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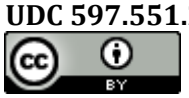

Lidiia Polotnianko, Olha Mekhed

CHANGES IN THE MORPHOLOGICAL INDICATORS OF CARP UNDER THE ACTION OF MYCOTOXIN T2

Лідія Полотнянко, Ольга Мехед

ЗМІНИ МОРФОЛОГІЧНИХ ПОКАЗНИКІВ КОРОПА ЗА ДІЇ МІКОТОКСИНУ Т2

ABSTRACT

Mycotoxins, toxic substances produced by fungi, are one of the most common contaminants of feed and food products in Ukraine. Favorable climatic conditions and anthropogenic influence contribute to their active development and spread. Contamination with mycotoxins can lead to significant economic losses in the agro-industrial complex and negatively affect the health of animals and people. A complete list and detailed description of poisoning symptoms can be used as indicators to identify poisons as well as non-infectious fish diseases.

The purpose of the work: to investigate the effect of mycotoxin T2 on the morphological parameters of the carp organism. The object of the study: peculiarities of changes in the morphological indicators of fish under the influence of mycotoxin T2. The subject of the study: the effect of mycotoxin T2 on external indicators of organs and tissues of carp.

Methodology. The object of the study were two-year-old carp: scaly and mirror carp (*Cyprinus carpio* L.) weighing 200-300 g. Experiments to study the effect of mycotoxin were carried out in 200-liter aquariums with settled tap water, in which fish were placed at the rate of 1 specimen per 40 dm^3 of water. In all cases, control was carried out and a constant hydrochemical regime of water was maintained. The concentration of mycotoxin corresponding to 2 MPC was achieved by adding calculated amounts of the mycotoxin solution. The zoological (L) and industrial (l) lengths of fish were determined, Fulton's fattening factor (Q). All results were processed statistically.

The scientific novelty of the work is that the complex effect of mycotoxin T2 and the morphological indicators of mirror carp and scaly carp were studied for the first time.

Conclusions. As a result of the study, a negative effect of mycotoxin T2 on the morphological parameters of the carp organism was established. Under the influence of T-2 toxin, significant changes in the structure of gills, skin, fins and internal organs were observed in fish. Discoloration of the ends of the petals, the appearance of light spots and numerous hemorrhages were found in the gills, which indicates a violation of oxygen exchange. On the skin of the fish, the formation of whitish mucus was recorded, as well as separate ulcers, which are a sign of dermonecrotic processes. It was also established that mycotoxin T2 causes disorders of a hemorrhagic nature, manifested in numerous hemorrhages in muscle tissues and organs of the digestive system. A comparative analysis of the effects of the toxin on scaly and mirror carp showed that scaly carp had higher endurance, which may be due to its better growth rates and resistance to adverse conditions. Thus, mycotoxin T2 poses a significant threat to fish health and can negatively affect aquaculture performance. This study highlights the need to control feed quality and mycotoxin content to prevent intoxication in fish farming.

Key words: scaly carp, morphological indicators, mycotoxin T2

АНОТАЦІЯ

Мікотоксини, токсичні речовини, що утворюються грибами, є одними з найпоширеніших забруднювачів кормів та продуктів харчування в Україні. Сприятливі кліматичні умови та антропогенний вплив сприяють їхньому активному розвитку та поширенню. Зараження мікотоксинами може призводити до значних економічних втрат в агропромисловому комплексі та негативно впливати на здоров'я тварин і людей. Повний перелік та детальна характеристика симптомів отруєння можуть бути використані як індикатори для визначення отрут, а також незаразних захворювань риб.

Мета роботи: дослідити вплив мікотоксину Т2 на морфологічні показники організму коропа. Об'єкт дослідження: особливості змін морфологічних показників риб за дії мікотоксину Т2. Предмет дослідження: вплив мікотоксину Т2 на зовнішні показники органів та тканин коропа.

Методологія. Об'єктом дослідження були двохлітні коропи: лускатий та дзеркальний (*Cyprinus carpio* L.) масою 200-300 г. Досліди по вивченню впливу мікотоксину проводили у 200-літрових акваріумах з відстояною водопровідною водою, в які рибу розміщували з розрахунку 1 екземпляр на 40дм^3 води. В усіх випадках здійснювався контроль та підтримувався постійний гідрохімічний режим води. Концентрацію мікотоксину, що відповідала 2 ГДК досягалася шляхом внесення розрахункових кількостей розчину мікотоксину. Визначали зоологічну (L) та промислову (l) довжини риб, коефіцієнт вгодованості за Фултоном (Q). Усі результати були оброблені статистично.

