

Characteristics of metabolic disorders in laying hens with dermanysosis

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ABSTRACT

Dermanysosis is a common ectoparasitic disease of birds. Some characteristics of metabolic disorders were identified in Hy-Line laying hens with such a disease. The disease caused by *Dermanyssus gallinae*, a poultry red mite, was detected during a complex parasitological survey in one of two industrial poultry buildings inspected. A high degree of mite infestation was found in the poultry building where the hens of the experimental group were kept. This condition was considered to be a stress factor for the hens, i.e. as a disturbance of their comfortable living conditions. The *D. gallinae* parasite infestation caused a decrease in erythrocytes and leukocytes, and in hemoglobin concentration in the laying hens. Changes in the content of some stress-associated hormones were analyzed, and they showed an increase in cortisol levels and a decrease in triiodothyronine. Multiple metabolic rate disorders in the organism of the infested hens were revealed. In dermanysosis stimulation of gluconeogenesis occurred and an increase in the proportion of oxygen-free glycolysis in the hens. These changes were obviously due to the molecular effects of the increase in stress. The hens from the experimental group were found to have high concentrations of lipid peroxidation products as compared to the control. Increased lipid peroxidation was found, together with a decrease in the total antioxidant defense of the experimental laying hens' organisms. The research results add to our understanding of how a high degree of infestation of a poultry building by *D. gallinae* impacts the organism of Hy-Line hens.

Key words: *Dermanyssus gallinae*; poultry red mite; metabolism; lipid peroxidation; cortisol; triiodothyronine

Introduction

Any (biotic or abiotic) environmental factor causes a homeostatic imbalance in living organisms, i.e. a state of stress (SELYE, 1956; ESCH et al., 1975). The body responds to each environmental factor (irritant) by a certain reaction of the body system, whose receptors perceive it. Stimuli

(stress factors) of different strength and type - technological, physical, chemical, feed, transport and biological - affect poultry in an industrial poultry environment (SURAI et al., 2019). The latter may be manifest, for example, as parasitic diseases.

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Parasitic diseases are widespread in farming systems (AKBAYEV et al., 2019). One of the main adverse environmental factors for birds in the industrial sector are ectoparasites, such as the poultry red mite *Dermanyssus gallinae*, a parasitic agent causing dermanysiosis, known as a common ectoparasitosis. This ectoparasite, when piercing the host's skin (COSOROABA, 2001), injects toxic saliva causing the corresponding adverse reactions in the bird's organism: itching, increased irritability, anemic and toxic syndromes, and exhaustion (MAGDAS et al., 2006). Every night the laying hen may lose up to 3% of its total blood. In this case, the daily blood loss from the birds' body stimulates incomplete erythropoiesis, accompanied by the formation of a large number of reticulocytes with a low content of hemoglobin, while increasing the risk of uncompensated hypoxic phenomena in tissues, with associated acidosis (O'BRIEN et al., 2001).

The effect of parasitic agents on the animal organism is multifaceted. First of all, they act as stress factors for their hosts, and change the concentration of glucocorticoids (ST. JULIANA et al., 2014). The development of oxidative stress in parasitosis in animals has also been proved (MOUGEOT et al., 2010; SAMADIEH et al., 2017). It is important to emphasize that oxidative stress is a physiological state in which the synthesis of active forms of oxygen and nitrogen exceed the possibilities of the antioxidant defense, causing damage to all cellular structures (MOUGEOT et al., 2010). It was found that the parasites cause oxidative damage in proportion to the infestation level (MOUGEOT et al., 2010; SAMADIEH et al., 2017). They primarily cause both destructive and functional disorders of all glands with internal secretion (MANNAPOVA and KALYUZHNY, 2010), in particular the thyroid gland, which has a significant impact on adequate nervous system functioning and on the establishment of behavioral reactions (GUDIN et al., 2010). Thus, the exposure of the hen's organism to a hematophagus agent, particularly the poultry red mite *D. gallinae*, will affect their hematological and biochemical parameters.

The purpose of this study was to examine the characteristics of metabolic disorders in Hy-Line laying hens with dermanysiosis. The study was performed during 2019 on a poultry farm in Russia.

