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SURVIVAL RATES OF EGGS OF *TRICHURIS MYOCASTORIS* (NEMATODA, TRICHURIDAE) UNDER DIFFERENT TEMPERATURE REGIMES

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Survival Rates of Eggs of *Trichuris myocastoris* (Nematoda, Trichuridae) under Different Temperature Regimes. Mykhailiutenko, E., Kruchynenko, O., Mykhailiutenko, S., Peredera, O., Peredera, R., Kone, M., Syzonenko, N., Volovyk, L. — The environmental temperature is one of the most important abiotic factors that significantly affects the development and survival of exogenous stages of development of parasitic nematodes, especially geohelminths. This study aimed to evaluate the effect of temperature on the survival and development of eggs isolated from the gonads of female nematodes *Trichuris myocastoris* Enigk, 1933, under laboratory conditions in vitro. Experimental studies demonstrated that at a temperature regime from 15°C to 35 °C, the duration of formation of motile larvae in egg cultures ranged from 35 to 170 days, and their survival rates ranged from 61.0 to 87.7%. At a temperature regime of 25 °C the largest number of viable eggs of *T. myocastoris* was formed, 87.7%. The shortest period of larval formation in eggs was 35 days at a temperature of 35 °C, with 73.7% of viable eggs. The period of embryogenesis lasted 35 days at 35 °C, 55 days at 25 °C, and 170 days at 15 °C. The lethality rate of eggs of *T. myocastoris*, depending on the cultivation temperature, varied significantly and was 26.3% at a temperature of 35 °C, 12.3% at 25 °C, and 39.0% at 15 °C. The growth and development of eggs during embryogenesis is accompanied by changes in their morphometric indicators. Depending

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on the temperature regime, we observed an increase of egg length by 2.2–4.5%, a decrease in egg width and shell thickness by 4.7–6.9% and 19.2–28.0%, respectively.

Key words: *Trichuris myocastoris*, nutria, nematode eggs, exogenous development, effect of temperature.

Introduction

Parasitism is widespread in nature. Parasites include species that are considered pathogenic to plants, animals and humans. Over long periods of evolution, parasites must adapt to different environments and conditions to ensure their survival in a wide range of hosts and environmental conditions (Baer, 1951; Lincicome, 1971; Matuska-Łyżwa et al., 2024).

For helminths, especially geohelminths, one of the factors favouring their transmission and distribution is the high resistance of embryonic stages of development to adverse environmental factors (Black et al., 1982; Simonato et al., 2019; Cociancic et al., 2020; Mohaghegh et al., 2021).

Among the abiotic factors that significantly affect the development and survival of geohelminth eggs, one of the most important is temperature, which affects the development of infective eggs and the possibility of further infection of susceptible animals (Gamboa, 2005; Manfredi, 2006; Yevstafieva et al., 2020 a; Yevstafieva et al., 2022). Each parasitic species requires a different time for development depending on the temperature (Mirzayans, 1969; Young et al., 1980; van Dijk & Morgan, 2008; Ashad et al., 2013).

Whipworms of the genus *Trichuris* Roederer, 1761 at the exogenous stages of development are among the most resistant nematodes, which is associated with the structures of their egg shells (Meng et al., 1986; Ghiglietti et al., 1995; Roepstorff & Murrell, 1997; Mahmoud, 2002). At the same time, the duration of embryogenesis, survival rates and the number of infective eggs for different species of *Trichuris* also depend on the temperature regime. Various studies demonstrated that the embryonic period for *T. trichiura* Linnaeus, 1758, *T. muris* Schrank, 1788 and *T. vulpis* (Froelich, 1789) Smith, 1908 ranged from 9 to 37 days at temperature fluctuations from 25 to 35 °C (Beer, 1971, 1976). It was experimentally confirmed that the optimal temperature for the formation of the maximum number of infective eggs of *T. ovis* Abildgaard, 1795 and *T. globulosa* Linstow, 1901, isolated from sheep, was 27 °C, at which 84.3 and 76.3% of viable eggs were formed on days 30 and 39, respectively (Melnychuk & Berezovsky, 2018). In another study, the optimal temperature for the development of eggs of *T. globulosa*, isolated from cattle, was 25 °C, at which the largest number of infective eggs, 76.3%, was formed in 48 days. When the temperature decreased to 20 °C or increased to 30 °C, the survival rate of nematode eggs decreased to 74.0 and 68.0%, and their maturation period was 56 and 32 days, respectively (Yevstafieva et al., 2020 b). For the eggs of *T. skrjabini* Baskakov, 1924, isolated from sheep, the optimal temperature was also 25 °C. At this temperature, the survival rate was higher and amounted to 80.3% on day 54. Less favouring to the process of embryogenesis were temperatures of 20 °C and 30 °C, at which 77.0 and 75.3% of infective eggs were formed on day 63 and 45, respectively (Yevstafieva et al., 2023). In a study of the effect of temperature on the development of eggs of *T. sylvila-*