Наукова новизна роботи полягає у тому, що вперше вивчено комплексний вплив мікотоксину Т2 та морфологічні показники коропа дзеркального та коропа лускатого.

Висновки. У результаті дослідження було встановлено негативний вплив мікотоксину Т2 на морфологічні показники організму карпа. Під дією токсину Т2 у риб спостерігались суттєві зміни в структурі зябер, шкірних покривів, плавців та внутрішніх органів. У зябрах були виявлені знебарвлення кінців пелюсток, поява світлих плям та численні крововиливи, що вказує на порушення кисневого обміну. На шкірі риб зафіксовано утворення білуватого слизу, а також окремі виразки, що є ознакою дермонекротичних процесів. Також було встановлено, що мікотоксин Т2 викликає порушення геморагічного характеру, що проявляється у численних крововиливах у тканинах м'язів та органах травної системи. Порівняльний аналіз впливу токсину на лускатого та дзеркального карпа показав, що лускатий карп має вищу витривалість, що може бути пов'язано з його кращими темпами росту та стійкістю до несприятливих умов. Таким чином, мікотоксин Т2 становить значну загрозу для здоров'я риб та може негативно впливати на показники аквакультури. Це дослідження підкреслює необхідність контролю за якістю кормів та вмістом мікотоксинів для попередження інтоксикації в рибному господарстві.

Ключові слова: короп лускатий, морфологічні показники, мікотоксин Т2

Formulation of the problem

Fish and fish products are among the main ones human protein foods. Historically, production in the field of aquaculture was one of the most developed sectors of the Ukrainian economy. Pollution of agricultural products mycotoxins are a global problem: 25 % of the world of grain production is affected by mycotoxins, and 36 % of all plant diseases and related products with the effect of mycotoxins. Mycotoxins in feed cause such negative consequences, such as an increase in morbidity, are massive poisoning of farm animals, poultry and fish.

The degree of manifestation of which depends on the degree of infection feed with mycotoxins, as well as age, sex, species characteristics of animals, their physiological state and diet feeding (Fotina et al., 2013).

Mycotoxins are natural toxic compounds synthesized by some types of fungi during their growth on plant material. They can enter the environment through contaminated feed and affect the health of animals and people who consume contaminated products. Carps, which are one of the key commercial species in freshwater and aquaculture, were used in our study.

The purpose of the work: to investigate the effect of mycotoxin T2 on the morphological parameters of the carp organism. The object of the study: peculiarities of changes in the morphological indicators of fish under the influence of mycotoxin T2. The subject of the study: the effect of mycotoxin T2 on external indicators of organs and tissues of carp.

Materials and methods

The object of the study were two-year-old carp: scaly and mirror carp (*Cyprinus carpio* L.) weighing 200-300 g. Experiments to study the effect of mycotoxin were carried out in 200-liter aquariums with settled tap water, in which fish were placed at the rate of 1 specimen per 40 dm^3 of water. In all cases, control was carried out and a constant hydrochemical regime of water was maintained. The concentration of mycotoxin corresponding to 2 MPC was achieved by adding calculated amounts of the mycotoxin solution. The zoological (L) and industrial (l) lengths of fish (Musiyenko et al., 2005) and Fulton's fattening factor (Q) were determined. All results were processed statistically.

Results and Discussions

The biological effect of T-2 toxin on the body of animals is characterized by a wide spectrum of toxic effects. It includes dermonecrotic, lymphopenic, immunosuppressive, neurotoxic effects and a number of remote effects (Nikolaenko et al., 2023).

The dermonecrotic effect is manifested by exudative dermatitis and hyperkeratosis of the skin around the mouth, necrosis of mucous membranes (Figs.1, 2).

Fig. 1. Hemorrhages on the skin of fish

Fig. 2. Hemorrhages on the skin and fins of fish

Among other important and characteristic signs of T2 toxicosis is hemorrhagic syndrome, which is manifested by numerous hemorrhages in the muscles, under the serous and on the mucous membranes of the alimentary canal (Yatsenko et al., 2017). It is believed that the basis of the hemorrhagic syndrome is a decrease in the blood clotting process due to a decrease in the level of prothrombin and antithrombin 3, a decrease in the activity of antiplasmin with a simultaneous increase in the content of kinins, which cause the expansion of blood vessels and increase the permeability of capillaries (Fig. 3).