Materials and methods

Keeping and feeding of laying hens. The poultry buildings were designed for 45,000 laying hens, battery cages are 4-stepped, with suction-and-exhaust ventilation, and natural and artificial lighting. Temperature and relative humidity in the poultry buildings complies with zootechnical requirements. The farm's own feed processing building provides the poultry with total mixed rations.

Parasitological study. The parasitological study of the poultry farm was performed comprehensively on the basis of epizootological and clinical data and laboratory tests.

The degree of mite infestation in the poultry buildings was recorded by counting parasites that fell onto a sheet of white paper. To do this, we placed a piece of white cardboard under the cells of the battery cages, hit the cages with a stick, took out a sheet of paper and collected the material in a container with the necessary markings (SPERANSKAYA and MUHAMEDSHINA, 1969). The mite infestation rate was determined by the number of mites collected from 1 (one) square meter (sqm) of the surface, and labelled as follows: +, a weak level of mite infestation, not more than 10 mites per 1 sqm; ++, average level of mite infestation, not more than 100 mites per 1 sqm; +++, high level of mite infestation, not more than 500 mites per 1 sqm; +++++, very high level of mite infestation, more than 500 mites per 1 sqm.

As a result of the complex parasitological study of the poultry premises, two poultry buildings were selected: one with healthy poultry (the control group) and the other with hens infested with *D. gallinae* (an experimental group). During the parasitological study of the poultry buildings (the experimental group), up to 500 live *D. gallinae* were collected from one sqm of the surface, so there was a high level of mite infestation in this poultry building, which was consequently designated as +++++.

According to GARKAVI et al., (1979), not all external effects should be considered as stress factors and, therefore, not “any” requirement applicable to the organism can be considered as a stress factor. The formation of adaptive reactions is considered depending on the level of exposure: weak, medium and high, believing that SELYE (1956) described response to high exposure. Thus, weak stimuli induce training reactions, arousal reactions develop to medium strength stimuli, and stress reactions to high ones. The reaction of stress occurs in three phases: the alarm reaction phase, the resistance phase and exhaustion. However, SELYE (1956) showed that if the stimulus is very strong or recurring, the exhaustion phase develops rapidly, which is typical for chronic stress. Thus, the strong stimuli include ectoparasites, in particular, parasitizing by *D. gallinae* on poultry farms at a mite infestation rate of +++.

The microscopy of scrapes from cell analysis equipment is shown in Fig. 1.



Fig. 1. Microscopy of scrapes from cell analysis equipment. *D. gallinae* (De Geer, 1778)

Blood sampling. Blood sampling was performed individually from the axillary vein of hens, using 10 randomly selected birds from the experimental and control groups, into sterile test tubes before morning feeding. The age of the hens was eight months at the time of blood sampling.

Hematological and biochemical parameters. Hematological and biochemical blood analysis was

performed using the generally accepted methods (KONDRAKHIN, 2004).

Erythrocytes and leukocytes were counted in a Goryaev chamber by a generally accepted method. Hemoglobin was determined by the colorimetric method using sodium lauryl sulfate.

A biochemical blood test was performed on a Cobas 6000 analyzer (test system: Roche Diagnostics, Switzerland). The colorimetric method was used to determine total protein, albumin, calcium and alkaline phosphatase. The enzymatic-colorimetric method was used to determine triglycerides, α -amylase, cholesterol, lipase and gamma glutamintransferase. The kinetic method was used to determine alanine aminotransferase, aspartate aminotransferase, creatinphosphokinase, creatinine and lactate dehydrogenase. Phosphorus was determined spectrophotometrically. The hexokinase method was used to determine glucose. The electrochemiluminescence immunoassay was used to determine cortisol and free triiodothyronine.

The concentration of lipid peroxidation products was determined using an SF-26 spectrophotometer, with Russian spectrometric method. Serum antioxidant activity was measured in vitro by suppressed lipid peroxidation in a biological fluid sample.

Clinical examination of laying hens. We examined 10 to 15 hens from different places in each poultry building. The methods used to determine ethological characteristics of the hens were: observation with records of movements, and assessment of the hens' reactions to various stimuli. The birds were weighed individually using hand-held portable scales - 10 birds from each group.

Ethical approval. All activities with animals were undertaken in accordance with the international regulatory standards (ANONYM., 1986; ANONYM., 2010). The design of this research work was approved at a meeting of the Academic Council of the Federal Research Center (No 2019/01/ FSC VIEW).