gi Tiner, 1950, isolated *from Lepus europaeus*, it was found that the most favourable temperature was 30 °C, at which 88.67% of viable eggs were formed in 20 days under laboratory conditions. With a decrease in temperature to 20 °C, the embryogenesis period was extended to 32 days, and the number of formed infective eggs decreased to 68.0%. At a temperature of 10 °C, egg development did not occur (Yevstafieva et al., 2021).

The available literature contains very little data on the biology of *T. myocastoris* Enigk, 1933, as well as the influence of temperature on its embryogenesis (Fataliev, 2013). Notably, researchers have shown the widespread distribution of this parasite in *Myocastor coypus* (Molina, 1782). In particular, in the Czech Republic, *T. myocastoris* was one of the most common nematodes of nutria, the infection rates ranged from 37 to 40% (Nechybová et al., 2018; Benovics et al., 2025). In South America, the rate of infection of nutria was 13.8%, and in Poland it ranged from 7.2 to 34.2% (Scheuring, 1990; Martino et al., 2012). At the same time, there is very little information on the spread of trichuriasis among nutria in Ukraine. Thus, eggs of the genus *Trichuris* were found in 100% of the examined nutria (60 animals) kept in amateur farms in the Sumy region. Moreover, the intensity of trichuriasis was highest in February (up to 37.2 ± 4.62 eggs), and the lowest in March (1.9 ± 2.93 eggs) and May (16.0 ± 2.68 eggs) (Osadcha & Zon, 2016). The aim of the present study was to investigate the effect of temperature on the survival and development of eggs isolated from the gonads of female nematodes *T. myocastrois* under laboratory conditions in vitro.

Material and Methods

Experimental studies were conducted during 2024 in the Laboratory of Parasitology of Poltava State Agrarian University (Ukraine). Specimens of *T. myocastoris* were collected from the large intestines of nutria (*Myocastor coypus*). In laboratory, eggs were obtained from the gonads of *T. myocastoris* females and washed into Petri dishes (not less than 100 eggs per dish) (Fig. 1).

Egg were cultivated at three different temperatures: 15 °C, 25 °C and 35 °C until the appearance of motile larvae in the eggs. Every 5–10 days, depending on the temperature regime, morphological changes and the stage of embryo development were

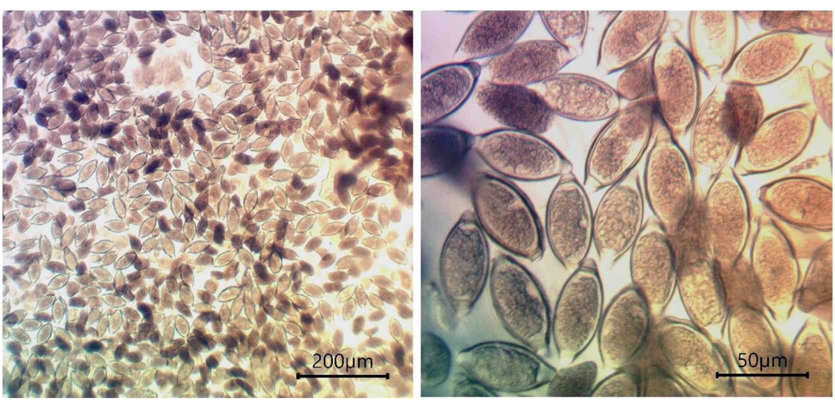

Fig. 1. Culture of eggs isolated from the gonads of female *Trichuris myocastoris*

identified in the cultures. The number of eggs at each stage of development was counted. The number of eggs that stopped developing or were destroyed was also calculated. In total, the cultivation of *T. myocastoris* eggs was carried out in three repetitions.

