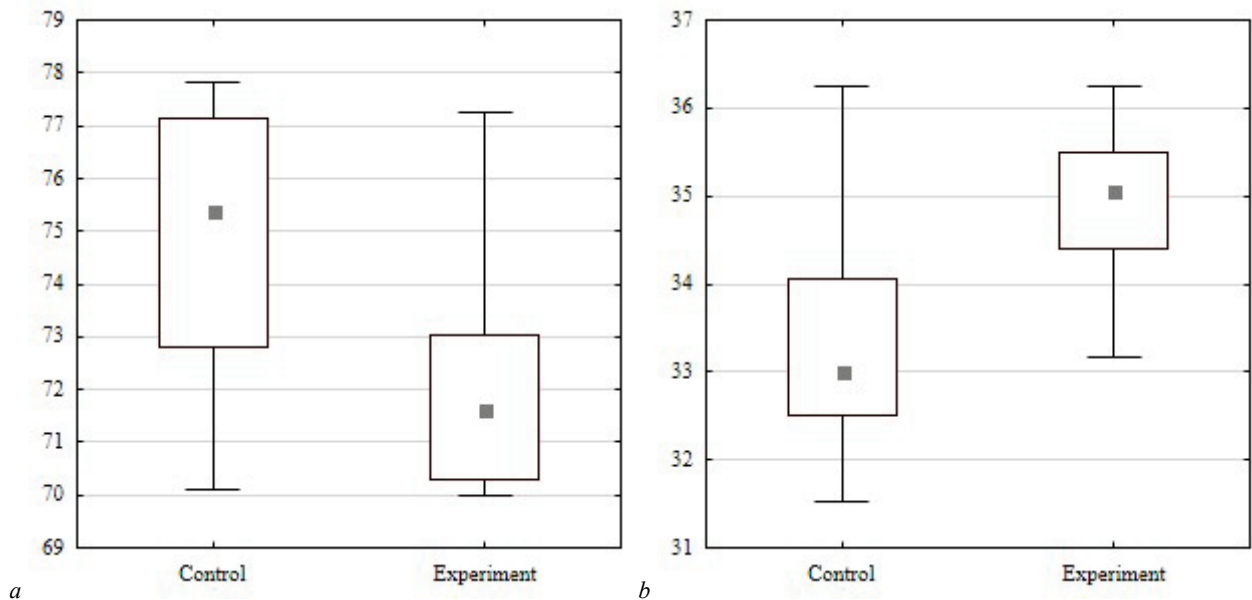


Fig. 4. Metric parameters of *T. skrjabini* eggs under the influence of 5.0% DZPT-2 (Experiment) for 12 h on the 54th day of cultivation: control – *T. skrjabini* eggs with distilled water; *a* – length of eggs, *b* – width of eggs (μm); the small square in the centre corresponds to the median, the lower and upper borders of the large rectangular correspond to the first and the third quartiles, respectively, vertical line segments, directed up and down from the rectangular, correspond to minimum and maximum values ($n = 20$)