Statistical analysis. The digital material obtained during the research work was statistically processed using the Student's test through Microsoft Excel. The results were considered reliable at $P \leq 0.05$ (* $P < 0,05$; ** $P < 0,01$; *** $P < 0,001$).

Results

Clinical examination of laying hens. D. gallinae affected Hy-Line laying hens' vital activity, and we also identified a decrease in body weight (1.63 ± 0.04 vs. 1.77 ± 0.03 kg in the control; $P < 0.05$), loss of plumage, scratching due to itching, pale mucous membranes, and anemic combs and earrings.

Infested laying hens from the experimental group had behavioral characteristics demonstrated as pronounced aggression and locomotor activity, excessive vocalization, anxiety and

hypersensitization to various environmental stimuli (personnel, prevention-care intervention) as compared with the behavior of individuals from the control. Our data comply with studies by KOWALSKI and SOKOL (2009).

Characteristics of hematological and biochemical parameters in laying hens. It was found that the parasitic factor had a significant impact on the hematological and biochemical parameters of the birds' blood (Table 1).

Table 1. Hematological and biochemical parameters of the Hy-Line laying hens' blood, (n=10)

Indicator	Experimental group	Control group
<i>Hematological parameters</i>		
Erythrocytes, $10^{12}/L$	$2.08 \pm 0.08^{**}$	2.84 ± 0.13
Hemoglobin, g/L	$108.3 \pm 5.94^{**}$	138.5 ± 4.65
Leukocytes, $10^9/L$	$17.32 \pm 1.11^{**}$	26.84 ± 1.78
<i>Biochemical parameters</i>		
Total Protein, g/L	$56.78 \pm 1.07^{**}$	65.74 ± 1.36
Albumins, g/L	$27.82 \pm 0.37^{**}$	31.49 ± 0.59
Globulins, g/L	$28.96 \pm 1.08^*$	34.25 ± 1.63
Alanine Aminotransferase, U/L	13.55 ± 0.29	14.78 ± 0.52
Aspartate Aminotransferase, U/L	247.64 ± 12.48	236.13 ± 2.42
Alkaline Phosphatase, U/L	898.15 ± 63.68	1035.46 ± 72.79
Creatinine, $\mu\text{mol}/L$	$44.3 \pm 1.9^{***}$	30.82 ± 0.98
Creatinphosphokinase, U/L	2534.43 ± 159.91	2322.48 ± 87.97
Cholesterol, mmol/L	$2.44 \pm 0.26^{***}$	4.45 ± 0.25
Triglycerides, mmol/L	$4.52 \pm 0.31^{**}$	6.34 ± 0.26
Lipase, U/L	12.68 ± 0.34	12.59 ± 0.27
Antioxidant Activity in Blood Serum, %	$49.0 \pm 1.33^*$	54.4 ± 1.85
Lipids Containing Isolated Double Bonds, relative units	$3.74 \pm 0.29^*$	2.47 ± 0.33
Diene Conjugates, relative units	$2.36 \pm 0.29^*$	1.57 ± 0.15
Triene Conjugates, relative units	1.05 ± 0.12	0.97 ± 0.22
Oxodiene Conjugates, relative units	$1.15 \pm 0.11^{**}$	0.61 ± 0.1
Schiff's Base, relative units	1.15 ± 0.12	0.79 ± 0.13
Glucose, mmol/L	$13.45 \pm 0.34^{**}$	12.19 ± 0.17
α -Amylase, U/L	$285.6 \pm 42.24^*$	162.6 ± 13.28
Lactate Dehydrogenase, U/L	$1610.24 \pm 34.56^{***}$	1167.84 ± 56.96
Gamma Glutaminetranferase, U/L	16.62 ± 1.28	15.48 ± 0.6
Calcium, mmol/L	3.39 ± 0.19	3.76 ± 0.14
Phosphorus, mmol/L	1.79 ± 0.12	1.89 ± 0.08
Cortisol, nmol/L	$0.83 \pm 0.03^{***}$	0.23 ± 0.05
Free Triiodothyronine, pmol/L	$6.23 \pm 0.11^{***}$	7.29 ± 0.06

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

In the blood of hens with dermanysiosis, we observed a low erythrocyte count at 2.08 ± 0.08 vs. $2.84 \pm 0.13 \cdot 10^{12}/L$ in the control ($P < 0.01$), and low hemoglobin concentration at 108.3 ± 5.94 vs. 138.5 ± 4.65 g/L in the control ($P < 0.01$). The leukocyte count in hens from the experimental group was 17.32 ± 1.11 versus $26.84 \pm 1.78 \cdot 10^9/L$ in the control group ($P < 0.01$).

