UDC 636.52/58:636.083:591.044:591.111
DOI: 10.31521/2313-092X/2021-3(111)-9

Ukrainian Black Sea Region Agrarian Science
Vol. 25, No. 3

The influence of the size of the grouping of chickens on the non-specific reactivity of their organism

Yu. Osadcha*

PhD in Agricultural Sciences, Associate Professor
https://orcid.org/0000-0003-4126-2456

National University of Life and Environmental Sciences of Ukraine

Abstract. Over the past decades, egg poultry farming has undergone a certain specificity, concentration and intensification, which contributed to radical changes in the main production processes, as well as to the use of high-tech cage equipment for keeping laying hens, which to one degree or another affects the condition of hens and the quality of edible eggs. Chicken health is an important part of normal functioning and high productivity of chickens. For the health of chickens, the normal and full functioning of the immune system is necessary, which is influenced by various technological factors, one of which is the size of the grouping of chickens in cages. The purpose of the article is to investigate the non-specific reactivity of chickens under the influence of the size of the grouping with the same density of laying hens in cages that are similar in design. Egg-laying hens of the industrial flock "Hy-Line W-36" were used as the object of research. Experiments with experimental animals were conducted in accordance with the rules of the European Convention on the Protection of Vertebrate Animals. Under the conditions of a modern complex for the production of edible eggs, 4 groups of chickens were formed, each of which was kept in a separate analogue poultry house. The non-specific reactivity of the hens' organism under the influence of the size of the grouping with the same density of laying hens in cages analogous to the construction was studied. It was found that with a decrease in the size of the grouping of chickens, there is a shift of the leukocyte formula to the left, a preference for non-specific protective cells, which occurs as a result of a functional increase in the proliferative activity of the bone marrow and is expressed in an increase in the number of heterophils and an increase in their activity in the macrophage-macrophage immune response system

Keywords: chickens, stress, immunohematological indices, nonspecific reactivity, endogenous intoxication

INTRODUCTION

Over the past decades, egg poultry farming has undergone specialization, concentration and intensification, which has led to significant changes in the main production processes, including the use of high-tech cage equipment for keeping laying hens, which in one way or another affects the welfare of chickens and the quality of edible eggs [1]. Health is an integral part of the well-being of chickens and a prerequisite for their high productivity. For good health, the full functioning of the immune system is important, which is affected by various technological stressors, one of which is the size of the grouping of chickens in cages.

The parameters of the size of the grouping of laying hens of an industrial flock in cages are not provided for by the current domestic regulations, and according to the recommendations of the cross developer, they should be at least 7 goals [2], although in practice they reach 100 goals, so they need to be clarified when using 12-tier cage batteries of classic constructions However, the influence of the size of the grouping of chickens on their body, under cage keeping with the same provision of space, was studied mainly on small groups of birds, up to 10 heads in size [3-5], or cages of different designs and manufacturers were

Article's History:
Received: 1.03.2021
Revised: 30.06.2021
Accepted: 26.08.2021

Suggested Citation:
Osadcha, Yu. (2021). The influence of the size of the grouping of chickens on the non-specific reactivity of their organism. *Ukrainian Black Sea Region Agrarian Science*, 25(3), 75-83.

used in the experiments, which makes it impossible to adequately comparison [6]. Thus, there is a need to study the influence of the size of the grouping on the body of chickens, with the same density of laying hens in cages that are similar in design.Non-specific reactions characteristic of all types of stress are mainly the reactivity of the hypothalamic-pituitary-adrenocortical system and autonomic functions, including cardiovascular and hematopoiesis [7; 8]. G. Selye defined stress as a non-specific reaction of the body that develops under the influence of various causal factors. All exogenous and endogenous factors that create increased demands on the body are called stressors [9]. Despite their diversity, the body responds to a stereotyped form of biochemical, functional and structural changes, adaptation to new conditions. G. Selye established that during the action of stressors, the body responds with non-specific defense reactions – the heartbeat accelerates, blood pressure rises, and the concentration of corticosteroids in the blood increases.