Morphometric parameters of *T. myocastoris* eggs during growth and development were studied using the ToupView program version × 64, 4.10.17015.20200426 (Hangzhou ToupTek Photonics Co., Ltd, China). Microphotography was performed using a SIGETA M3CMOS 14000 14.0 MP digital camera (China).

Standard deviation (SD) and average values (M) were calculated. Significance of the difference between average values in the studied *T. myocastoris* eggs (length, width and shell thickness) was calculated using one-way analysis of variance and F-test for 95 % confidence level.

Results and Discussion

In developing *T. myocastoris* eggs, regardless of the temperature regime, six stages of development were morphologically distinguished, namely: zygote (Fig. 2, *a*), cleavage and formation of blastomeres (Fig. 2, *b*), bean-like embryo (Fig. 2, *c*), tadpole-like embryo (Fig. 2, d), larval formation (Fig. 2, *e*) and formed motile larva (Fig. 2, *f*).

The duration of embryogenesis and the viability of eggs were significantly influenced by the temperature. Thus, at a temperature of 15 °C, the development of eggs was the longest and lasted 170 days. This temperature regime was the most unfavourable, since the smallest number of eggs reached the motile larval stage, 61.0 ± 2.0%, and the largest number of eggs died, 39.0 ± 2.0% (Table 1).

Before cultivation, all nematode eggs were at the zygote stage. During the experiment, the number of eggs at this stage gradually decreased to 8.0 ± 3.0% by day 80. Starting from day 10 of cultivation, eggs at the stage of cleavage and formation of blastomeres were detected in the amount of 20.7 ± 2.5%. On day 40, the largest number of eggs at this stage was detected, 44.0 ± 4.4%, and subsequently their number decreased to 7.0 ± 2.0% by day 90. Eggs at the bean-like stage were detected from day 40 in the amount of 7.0 ± 2.0%; on day 70 their maximum number was 41.0 ± 1.7%; and on day 130 there were only 3.7 ± 1.5%. Eggs at the tadpole-like stage were detected from day 70 in an amount of 8.7 ± 3.5%; on day 100 their number was the largest, 34.3 ± 1.2%; and on day 150 there were only 5.0 ± 3.0% of them. The formation of larvae in eggs was recorded from the 90th day in the amount of 8.3 ± 4.0%; on the 130th day their maximum number was 35.7 ± 4.5%; and on the 160th day there were only 5.3 ± 3.5% of them. The formation of mobile larvae in eggs was recorded from the 130th day in the amount of 8.3 ± 6.0%, the number of them increased and the maximum number was detected on the 170th day, 61.0 ± 2.0%. At the same time, the death of eggs was recorded from the 50th day of cultivation and subsequently their number gradually increased from 10.7 ± 2.5 to 39.0 ± 2.0%.

At a temperature of 25 °C, embryogenesis of *T. myocastoris* proceeded faster and on day 55 the largest number of eggs with motile larvae was formed, 87.7 ± 2.1% (Table 2).