There was a decrease in total protein, albumins and globulins by 13.6% ($P < 0.01$), 11.7% ($P < 0.01$) and 15.4% ($P < 0.05$) in the experimental group, accordingly, relative to the control. Creatinine in the blood of hens with dermanysiosis was 44.3 ± 1.9 vs. 30.82 ± 0.98 $\mu\text{mol}/L$ in the control ($P < 0.001$). In the blood of sick hens, we recorded low levels of cholesterol of 2.44 ± 0.26 mmol/L (vs. 4.45 ± 0.25 mmol/L in the control; $P < 0.001$), and triglycerides 4.52 ± 0.31 mmol/L (vs. 6.34 ± 0.26 mmol/L in the control; $P < 0.01$). Glucose ranged from 12.19 ± 0.17 to 13.45 ± 0.34 mmol/L - within the physiological range in the blood of both the experimental and control laying hens. We observed high activity of α -amylase and lactate dehydrogenase in the blood of the laying hens from the experimental group. The level of antioxidant activity in blood serum of hens with ectoparasitosis was $49.0 \pm 1.33\%$ (versus $54.4 \pm 1.85\%$ in the control; $P < 0.05$). In the blood of hens with dermanysiosis, we identified a significant increase in lipids that contain isolated double bonds, and diene and oxodiene conjugates, respectively, as compared to the control.

Cortisol was at 0.83 ± 0.03 nmol/L in the experimental hens' blood (0.23 ± 0.05 nmol/L in the control; $P < 0.001$). The free triiodothyronine concentration was 6.23 ± 0.11 pmol/L in the experimental hens' blood (7.29 ± 0.06 pmol/L in the control; $P < 0.001$).

Discussion

On the basis of the theory of stress, SELYE (1956) highlights the "triad of physiological changes": increased glucocorticoid synthesis, reduction of thymus, and petechial hemorrhages (ulcers) in the gastrointestinal tract. In experimental group, the hens' cortisol was 3.6 times higher ($P < 0.001$) than in the control group. The increase in this hormone level is obviously caused by the

development of a stress-reaction in the organism of the experimental hens, which is necessary for balancing the negative consequences of stress, and maintenance of the adaptive capacity of the organism due to the intensity regulation of central metabolic processes: the carbohydrate-energetic, lipid and protein metabolism (GUDIN et al., 2010).

One of the physiological effects of glucocorticoids in prolonged excessive synthesis is immunosuppressive action expressed by lymphoid tissue involution and the death of immune cells. The decrease in leukocytes activity by 1.5 times ($P < 0.01$) in the hens from the experimental group indicates immunosuppression. The paper by KOZIATEK-SADŁOWSKA and SOKOL (2020) confirms that *D. gallinae* parasitizing results in destabilized immune processes in the hen's body. Often, immunosuppression is due to a decrease in the secretory activity of the thyroid gland.

According to the majority of authors (GORODETSKAYA and KORENEVSKAYA, 2009; INDYUHOVA et al., 2016), a decrease in the thyroid-producing function of the thyroid gland is observed following various environmental stimuli in animals. In our studies, we also noted a decrease in its activity in laying hens by determining the concentration of triiodothyronine in their blood, as this is the most active form of thyroid hormones. Thus, the level of "free triiodothyronine" is significantly less in the experimental group, by 14.5% ($P < 0.001$) when compared to the control.