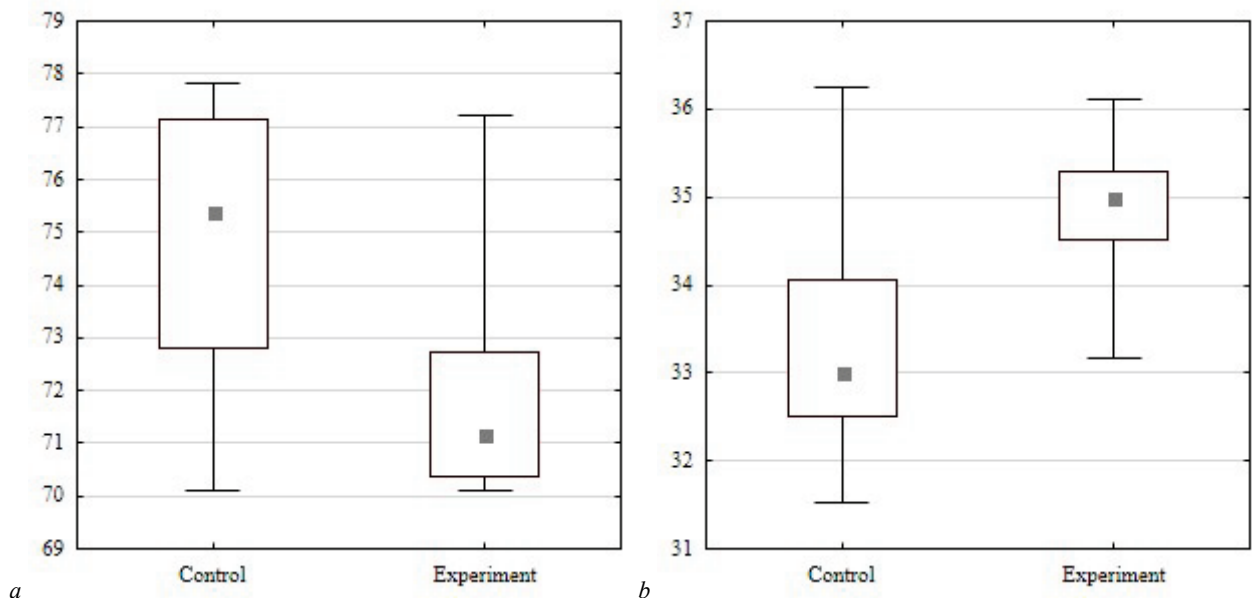


Fig. 5. Metric parameters of *T. skrjabini* eggs under the influence of 0.24% Dixclor (Experiment) for 24 h on the 54 day of cultivation: control – *T. skrjabini* eggs with distilled water; *a* – length of eggs, *b* – width of eggs (μm); see Fig. 4

Our research revealed morphological destructive changes in the test cultures of *T. skrjabini* under the treatment of the most effective concentrations of DZPT-2 and Dixclor. The changes in nematode eggs were characterized by the appearance and accumulation of air bubbles under the

egg shell, the arrest of embryonic development at the bean-like embryo stage, the loosening and resorption of the embryo, thinning, deformation and destruction of the shell, swelling of egg plugs. The changes in the morphological structure of parasite eggs under the action of disinfectants

have been shown in other studies. Thus, the outer layer of *T. canis* eggs peeled off, and the development of *A. suum* eggs was delayed as a result of exposure to chemicals (Verocai et al., 2010; Oh et al., 2016). The destructive changes in experimental test cultures of the eggs of *T. skrjabini* that we discovered were accompanied by changes in the morphometric parameters of eggs. In particular, on the 54 day of cultivation, the length of eggs was lower by 3.9% ($P < 0.001$), and their width was greater by 4.8–

5.1% ($P < 0.001$) compared to similar indicators in the control test culture. At the same time, in the control test culture, embryogenesis was accompanied by an increase in the length of eggs by 4.2% ($P < 0.001$) and a decrease in their width by 4.9% ($P < 0.001$). The obtained results allow us to recommend the tested disinfectants in defined and effective concentrations and exposures for effective control and prevention of trichuriasis on livestock farms.