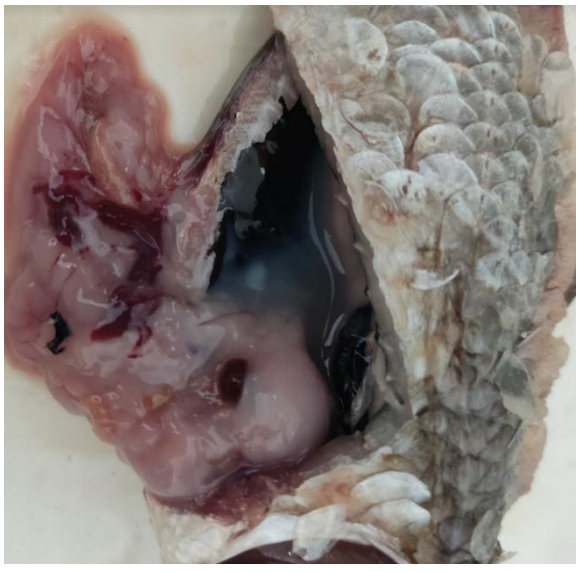

Fig. 3. Hemorrhages in the organs of the digestive tract

T2-toxin damages the intestinal mucosa, which leads to its ulceration, villous atrophy, and necrotic changes. The thickness of the intestinal wall decreases, and areas of destruction and inflammatory infiltration are observed in the epithelium. Violation of the morphology of the digestive tract affects the processes of digestion and assimilation of nutrients.

Disorganization of the structural architecture of the liver lobes, swelling of the intercellular space and destruction of membranes is observed. Pigments such as lipofuscin may accumulate in the cytoplasm of cells, indicating oxidative stress.

Figure 4 shows the liver of a carp exposed to mycotoxin T2.

Fig. 4. Morphological changes of carp organs under the action of mycotoxin

Indicative of T2 toxicosis is a violation of the morphological composition of the blood, manifested by leukopenia, lymphocytopenia, thrombocytopenia, and anemia. Hematological changes in T2 toxicosis are accompanied by degenerative and necrotic processes in immunocompetent organs and an immune-suppressive state. Central and peripheral organs of the immune system (red bone marrow, lymphoid formations of the intestine) are affected.

T2 toxin suppresses the body's immune functions. This is accompanied by a decrease in indicators of non-specific protection of the body (phagocytosis), the titer of natural antibodies, cellular (T lymphocytitis of their subpopulation) and humoral (immune-globulin) immunity.

It is believed that the main role in the pathogenesis of T2 toxicosis is played by the ability of T2 toxin to disrupt protein and nucleic acid synthesis.

At the molecular level, the inhibition of T2 protein synthesis by the toxin is associated with the blocking of translation initiation. Moreover, it was established that toxins capable of suppressing the initiation of translation have more pronounced toxic properties compared to those that affect the later stages of protein synthesis in ribosomes. Violation of protein synthesis is the result of the cytotoxic effect of T2 toxin (Mekhed, 2024). First of all, cells capable of active division, including the mucous membrane of the alimentary canal, hematopoietic tissues, ovaries, and testes, are affected by this. The appearance of a number of clinical signs in poisoning with trichothecene mycotoxins, including T2 toxin (hypodynamia, hypothermia, tachycardia) is associated with a violation of energy metabolism (Polotnianko & Mekhed, 2023).

In addition to the mentioned effects of the biological action of T2 toxin, a violation of the functional activity of cellular organelles – mitochondria, lysosomes, endoplasmic reticulum and the interaction of the toxin with the SH-groups of enzymes, as well as stimulation

of lipid peroxidation processes, is also characteristic.

The ability of T2 toxin to interact with the SH-groups of the active centers of enzymes is accompanied by a decrease in the activity of a number of systems that primarily ensure its metabolism and removal from the body (SH-glutathione).

Important importance in the biological action of T2 toxin is assigned to the state of lipid peroxidation (LPO) and the system of antioxidant protection of the body (AOZ). As a result of LPO stimulation, free radicals, lipid peroxides and hydroperoxides, reactive oxygen species (superoxide anion, peroxynitrite, nitric oxide, hydrogen peroxide) accumulate in the body, which can disrupt the structure and function of cell membranes. At the same time, the activity of the AOZ system, which is represented by enzymatic and non-enzymatic links, decreases. Suppression of the enzymatic link of AOZ is manifested by a decrease in the activity of enzymes: superoxide dismutase, glutathione peroxidase, glutathione reductase, catalase, etc. Violation of the non-enzymatic link of the AOZ is accompanied by a decrease in the level of natural antioxidants – tocopherols, vitamin A and carotenoids, vitamin D, ascorbic and uric acids in the blood and tissues of the body.