As is commonly known, a reduction in thyroid hormones is directly related to anemia development. Hematological parameters in birds with dermanysiosis clearly demonstrate the development of anemic syndrome. The levels of red blood cells in hens infested by *D. gallinae* were reduced 1.4 times ($P < 0.01$) in comparison with the healthy birds. It should be noted that in anemia, respiratory blood function becomes abnormal and hypo-oxygenation develops of tissues and acidosis (KRUGLOVA, 2013). In the experimental group, the hemoglobin concentration was also reduced by 21.8% ($P < 0.01$) in relation to the control value, which indicates a decrease in oxidoreduction rate in the organism. It is known that the most important function of hemoglobin in the body is the transfer

of oxygen to organs and tissues. Inadequate oxygen supply to the body tissues leads to mitochondrial respiratory chain disruption (the activity of enzyme complexes in the respiratory chain changes and the level of high-energy compounds (ATP) decreases), resulting in the development of hypoxia conditions. Therefore, energy-dependent reactions are affected in hypoxia. As is commonly known, this is accompanied by the activation of the formation of excess free radicals, creating the prerequisites for initiation of lipid peroxidation and the development of irreversible destructive changes in cells (ZARUBINA, 2011). At the same time, the respiratory depression of the blood of the hens from the experimental group causes multi-faceted disorders of the body's metabolic rate in general.

The decrease in erythrocytes and hemoglobin induced a reduction in the intensity of some metabolic processes in the hens from the experimental group. A decrease was found in total protein by 13.6% ($P < 0.01$) in the hens of the experimental group relative to the control. Obviously, this is also associated with the activation of gluconeogenesis in the liver affected by a higher concentration of cortisol in representatives of the experimental group. The substrates for this reaction are glycogenic amino acids and lipid components (glycerol). When gluconeogenesis is activated, the blood glucose concentration increases, which is also reflected in our studies. In our trial, glucose content was significantly higher, by 10.3% ($P < 0.01$), when compared with the control group. This monosaccharide is a key source of free energy, which is intensively consumed by the body when exposed to stress factors.

A commonly used form of glucose use is glycolysis. However, with the development of hypoxia, the anaerobic pathway for breaking down glucose into lactic acid prevails in the body. The key glycogen enzyme that converts pyruvate into lactate is lactate dehydrogenase (LDH). Thus, a reliable increase in activity of this enzyme was noted (1610.24 ± 34.56 versus 1167.84 ± 56.96 U/L in control; $P < 0.001$) in hens from the experimental group. An increase in LDH activity in the blood of laying hens with dermanysosis reflects an increase in the proportion of glycolysis, as well as

the development of hypoxia and a decrease in ATP synthesis.

Analyzing the activity of α -amylase, it was found that hens from the experimental group had a statistically significant 1.8 times higher rate ($P < 0.05$) when compared to the control. Obviously, this fact is connected with the intensive consumption of glycogen in hen's organism from the experimental group and, as a result, the increased activity of this enzyme in blood as noted elsewhere (NATER et al., 2006).

According to the data presented in Table 1, it should be noted that the intensity of protein metabolism decreased in the laying hens from the experimental group. Thus, their albumin level was 11.7% lower ($P < 0.01$) and its value was not within the reference values. As is commonly known, albumin is a basic plasma protein synthesized by the liver. It performs transport functions, supports oncotic blood plasma pressure, and is a key indicator of the body's amino acid reserve (GUDIN et al., 2010). The data obtained indicate exhaustion of the body's reserve capabilities, as confirmed in the study by KUKLIN et al. (2016).

The decrease in the globulin level by 15.4 % ($P < 0.05$) in the experimental group, when compared with the control, is connected with a decrease in the γ -globulin fraction and, as a consequence, suppression of immune processes in the organism caused by the prolonged effects of high cortisol concentrations, as noted by KOWALSKI and SOKOL (2009).

While, the lower level of alanine aminotransferase in the hens from the experimental group (13.55 ± 0.29 vs. 14.78 ± 0.52 U/L in the control) indicates a decrease in the interconnection primarily between the carbohydrate and amino acid exchange, and with it the possibility of performance of the alanine cycle, which plays an important part in the energy exchange of muscle tissue. This is confirmed by the study by AZARNOVA (2014), who states that any initial stress is accompanied by an increase in these interrelationships to ensure effective metabolic interaction and the adequacy of compensatory functions, while in chronic stress the opposite is recorded.

The activation of glucocorticoid synthesis in the laying hens' organisms affected the skeletal muscles, which are a powerful protein depot. Glucocorticoids in muscles inhibit the synthesis of proteins, and increase their proteolysis and consequently the yield of amino acids in the blood. These reactions are necessary to maintain gluconeogenesis. Creatinine participates in the energy metabolism of muscle tissue, and is also a product of protein degradation. The increase in creatinine levels in the experimental hens, and the tendency of creatinine phosphokinase activity increased by 9.1%, respectively, indicate muscle loss, which is in agreement with AKBAYEV et al. (2019).