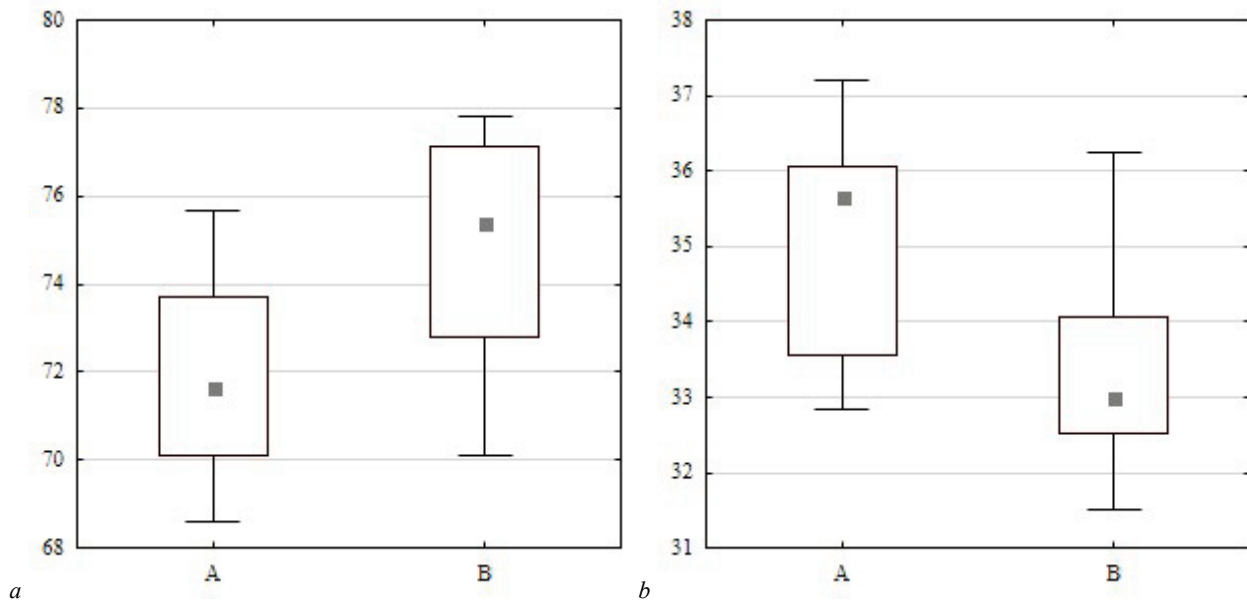


Fig. 6. Metric parameters of *T. skrjabini* eggs in control culture on the 54th day of cultivation: A – before cultivation, B – on the 54th day of cultivation; a – length of eggs, b – width of eggs (µm); see Fig. 4

Conclusion

The ovicidal efficiency of the mixture of glutaraldehyde, sodium dodecyl sulfate, and essential oil (DZPT-2), as well as the mixture of sodium bisulfate, sodium chlorite, and sodium percarbonate (Dixclor) on the viability of *Trichuris skrjabini* eggs during their embryogenesis was established by the experimental studies. A high level (97.5–100%) of ovicidal efficiency was noted of DZPT-2 in concentrations of 4.5% (exposure 6–12 h) and 5.0% (exposure 3–12 h), as well as Dixclor in a concentration of 0.24% (exposure 12 and 24 h). With decreasing concentration, the disinfectants showed a satisfactory (60.2–87.3%) and unsatisfactory (13.5–54.9%) level of ovicidal efficiency against *T. skrjabini* eggs. The destructive effect of disinfectants was accompanied by morphological changes in eggs, which were characterized by a stop in their development, resorption and deformation of the embryo, accumulation of air under the shell, swelling of egg plugs. Such changes were also confirmed by the metric parameters of the length and width of the eggs, which in the process of embryogenesis on the 54th day of the experiment turned out to be significantly different from the similar parameters of the eggs in the control test cultures.

The study was carried out within the framework of the initiative topic of scientific work “Monitoring, implementation of improved methods of diagnosis, treatment and prevention of invasive animal diseases” (state registration No. 0121U100644).

The authors state that there is no conflict of interest.

References

Bessat, M., & Dewair, A. (2019). Assessment of the inhibitory effects of disinfectants on the embryonation of *Ascaridia columbae* eggs. *PLoS One*, 14(5), e0217551.
 Bhattacharjee, K., Bora, S., & Deka, D. K. (2021). Prevalence of gastrointestinal parasites in sheep of Assam, India. *International Journal of Current Microbiology and Applied Sciences*, 10(2), 1805–1812.