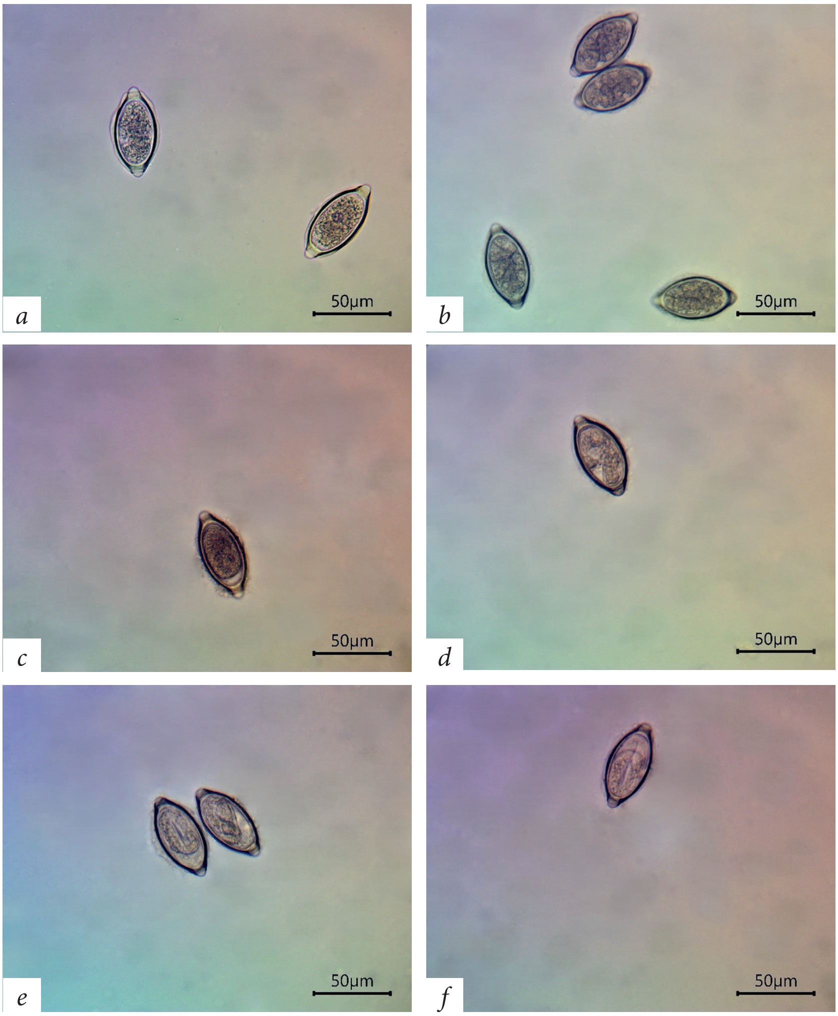

Fig. 2. *Trichuris myocastoris* eggs at different stages of development: *a* — zygote; *b* — cleavage and formation of blastomeres; *c* — bean-like embryo, *d* — tadpole-like embryo; *e* — larval formation; *f* — motile larva

During cultivation, the number of eggs at the zygote stage gradually decreased from 100.0% (before cultivation) to 4.3 ± 2.5% (on day 30). Starting from day 5 of cultivation, eggs at the stage of cleavage and formation of blastomeres were detected in the amount of 52.3 ± 3.1%. On day 10, the largest number of eggs at this stage was detected, 56.7 ± 2.1%, and subsequently that number decreased to 9.7 ± 4.0% on day 25. Eggs at the bean-like stage were detected from day 15 in the amount of 24.7 ± 3.1%; on day 20 their maximum number was 43.3 ± 6.1%; and on day 30 only 10.0 ± 4.4% of eggs were observed at this stage. Eggs at the tadpole-like stage were detected from day 20 in an amount of 15.3 ± 5.9%; on day 25 their number was maximum, 20.3 ± 4.2%, and on day 40 there were only 5.0 ± 1.7% of them remaining. The formation of larvae in eggs was recorded from the day 25 in the amount of 20.7 ± 2.5%; on day 35 their maximum number was 41.7 ± 3.1%; and on day 50 there were only 6.3 ± 2.5% of eggs

Table 1. **Indicators of embryogenesis of *Trichuris myocastoris* in laboratory culture at 15°C (n = 100, M ± SD)**