Examination of the hens' weight confirmed the above (this indicator was 8.0% lower in the experimental group than in the control; $P < 0.05$).

In the blood of the laying hens from the experimental group, we found a decrease in cholesterol by 1.8 times ($P < 0.001$) as compared to the control group. It is conceivable that this results from the increased synthesis of the steroid hormone, cortisol.

In adipose tissue, glucocorticoids show catabolic action, which was confirmed in our paper. Thus, the level of triglycerides in the laying hens' blood in the experimental group decreased 1.4 times ($P < 0.01$) in relation to the control. This, obviously, indicates some degree of exhaustion of lipid depots, due to prolonged exposure to cortisol in previous periods, which was necessary to maintain gluconeogenesis in the liver.

These negative changes were obviously caused by the disorders resulting from the molecular consequences of stress development, namely, induction of abnormal stimulation of free-radicals and, as a consequence, lipoperoxide processes.

Non-enzymatic free-radical oxidation is known to occur continuously in animal and human tissues during their natural life activities (ZHURAVLEV and ZUBKOVA, 2008). According to research (SURAI et al., 2019), an abnormally high level of free radical synthesis develops when mitochondrial respiratory chain disorder occurs. Lipid peroxidation (POL) is a free-radical process that is initiated by the formation of a reactive

oxygen intermediate. The main substrate of this reaction is polyunsaturated fatty acids, which are part of the cell membrane phospholipids. At different phases of this process, lipoperoxidation products are formed: diene, trienoic and oxodiene conjugates, Schiff's bases, etc. POL products are able to damage the protein and lipid components of the membranes, inactivate enzymes, hormones and other biologically active substances, disturb the integrity of receptors, result in the formation of mutagenic complexes, and disrupt the structures of hereditary information. The physiological level of POL products is controlled by the body's antioxidant system. Under the systemic effects of these emergency factors, the processes of free-radical oxidation are activated, causing depletion of antioxidant protection reserves.

In our study, the body's total antioxidant protection in the laying hens from the experimental group decreased by 10.0% ($P < 0.05$) in comparison with the control. The decrease in the antioxidant pool caused a significant increase in lipid level containing isolated double bonds and diene conjugates - by 1.5 times ($P < 0.05$), trienoic conjugates - by 8.2% and oxodiene conjugates - by 1.9 times ($P < 0.01$), Schiff's bases - by 1.5 times, in comparison with the control. The stressful state of the hens in the experimental group was accompanied by excessively activated lipid peroxidation, which indicates the tension of all adaptation systems in the hen's organism (AZARNOVA, 2014).

The level of lipid peroxidation in birds also increases with the dynamic inflammatory process that develops in laying hens at the areas of the daily bites caused by *D. gallinae* (ZHURAVLEV and ZUBKOVA, 2008).

Thus, the hematological and biochemical parameters of hens infested by *D. gallinae* demonstrated the results of the host-parasite relationships in the industrial sector, which veterinarians should know about.

Conclusion

The research results presented indicate the occurrence of all the signs of extreme stress caused by *D. gallinae* in laying hens, reflected in a significant change in the endocrine profile of their

organism. The study stressor was accompanied by excessive induction of free radical processes in the bodies of the laying hens with dermanyssosis, which gave rise to the intensification of lipid peroxidation. This led to the destabilization and exhaustion of the main metabolic processes (protein, lipid and carbohydrate metabolism), and homeostatic imbalance in the body of hens with dermanyssosis.