The differences in the obtained results of the quantitative indicators of the exterior of two-year-old carp when being in conditions of mycotoxin toxicity for 14 days (Table 1) are not reliable. At the same time, there is a tendency to decrease the mass of fish.

Table 1

Changes in carp exterior indicators under conditions of toxicosis (M±m, n=5)

Indicator	Physiological conditions	T2
Q	2,10±0,22	2,14±0,28
L, cm	29,60±2,40	27,70±2,27
l, cm	25,12±2,12	22,72±3,20
m, g	311,80±8,14	252,48±12,26

In order to more thoroughly study the effect of mycotoxin T2 on the body of fish, we studied the external changes of the integuments, fins and internal organs of the carp (Zhelai et al., 2023.). The results of the experiments are presented in Table 2.

Comparing the morphological changes under the action of mycotoxin in representatives of two breeds of carp, it is possible to draw a conclusion about greater endurance of scaly carp compared to mirror carp, which can be explained by better growth rates and endurance of scaly carp.

Conclusions

As a result of the study, a negative effect of mycotoxin T2 on the morphological parameters of the carp organism was established. Under the influence of T2 toxin, significant changes in the structure of gills, skin, fins and internal organs were observed in fish. Discoloration of the ends of the petals, the appearance of light spots and numerous hemorrhages were found in the gills, which indicates a violation of oxygen exchange. On the skin of the fish, the formation of whitish mucus was recorded, as well as separate ulcers, which are a sign of dermonecrotic processes. It was also established that mycotoxin T2 causes disorders of a hemorrhagic nature, manifested in numerous hemorrhages in muscle tissues and organs of the digestive system. A comparative analysis of the effects of the toxin on scaly and mirror carp showed that scaly carp had higher endurance, which may be due to its better growth rates and resistance to adverse conditions. Thus, mycotoxin T2 poses a significant threat to fish health and can negatively affect aquaculture performance. This study highlights the need to control feed quality and mycotoxin content to prevent intoxication in fish farming.

Table 2

Morphological changes of integuments, fins and internal organs of scaly (S) and mirror (M) carp under the influence of mycotoxin T2

Organ systems	Sign	Physiological conditions	T2	
			S	M
Gill	Discoloration of the ends of the petals	-	+	+
	White slime on the petals	-	+	+
	The presence of light spots	-	±	+
	Color change	-	+	+
	Uneven length of petals	-	+	+
	Hemorrhages on the gill covers	-	+	+
Skin coverings of the body	The presence of whitish mucus on the scales	-	+	+
	Numerous hemorrhages	-	-	-
	Ulcers at the base of the skull	-	-	-
	Ulcers	-	-	±
Fins	The lower blade of the tail is dark behind the upper	-	-	-
	Alone hemorrhages in the calves	-	+	+
	Numbers of hemorrhages in the calves and thoracic	-	-	-
Muscles	Turgor is weak, the body sags, it is pressed under the fingers	-	-	-
Heart	Color unevenness	-	-	-
	Dark red color	+	+	+
Hepatopancreas	Graininess of fabrics	-	±	±
	Pale color	-	-	-
	Disorders of the bile ducts	-	-	-
	Color uniformity	+	+	±
	Size increase	-	-	-
Bilious bladder	Increase in size	-	±	+
	Thin wall	-	±	±
	Changed color of bile	-	-	-
Intestine	The presence of stones	-	-	-

Note: + – sign is clearly expressed in all fish of the group; ± – sign is not present in all fish of the group; - – the sign is not expressed

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Набір даних доступний за запитом до авторів / Dataset available on request from the authors.

Заява інституційної ревізійної ради / Institutional Review Board Statement

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Заява про інформовану згоду / Informed Consent Statement

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Information about the authors:

Polotnianko L. [*in Ukrainian:* **Полотнянко Л.] [1],** Ph. D. student, email: chreglab@vetmed.gov.ua
ORCID: 0000-0001-8665-2648
Department of Biology, T.H. Shevchenko National University «Chernihiv Colehium»
53 Hetmana Polubotka Street, Chernihiv, 14013, Ukraine

Mekhed O. [*in Ukrainian:* **Мехед О.] [2],** Cand. Sc. (Biol.), D. Sc. (Pedagogics), Prof., email: mekhedolga@gmail.com
ORCID: 0000–0001–9485–9139 Scopus Author ID: 6506181994 ResearcherID: AAC–7333–2021
Department of Biology, T.H. Shevchenko National University «Chernihiv Colehium»
53 Hetmana Polubotka Street, Chernihiv, 14013, Ukraine

[1] Study design, data collection, manuscript preparation.
[2] Data collection, statistical analysis, manuscript preparation.