Day of study	Stage of development, %						Stopped development, egg death, %
	Zygote	Cleavage and blastomere formation	Bean-like embryo	Tadpole-like embryo	Formation of larva	Formation of motile larva	
Before cultivation	100.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
10	79.3 ± 2.5	20.7 ± 2.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
20	70.3 ± 5.5	29.7 ± 5.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
30	60.3 ± 2.1	39.7 ± 2.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
40	49.0 ± 6.2	44.0 ± 4.4	7,0 ± 2,0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
50	40.0 ± 2.0	34.0 ± 2.0	15.3 ± 2.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	10.7 ± 2.5
60	25.7 ± 9.3	30.3 ± 4.2	31.3 ± 6.7	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	12.7 ± 2.1
70	16.3 ± 6.7	14.0 ± 3.6	41.0 ± 1.7	8.7 ± 3.5	0.0 ± 0.0	0.0 ± 0.0	20.0 ± 1.0
80	8.0 ± 3.0	10.3 ± 1.2	39.3 ± 0.6	18.7 ± 3.8	0.0 ± 0.0	0.0 ± 0.0	23.7 ± 1.5
90	0.0 ± 0.0	7.0 ± 2.0	31.3 ± 1.5	27.3 ± 1.5	8.3 ± 4.0	0.0 ± 0.0	26.0 ± 2.6
100	0.0 ± 0.0	0.0 ± 0.0	19.0 ± 2.0	34.3 ± 1.2	18.3 ± 6.7	0.0 ± 0.0	28.3 ± 4.5
110	0.0 ± 0.0	0.0 ± 0.0	13.0 ± 2.0	27.3 ± 1.2	26.3 ± 5.7	0.0 ± 0.0	33.3 ± 3.5
120	0.0 ± 0.0	0.0 ± 0.0	8.7 ± 1.5	21.3 ± 3.2	34.7 ± 3.1	0.0 ± 0.0	35.3 ± 4.7
130	0.0 ± 0.0	0.0 ± 0.0	3.7 ± 1.5	15.0 ± 1.0	35.7 ± 4.5	8.3 ± 6.0	37.3 ± 1.5
140	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.0 ± 2.0	33.0 ± 9.2	18.7 ± 8.7	37.3 ± 1.5
150	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.0 ± 3.0	13.3 ± 2.5	43.7 ± 4.0	38.0 ± 2.6
160	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.3 ± 3.5	55.7 ± 4.7	39.0 ± 2.0
170	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	61.0 ± 2.0	39.0 ± 2.0

Table 2. **Indicators of embryogenesis of *Trichuris myocastoris* in laboratory culture at a temperature of 25°C (n = 100, M ± SD)**

Day of study	Stage of development, %						Stopped development, egg death, %
	Zygote	Cleavage and blastomere formation	Bean-like embryo	Tadpole-like embryo	Formation of larva	Formation of motile larva	
Before cultivation	100.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
5	47.7 ± 3.1	52.3 ± 3.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
10	35.7 ± 3.5	56.7 ± 2.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	7.7 ± 1.5
15	22.7 ± 5.0	43.3 ± 3.5	24.7 ± 3.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.3 ± 2.1
20	11.7 ± 3.1	19.3 ± 2.5	43.3 ± 6.1	15.3 ± 5.9	0.0 ± 0.0	0.0 ± 0.0	10.3 ± 3.1
25	9.7 ± 4.0	9.7 ± 4.0	29.3 ± 4.5	20.3 ± 4.2	20.7 ± 2.5	0.0 ± 0.0	10.3 ± 3.1
30	4.3 ± 2.5	0.0 ± 0.0	10.0 ± 4.4	16.0 ± 3.0	27.3 ± 7.6	31.3 ± 3.2	11.0 ± 2.6
35	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.7 ± 2.5	41.7 ± 3.1	35.0 ± 5.3	11.7 ± 2.5
40	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	5.0 ± 1.7	30.0 ± 2.6	53.0 ± 4.0	12.0 ± 2.0
45	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	11.3 ± 2.5	76.3 ± 3.8	12.3 ± 2.1
50	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	6.3 ± 2.5	81.3 ± 3.8	12.3 ± 2.1
55	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	87.7 ± 2.1	12.3 ± 2.1

Table 3. **Indicators of embryogenesis of *Trichuris myocastoris* in laboratory culture at a temperature of 35 °C (n= 100, M ± SD)**

Day of study	Stage of development, %						Stopped development, egg death, %
	Zygote	Cleavage and blastomere formation	Bean-like embryo	Tadpole-like embryo	Formation of larva	Formation of motile larva	
Before cultivation	100.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
5	17.7 ± 5.1	82.3 ± 5.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
10	8.0 ± 3.0	44.7 ± 5.5	27.0 ± 12.8	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	20.3 ± 5.5
15	4.0 ± 2.0	19.0 ± 2.6	42.3 ± 3.2	11.0 ± 2.0	0.0 ± 0.0	0.0 ± 0.0	23.7 ± 2.9
20	0.0 ± 0.0	3.3 ± 1.5	18.7 ± 3.5	32.7 ± 3.1	11.3 ± 3.1	8.7 ± 5.0	25.3 ± 3.1
25	0.0 ± 0.0	0.0 ± 0.0	4,0 ± 2,0	15.3 ± 1.2	24.7 ± 1.2	30.0 ± 2.0	26.0 ± 2.0
30	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	9.7 ± 5.7	64.0 ± 7.8	26.3 ± 2.5
35	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	73.7 ± 2.5	26.3 ± 2.5

at this stage. The mobile larvae in eggs were recorded from day 30 in the amount of 31.3 ± 3.2%; this number increased to 87.7 ± 2.1% by the day 55. At the same time, the dead eggs were recorded from the day 10 of cultivation and their number increased from 7.7 ± 1.5 to 12.3 ± 2.1% on day 55 (Table 2).