References

- AKBAYEV, R. M., A. S. BELOUS, E. V. TRUBNIKOVA, E. S. BOGDANOVA, A. V. BELYAKOVA, E. Y. EPOVA, M. V. ZYLKOVA, Y. K. BIRYUKOVA, A. B. SHEVELEV (2019): Impact of poultry red mite (*Dermanyssus gallinae*) infestation on blood parameters of laying hens. *BioNanoScience* 10, 318-329.
DOI: 10.1007/s12668-019-00705-0
- ANONYMOUS (1986): European convention for the protection of vertebrate animals used for experimental purposes or other scientific purposes (executed in Strasbourg on 18.03.1986).
- ANONYMOUS (2010): Directive of the European Parliament and of the Council 2010/63/EU of 22 September 2010 on the protection of animals used for scientific purposes.
- AZARNOVA, T. O. (2014): Natural metabolites against free radicals. *Livestock of Russia* 52, 51-52.
- COSOROABA, I. (2001): Massive *Dermanyssus gallinae* invasion in battery-husbandry raised fowls. *Rev. Med. Vet.* 152, 89-96.
- ESCH, G. W., J. W. GIBBONS, J. E. BOURQUE (1975): An analysis of the relationship between stress and parasitism. *Am. Midl. Nat.* 2, 339-353.
DOI: 10.2307/2424167
- GARKAVI, L. H., E. B. KVAKINA, M. V. UKOLOVA (1979): Adaptive reactions and organism resistance. *Rus. University, Rostov-on-Don*, pp. 78-81.
- GORODETSKAYA, I. V., N. A. KORENEVSKAYA (2009): Resistance of organism to chronic stress depends on thyroid status. *Vestnik of VGMU*. 3, 13-20.
- GUDIN, V. A., V. F. LYSOV, V. I. MAXIMOV (2010): *Physiology and Ethology of Poultry*. Textbook. "Lan" Publishing House, St. Petersburg, pp. 276-309.
- INDYUHOVA, E. N., T. O. AZARNOVA, V. I. MAXIMOV, M. S. NAIDENSKIY, S. Y. ZAITSEV (2016): Monitoring of hen embryogenesis at iodized nutrition in ovo in hyperthermia conditions during incubation. *Veterinary Medicine*. 10, 54-58.
- KONDRAKHIN, I. P. (2004): *Methods of Veterinary Clinical Laboratory Diagnostics*. Handbook. "Koloss" Publishing House, Moscow, pp. 76-230.
- KOWALSKI, A., R. SOKOL (2009): Influence of *Dermanyssus gallinae* (poultry red mite) invasion on the plasma levels of corticosterone, catecholamines and proteins in layer hens. *Pol. J. Vet. Sci.* 2, 231-235.
- KOZIATEK-SADŁOWSKA, S., R. SOKOL (2020): Changes in the percentages of B- and T-lymphocytes and antibody titres in laying hens infested with *Dermanyssus gallinae* - a preliminary study. *Animals* 10, 987.
DOI: 10.3390/ani10060987
- KRUGLOVA, Y. S. (2013): *Diseases of blood system in animals. Anemia and hemorrhagic diathesis*. Educational guidance. Moscow State Academy of Veterinary Medicine and Biotechnology named after K. I. Skryabin, Moscow, pp. 52-98.
- KUKLIN, V. V., M. M. KUKLIN, I. S. USYAGINA, D. G. MATISHOV (2016): Special aspects of physiological and biochemical response of fish-eating birds to parasitic infection and contamination of habitats in the Eastern Pryazovia. *Science of Southern Russia* 1, 51-60.
- MAGDAS, C., F. CHIRILĂ, N. FIT, A. CRISTE, H. BACIU (2006): Epidemiologic study of *Dermanyssus gallinae* (Acari: Dermanyssidae) infestation in birds, from three localities on Cluj area. *Buletin USAMV-CN* 1-2, 309-314.
- MANNAPOVA, R. T., S. I. KALYUZHNY (2010): Influence of the combined therapy of cryptosporidiosis on the biochemical values of the pig blood. *Russian Journal of Parasitology* 1, 114-119.
- MOUGEOT, F., J. MARTINEZ-PADILLA, J. D. BLOUNT, L. PEREZ-RODRIGUEZ, L. M. I. WEBSTER, S. B. PIERTNEY (2010): Oxidative stress and the effect of parasites on a carotenoid-based ornament. *J. Exp. Biol.* 3, 400-407.
DOI: 10.1242/jeb.037101
- NATER, U. M., R. LAMARCA, L. FLORIN, A. MOSES, W. LANGHANS, M. M. KOLLER, U. EHLERT (2006): Stress-induced changes in human salivary alpha-amylase activity - associations with adrenergic activity. *Psychoneuroendocrinology* 1, 49-58.
DOI: 10.1016/j.psyneuen.2005.05.010
- O'BRIEN, E. L., B. L. MORRISON, L. S. JOHNSON (2001): Assessing the effects of haematophagous ectoparasites on the health of nestling birds: haematocrit vs haemoglobin levels in House Wrens parasitized by blow fly larvae. *J. Avian Biol.* 1, 73-76.
DOI: 10.1034/j.1600-048x.2001.320110.x
- SAMADIEH, H., G. R. MOHAMMADI, M. MALEKI, H. BORJI, M. AZIZZADEN, M. HEIDARPOUR (2017): Relationships between oxidative stress, liver, and erythrocyte injury, trace elements and parasite burden in sheep naturally infected with *Dicrocoelium dendriticum*. *Iran J. Parasitol.* 1, 46-55.
- SELYE, H. (1956): *The Stress of Life*. McGraw-Hill, New York, pp. 4-47.