Activation of the adrenal cortex, as a center of stress reactions, is accompanied by numerous changes in blood composition. Many researchers [10-12] adopted these changes as criteria for assessing the stress state of birds, which make it possible to detect the stress effect of various factors on their body and to determine the intensity and duration of the stress state. When stress is detected by evaluating these criteria, which are based on the basis of an intense and constant reactive response, the ratio of heterophils and lymphocytes is most often used [13; 14]. Since it has been proven [15] that during the development of a stressful state, this indicator increases due to the increased proliferation of hematopoietic stem cells, increased production of heterophils, and due to the abortive release of immature heterophil cells from the bone marrow into the bloodstream and the migration of lymphocytes from it to the tissues. In addition, changes in the ratio of heterophils and lymphocytes correlate with the concentration of corticosterone in the blood of chickens and are proportional to the degree of exposure to stressors of various nature [16; 17].

The ratio of heterophils and lymphocytes is an integral immunohematological index, which in human medicine is known as the Krebs index [18]. In addition to it, humane medicine uses a whole panel of immunohematological indices that indirectly reflect the state of the immune system and the course of adaptation processes in the body [19; 20].Recently, a marker panel, which includes the index of leukocyte shift (ILS), the index of the ratio of heterophils and lymphocytes (IRHL or the Krebs index), the index of the ratio of leukocytes and IRL, lymphocyte-granulocyte index (LGI), general index (GI), index immunoreactivity (IIR), the index of the ratio of heterophils and monocytes (IRHM), the index of the ratio of lymphocytes and monocytes (IRLM), the leukocyte index (LI) and the index of the ratio of lymphocytes and eosinophils (IRLE) are also used in animal husbandry [21-23].

The size of the bird group puts pressure on the main structures of the brain, which correlates with the increased demands on birds that live in relatively large, complex and dynamic social organizations [24]. These requirements are mostly related to competition for food or access to other valuable resources. Variations in group size in natural populations are self-regulating, but in the conditions of industrial chicken keeping, they are absent. The bird does not have the opportunity to leave the group environment, as a result of which intensified aggressive interactions are formed, which can contribute to despotic behavior [25]. However, recent research shows that the social behavior of birds is not limited to the formation of a hierarchy, and it is much more plastic and dynamic than previously thought.

Thus, earlier it was believed that chickens (Galus galus domesticus) are a social species that, being in a group, creates a stable hierarchy of dominance, which is established due to aggressive interactions [26]. As soon as a stable hierarchy is formed, aggressive interactions are replaced by dominance-subordination interactions. According to this type of hierarchy, chickens recognize group mates individually and remember the results of aggressive encounters. The frequency and intensity of aggressive interactions for the formation of a stable hierarchy is determined by the size of the group, since the establishment of dominance relations in larger groups requires a greater number of interactions between group members. Further studies showed [27] that in large groups it is difficult for chickens to remember the results of all interactions, which leads to a decrease in the stability of the social structure of the group. These results led to the idea that birds in large groups establish a more flexible, tolerant system of behavior. That is, in large groups, where individual recognition is impossible, the bird builds social interactions through a plastic tolerant system of behavior. This behavioral plasticity allows the bird to change strategies and more easily adapt to different technological (social and physical) conditions within a limited grouping [28].

Researchers associate an increase in the size of a group of chickens (more than 10 heads) due to their keeping in cages of multi-tiered batteries with a decrease in the preservation of livestock and a deterioration in productivity, which are manifestations of stressful conditions [28-30]. There are also reports that keeping chickens in medium-sized groups (about 30 heads) can provoke social stress in them, which is also accompanied by a decrease in productivity, since the size of such a group is too large to form a stable hierarchy, but too small for a tolerant

social system [31; 32]. *The purpose of the work* is to study the non-specific reactivity of the hens' body under the influence of the size of the grouping with the same density of laying hens in cages that are similar in design.

MATERIALS AND METHODS

Egg-laying hens of the industrial flock "Hy-Line W-36"were used as an object of research. Experiments with experimental animals were performed in accordance with the rules of the European Convention for the Protection of Vertebrate Animals (Official Journal of the European Union L276/33, 2010).

In the conditions of a modern complex for the production of edible eggs, 4 groups of chickens were formed, each of which was kept in a separate aviary-analogue in terms of area (2915 m^2), equipped with 12-tier cage batteries "Big Dutchman" (Germany), the size of which varied. Depending on the size of the cages, with the same stocking density (23.0 heads/m^2), the number of chickens in them was different. The size of the grouping of chickens in each cage of the 1st group (cage 362×112.0 cm) was 93 heads, the 2nd group (cage 360×62.55 cm) – 52 heads, the 3rd (cage 120×62.55 cm) – 17 heads. and 4th (cage 70×56 cm) – 9 goals. (Table 1).