At a temperature of 35 °C, embryogenesis of *T. myocastoris* was the fastest, and on day 35 73.7 ± 2.5% of eggs contained motile larvae (Table 3).

In the process of development, the number of eggs at the zygote stage gradually decreased from 100.0% (before cultivation) to 4.0 ± 2.0% (on day 15). On day 5 of cultivation, the largest number of eggs at the stage of cleavage and formation of blastomeres was detected, 82.3 ± 5.1%. Subsequently, their number decreased to 3.3 ± 1.5% on day 20. Eggs at the bean-like stage were detected from day 10 in the amount of 27.0 ± 12.8%, on day 15 their maximum number was 42.3 ± 3.2%, and on day 25, there were only 4.0 ± 2.0% of them. Eggs at the tadpole-like stage were detected from day 15 in an amount of 11.0 ± 2.0%, on day 20 their number was maximum, 32.7 ± 3.1%, and on day 25 their number remained at 15.3 ± 1.2%. The formation of larvae in eggs was recorded from day 20 in the amount of 11.3 ± 3.1%; on day 25 their maximum number was 24.7 ± 1.2%; and on day 30 only 9.7 ± 5.7% of them remained. The formation of mobile larvae in eggs was first recorded on day 20 in the amount of 8.7 ± 5.0%, and during the experiment their number increased and reached maximum values on day 35, 73.7 ± 2.5%. The death of eggs was recorded from day 10 of cultivation and by the end of the experiment their number increased from 20.3 ± 5.5 to 26.3 ± 2.5%.

During the experiment, changes in egg width, length and thickness of the shell were recorded. In particular, the length of eggs with a mobile larva inside, regardless of the temperature regime of cultivation, was greater ($P < 0.001$) compared to similar indicators in eggs at the zygote stage. At a temperature of 15 °C, the length of these eggs increased by 3.9% (64.5 ± 1.9 μm), at a temperature of 25 °C by 4.5% (64.7 ± 1.6 μm), at a temperature of 35 °C by 2.2% (63.7 ± 1.8 μm) (Fig. 3).

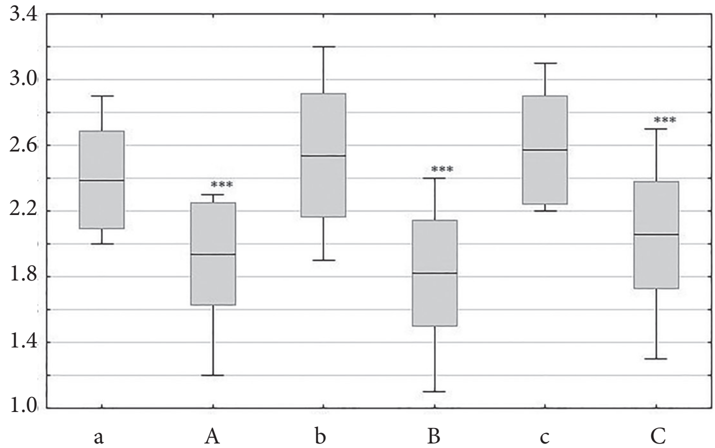

Fig. 3. Length of *Trichuris myocastoris* eggs during growth and development (μm): at 35 °C (a, A), at 25 °C (b, B), at 15 °C (c, C); zygote stage (a, b, c), stage of formation of a motile larva in the egg (A, B, C); *** P < 0.001 — relative to egg length at the zygote stage