Blazkowska, J., Wojcik, A., Kumatowski, P., & Szwabe, K. (2013). Geohelminth egg contamination of children's play areas in the city of Lodz (Poland). *Veterinary Parasitology*, 192, 228–233.
 Bojar, H., & Klapeć, T. (2018). Contamination of selected recreational areas in Lublin Province, Eastern Poland, by eggs of *Toxocara* spp., *Ancylostoma* spp. and *Trichuris* spp. *Annals of Agricultural and Environmental Medicine*, 25(3), 460–463.
 Boyko, A. A., & Brygadyrenko, V. V. (2017). Changes in the viability of the eggs of *Ascaris suum* under the influence of flavourings and source materials approved for use in and on foods. *Biosystems Diversity*, 25(2), 162–166.
 Boyko, O. O., & Brygadyrenko, V. V. (2019a). The impact of acids approved for use in foods on the vitality of *Haemonchus contortus* and *Strongyloides papillosus* (Nematoda) larvae. *Helminthologia*, 56(3), 202–210.
 Boyko, O. O., & Brygadyrenko, V. V. (2019b). Nematicidal activity of aqueous solutions of plants of the families Cupressaceae, Rosaceae, Asteraceae, Fabaceae, Cannabaceae and Apiaceae. *Biosystems Diversity*, 27(3), 227–232.
 Boyko, O. O., & Brygadyrenko, V. V. (2021a). Nematicidal activity of aqueous tinctures of plants against larvae of the nematode *Strongyloides papillosus*. *Tropical Biomedicine*, 38(2), 85–93.
 Boyko, O., & Brygadyrenko, V. (2021b). Nematicidal activity of essential oils of medicinal plants. *Folia Oecologica*, 48(1), 42–48.
 Boyko, O., & Brygadyrenko, V. (2022). Nematicidal activity of inorganic food additives. *Diversity*, 14, 663.
 Cole, R., & Viney, M. (2018). The population genetics of parasitic nematodes of wild animals. *Parasites and Vectors*, 11(1), 590.
 de Souza, M., Pimentel-Neto, M., de Pinho, A. L., da Silva, R. M., Farias, A. C., & Guimarães, M. P. (2013). Seasonal distribution of gastrointestinal nematode infections in sheep in a semiarid region, Northeastern Brazil. *Brazilian Journal of Veterinary Parasitology*, 22(3), 351–359.
 Dunn, J. J., Columbus, S. T., Aldeen, W. E., Davis, M., & Carroll, K. C. (2002). *Trichuris vulpis* recovered from a patient with chronic diarrhea and five dogs. *Journal of Clinical Microbiology*, 40(7), 2703–2704.
 Fernando, S. U., Udagama, P., & Fernando, S. P. (2021). Effect of urbanization on zoonotic gastrointestinal parasite prevalence in endemic toque macaque (*Macaca sinica*) from different climatic zones in Sri Lanka. *International Journal for Parasitology: Parasites and Wildlife*, 17, 100–109.
 Gao, X., Wang, H., Li, J., Qin, H., & Xiao, J. (2017). Influence of land use and meteorological factors on the spatial distribution of *Toxocara canis* and *Toxocara cati* eggs in soil in urban areas. *Veterinary Parasitology*, 233, 80–85.