- SPERANSKAYA, V. M., P. A. MUHAMEDSHINA (1969): Hens' ectoparasites and means of their control in the conditions of the North-Western zone of the RSFSR and Eastern Georgia. Reports of the All-Union Conference on the natural disease nidity and general issues of animal parasitology. Tashkent, Uzbekistan, pp. 64-70.
- ST. JULIANA, J. R., I. S. KHOKHLOVA, N. WIELEBNOWSKI, B. P. KOTLER, B. R. KRASNOV (2014): Ectoparasitism and stress hormones: strategy of host exploitation, common host-parasite history and energetics matter. *J. Anim. Ecol.* 5, 1113-1123.
DOI: 10.1111/1365-2656.12217
- SURAI, P. F., I. I. KOCHISH, V. I. FISININ, M. T. KIDD (2019): Antioxidant Defence Systems and Oxidative Stress in Poultry Biology: An Update. *Antioxidants*. 7, 235.
DOI: 10.3390/antiox8070235
- ZARUBINA, I. V. (2011): Modern outlooks on the pathogenesis of hypoxia and its pharmacological correction. *Reviews of clinical pharmacology and drug therapy*. 3, 31-48.
- ZHURAVLEV, A. I., S. M. ZUBKOVA (2008): Antioxidants. Free-radical pathology. Textbook. Moscow State Academy of Veterinary Medicine and Biotechnology named after K. I. Skryabin of the Federal State Educational Institution of Higher Professional Education, Moscow, pp. 20-37.

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INDYUHOVA, E. N., M. V. ARISOV, V. I. MAXIMOV, T. O. AZARNOVA: Značajke metaboličkih poremećaja u kokoši nesilica infestiranih crvenom grinjom *Dermanyssus gallinae*. Vet. arhiv 92, 161-169, 2022.

SAŽETAK

Crvena grinja *Dermanyssus gallinae* (*D. gallinae*), poznata još kao tekut, česti je vanjski parazit ptica. U Hy-Line kokoši nesilica infestiranih s navedenim grinjom istražene su neke značajke metaboličkih poremećaja. Infestacija je otkrivena za vrijeme inspekcije dva industrijska objekta za peradarsku proizvodnju. Sveobuhvatnom parazitološkom obradom utvrđen je visok stupanj infestacije grinjama u jednom od dva objekta, u kojemu su držane kokoši iz pokusne skupine. Stanje je uzrokovalo narušavanje povoljnih uvjeta za uzgoj što je rezultiralo stresom za kokoši. Došlo je do smanjenje broja eritrocita i leukocita te koncentracije hemoglobina. Analizirane su promjene hormona povezanih sa stresom, koje su pokazale porast razine kortizola i smanjenje razine trijodtironina. U infestiranih kokoši nesilica otkriveni su višestruki metabolički poremećaji. Uočena je stimulacija glukoneogeneze i porast udjela glikolize bez prisutnosti kisika, a te su promjene očito uzrokovane molekularnim učincima porasta stresa. Kokoši iz pokusne skupine imale su veću koncentraciju produkata lipidne peroksidacije u usporedbi s kontrolnom skupinom. Porast lipidne peroksidacije uočen je s istodobnim smanjenjem ukupne antioksidacijske obrane organizma. Rezultati istraživanja pružaju bolje razumijevanje učinaka koji visok stupanj infestacije peradarskih objekata ektoparazitom *D. gallinae* ima na organizam Hy-Line kokoši nesilica.

Ključne riječi: *Dermanyssus gallinae*; tekut; metabolizam; lipidna peroksidacija; kortizol; trijodtironin