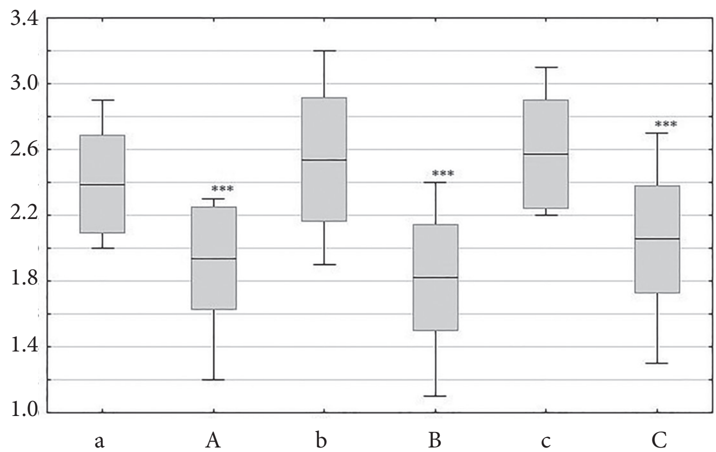

Fig. 4. Egg width of *Trichuris myocastoris* during growth and development (μm): at 35 °C (a, A), at 25 °C (b, B), at 15 °C (c, C); zygote stage (a, b, c), stage of formation of a motile larva in the egg (A, B, C); *** P < 0.001 — relative to egg width at the zygote stage

The width of infective eggs with a motile larva inside, regardless of the temperature regime of cultivation, on the contrary, turned out to be smaller (P < 0.001) compared to similar indicators in eggs at the zygote stage. At a temperature of 15 °C, the width of infective eggs decreased by 5.9% (28.8 ± 1.1 μm), at a temperature of 25 °C by 6.9% (28.3±1.3 μm), at a temperature of 35 °C — by 4.7% (28.7 ± 1.1 μm) (Fig. 4).

The thickness of the shell of infective eggs with a motile larva inside, regardless of the temperature regime of cultivation, also turned out to be smaller (P < 0.001) compared to similar indicator in eggs at the zygote stage. At a temperature of 15 °C, the shell thickness of infective eggs decreased by 19.2% (2.1 ± 0.3 μm), at a temperature of 25 °C by 28.0% (1.8 ± 0.3 μm), at a temperature of 35 °C by 20.8% (1.9 ± 0.3 μm) (Fig. 5).

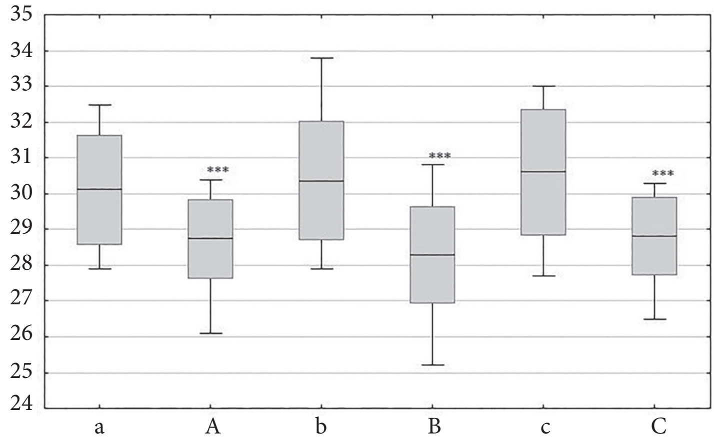

Fig. 5. Shell thickness of the eggs of *Trichuris myocastoris* during growth and development (μm): at 35 °C (a, A), at 25 °C (b, B), at 15 °C (c, C); zygote stage (a, b, c), stage of formation of a motile larva in the egg (A, B, C); *** $P < 0.001$ — relative to egg shell thickness at the zygote stage

The largest changes in the morphometric parameters of *T. myocastoris* nematode eggs were detected at a temperature of 25 °C, which was most favourable for the formation of viable eggs.

The available literature indicates that *T. myocastoris* is one of the most common nematodes in nutria (*Myocastor coypus*). This whipworm dwells in the large intestines (Martino et al., 2012; Nechybová et al., 2018; Benovics et al., 2025). It is known that the significant prevalence of geohelminths is associated with their high resistance to adverse environmental factors, including temperature, at exogenous stages of development (van Dijk & Morgan, 2008; Ashad et al., 2013; Yevstafieva et al., 2022). Therefore, it is relevant to study the influence of different temperature regimes on the growth, development and survival of *T. myocastoris* nematode eggs isolated from *Myocastor coypus*.