- Ghiglietti, R., Rossi, P., Ramsan, M., & Colombi, A. (1995). Viability of *Ascaris suum*, *Ascaris lumbricoides* and *Trichuris muris* eggs to alkaline pH and different temperatures. *Parassitologia*, 37, 229–232.
- Gortari, C., Cazau, C., & Hours, R. (2007). Nematophagous fungi of *Toxocara canis* eggs in a public park of La Plata, Argentina. *Revista Iberoamericana de Micología*, 24(1), 24–28.
- Klementowicz, J. E., Travis, M. A., & Grecis, R. K. (2012). *Trichuris muris*: A model of gastrointestinal parasite infection. *Seminars in Immunopathology*, 34(6), 815–828.
- Lindgren, K., Gunnarsson, S., Höglund, J., Lindahl, C., & Roepstorff, A. (2019). Nematode parasite eggs in pasture soils and pigs on organic farms in Sweden. *Organic Agriculture*, 10, 289–300.
- Maia Filho, de S. F., Nunes Vieira, J., Aires Beme, M. E., Stoll, F. E., Nascente, da S. P., Pötter, L., & Brayer Pereira, D. I. (2013). Fungal ovicidal activity on *Toxocara canis* eggs. *Revista Iberoamericana de Micología*, 30(4), 226–230.
- Mejer, H., & Roepstorff, A. (2006). *Ascaris suum* infections in pigs born and raised on contaminated paddocks. *Parasitology*, 133(3), 305–312.
- Mekonnen, G. (2021). A review on gastrointestinal nematodes in small ruminants. *Advances in Applied Science Research*, 12(7), 32.
- Melnychuk, V., & Yuskiv, I. (2018). Disinvasive efficacy of chlorine-based preparations of domestic production for eggs of nematodes of the species *Aonchotheca bovis* parasitizing in sheep. *Ukrainian Journal of Veterinary and Agricultural Sciences*, 1(2), 15–18.
- Melnychuk, V., Yevstafieva, V., Bakhur, T., Antipov A., & Feshchenko D. (2020). The prevalence of gastrointestinal nematodes (*Ostheopries*) in the central and south-eastern regions of Ukraine. *Turkish Journal of Veterinary and Animal Sciences*, 44(5), 985–993.
- Morrondo, P., Díez-Morrondo, C., Pedreira, J., Díez-Baños, N., Sánchez-Andrade, R., Paz-Silva, A., & Díez-Baños, P. (2006). *Toxocara canis* larvae viability after disinfectant-exposition. *Parasitology Research*, 99(5), 558–561.
- Oh, K. S., Kim, G. T., Ahn, K. S., & Shin, S. S. (2016). Effects of disinfectants on larval development of *Ascaris suum* eggs. *Korean Journal of Parasitology*, 54(1), 103–107.
- Paliy, A. P., Sumakova, N. V., Rodionova, K. O., Nalivayko, L. I., Boyko, V. S., Ihnatieva, T. M., Zhigalova, O. Y., Dudus, T. V., Anforova, M. V., & Kazakov, M. V. (2020). Disinvasive action of aldehyde and chlorine disinfectants on the test-culture of *Toxocara canis* eggs. *Ukrainian Journal of Ecology*, 2020, 10(4), 175–183.
- Roepstorff, A., & Murrell, K. D. (1997). Transmission dynamics of helminth parasites of pigs on continuous pasture: *Ascaris suum* and *Trichuris suis*. *International Journal for Parasitology*, 27(5), 563–572.
- Shalaby, H. A., Abdel-Shafy, S., Ashry, H. M., El-Moghazy, F. M. (2011). Efficacy of hydrogen peroxide and dihydroxy benzol mixture (disinfectant) on *Toxocara canis* eggs. *Research Journal of Parasitology*, 6, 144–150.
- Shears, R. K., & Grecis, R. K. (2022). Whipworm secretions and their roles in host-parasite interactions. *Parasites and Vectors*, 15(1), 348.
- Simniah, B. (1982). Daily egg production of *Ascaris lumbricoides*: The distribution of eggs in the faeces and the variability of egg counts. *Parasitology*, 84(1), 167–175.
- Tariq, K. A. (2015). A review of the epidemiology and control of gastrointestinal nematode infections of small ruminants. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences*, 85, 693–703.
- Verocai, G. G., Tavares, P. V., Ribeiro, F. de A., Correia, T. R., & Scott, F. B. (2010). Effects of disinfectants on *Toxocara canis* embryogenesis and larval establishment in mice tissues. *Zoonoses and Public Health*, 57, 213–216.
- Volkov, F. A., & Simonov, A. P. (1977). Metod opredelenija ovocidnoj i larvocidnoj jeffektivnosti razlichnyh sredstv [Method for determining the ovicidal and larvocidal effectiveness of different agents]. *Bulletin of the All-Union Order of the Red Banner of Labor K. I. Scriabin Institute of Helminthology*, 19, 47–50 (in Russian).
- Yevstafieva, V. A., Yuskiv, I. D., Melnychuk, V. V., Yasnolob, I. O., Kovalenko, V. A., & Horb, K. O. (2018). Nematodes of the genus *Trichuris* (Nematoda, Trichuridae) parasitizing sheep in central and south-eastern regions of Ukraine. *Vestnik Zoologii*, 52(3), 553–556.
- Zhang, S., Angel, C., Gu, X., Liu, Y., Li, Y., Wang, L., Zhou, X., He, R., Peng, X., Yang, G., & Xie, Y. (2020). Efficacy of a chlorocresol-based disinfectant product on *Toxocara canis* eggs. *Parasitology Research*, 119(10), 3369–3376.