For the first time in Ukraine, the effect of different temperatures on embryogenesis and survival of *T. myocastoris* nematodes isolated from the intestines of nutria kept in farms of the Poltava region in a temperate climate zone was studied in vitro. Regardless of the temperature regime, 6 morphologically different stages of development were identified: zygote, cleavage and formation of blastomeres, bean-like embryo, tadpole-like embryo, larval formation, and formation of a motile larva. Similar data were obtained by researchers, who studied the developmental features of nematodes *T. ovis* and *T. globulosa* (Melnychuk & Berezovsky, 2018; Yevstafieva et al., 2020 b).

We found that the period of development of eggs of *T. myocastoris* with decreasing temperature was extended; at 35 °C it was the shortest — 35 days, at 25 °C it was extended to 55 days, and at 15 °C it was the longest — 170 days. The most favourable temperature for egg development was 25 °C, at which the largest number of eggs with a mobile larva was formed — 87.7%. With increasing and decreasing temperature, the viability of eggs decreased: at 35 °C 73.7% of eggs with a mobile larva were formed, and at 15 °C the smallest number of viable eggs was formed — 61.0%. In our opinion, the temperature optimum for egg development (+ 25 °C) corresponds to the average July temperature in the Poltava region, which is +21.4 °C. The study by Fataliev (2013) in Azerbaijan, where the climate is characterized by average fluctuations in July temperatures from +29 °C on the plains (maximum up to +44 °C) and to –2 °C in the highlands, reported that during experimental cultivation of *T. myocastoris* eggs isolated from local nutria, at higher temperatures the formation of infective larvae occurred faster depending on the substrate. Thus, at +25 °C eggs matured in 49–74 days. If the temperature increased to +37 °C under the same cultivation conditions, the formation of infective larvae happened in 19–23 days. The present study demonstrated that although the time of egg development is reduced at an increased temperature, the egg survival decreases, which is important for understanding the influence of temperature not only on the development time of *T. myocastoris* eggs, but also on their ability to survive at certain temperatures.

Other researchers reported that optimal temperature for the development of eggs of the *T. globulosa* and *T. skrjabini* was also 25 °C, at which the largest number of viable eggs was formed in 48 and 54 days, respectively –76.3 and 80.3% (Yevstafieva et al., 2020b; Yevstafieva et al., 2023). Notably, the embryonic development of *T. trichiura*, *T. muris* and *T. vulpis* ranges from 9 to 37 days at temperatures ranging from 25 to 35 °C (Beer, 1971, 1976).

We experimentally determined for the first time that the growth and development of *T. myocastoris* eggs under different temperature regimes was accompanied by an increase in egg length (by 2.2–4.5%, $P < 0.001$), a decrease in egg width (4.7–6.9%, $P < 0.001$) and a thinning of the egg shell (by 19.2–28.0%, $P < 0.001$). Different changes in the parameters of nematode eggs during their embryogenesis were demonstrated by other studies. For example, the development of *T. ovis* eggs was accompanied by the increase in their width, the thinning of the shell, as well as the decrease in the total length of the eggs and the length of their plugs. Similarly, the development of *T. globulosa* eggs was accompanied by the decrease in their length, the thinning of the shell with simultaneous increase in their width, and the development of *T. vulpis* eggs was accompanied by the decrease in their length and thickness of the shell, as well as the increase in the width of the eggs and their plugs (Melnychuk & Berezovsky, 2018; Yevstafieva et al., 2019).

Conclusion

The duration of development and the survival rate of eggs of *T. myocastoris* isolated from *Myocastor coypus* depend on temperature. In experimental cultivation at laboratory conditions, the most favourable temperature for embryo development was 25 °C, at which the largest number of eggs with motile larvae was formed, 87.7%. The least favourable temperature for the development of eggs was 15 °C, at which the lowest number of eggs with motile larvae was formed, 61.0%. At a temperature of 35 °C, the embryogenesis was the fastest and lasted 35 days, at a temperature of 25 °C it was extended to 55 days, and at a temperature of 15 °C it was the longest, 170 days. The growth and development of *T. myocastoris* eggs from the zygote stage to the stage of motile larva in the egg was accompanied by their morphometric changes: increase in egg length by 2.2–4.5%, decrease in egg width by 4.7–6.9% and thinning of the egg shell by 19.2–28.0%.

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