Table 1. *Scheme of the experiment*

Characteristic	Group of hens			
	1	2	3	4
The number of tiers in the poultry house	12Number of cells			
Number of cages	4704	6048	18144	30912
Number of heads in the cage/the size of the grouping	93	52	17	9
Number of heads in the group	437472	314496	308448	278208
Planting density, heads/m^2	23.0			
Provision of area, cm^2/cap	436.0	433.0	441.5	435.6
Cage dimensions, cm: - length - depth	 362 112.0	 360 62.55	 120 62.55	 70 56
Cage area, cm^2	40544	22518	7506	3920
The number of nipples in the cage, pcs.	12	17	12	1.5
Feeding front, see	7.8	6.9	7.1	7.8
Area of the poultry house, m^2	2915			

During the experiment, the chickens were provided with drinking water, full-ration compound feed of the same composition and kept according to the requirements (VNTP-APK-04.05.).

The hemogram of laying hens was determined on the hematological analyzer Micros 60 (Horiba Ltd.) in the "Bald" laboratory (certificate No. LB/02/2016). For this, 30 samples of whole blood were taken from laying hens of each group at the age of 52 weeks. 1.0-1.5 ml of blood was collected from the subpterygoid vein in a test tube with EDTA.

To evaluate the non-specific reactivity of the chickens, integral immunohematological indices of intoxication (leukocyte shift index (ILS)), inflammatory activity (heterophil-to-lymphocyte ratio index (IRHL or Krebs index)) or heterophil-lymphocyte coefficient, leukocyte-ESR ratio index (IRHLC) were determined. granulocyte index (ILG), general index (GI)) and non-specific reactivity (immunoreactivity index (IIR), heterophil and monocyte ratio index (ISHM), lymphocyte and monocyte ratio index (ILM), leukocyte index (LI), lymphocyte ratio index and eosinophils (ESLE)) according to the following formulas [18; 20; 33; 34]: The leukocyte shift index (LSI) was calculated according to formula (1):

$$LSI = (E+B+H)/(Mo+L), \quad (1)$$

where E – eosenophils, B – basophils, H – heterophils, Mo – monocytes, L – lymphocytes.

The Krebs index (IK) was calculated according to formula (2):

$$IK = (R+S)/L, \quad (2)$$

where: R – rod-shaped heterophils,S – segmented heterophils, L – lymphocytes.

The lymphocyte-granulocyte index (ILG) was calculated according to the formula (3):

$$ILH = L\times10/(M+Y+R+S+E+B), \quad (3)$$

where L are lymphocytes, M are myelocytes, Y are young forms, R are rod-shaped heterophils, S are segmented heterophils, E are eosinophils, and B are basophils.

The ratio index of leukocytes and ESR (IL ESR) was calculated according to the formula (4):

$$IL\ ESR = L\times SOE/100, \quad (4)$$

where L – lymphocytes, ESR – erythrocyte sedimentation rate.

The general index (GI) was calculated according to the formula:

$$GI = ILG+IL\ ESR, \quad (5)$$

where ILG is a lymphocyte-granulocyte index, IL ESR is an index of the ratio of leukocytes and ESR.

The immunoreactivity index (IIR) was calculated according to the formula (6):

$$IIR = (L+E)/Mo, \quad (6)$$

where L are lymphocytes, E are eosinophils, Mo are monocytes.

The index of the ratio of heterophils and monocytes (IHM) was calculated according to the formula

$$IHM = (M+Y+R+S)/Mo, \quad (7)$$

where M are myelocytes, Y are young forms, R are rod-shaped heterophils, S are segmented heterophils, Mo are monocytes.

The index of the ratio of lymphocytes and monocytes (ISLM) was calculated according to the formula (8):

$$ISLM = L/Mo, \quad (8)$$

where L are lymphocytes, Mo are monocytes.

The lymphocyte index (LI) was determined from the ratio of lymphocytes and heterophils (9):

$$LI = L/H, \quad (9)$$

where L and H are the percentage of lymphocytes and heterophils in the leukocyte formula, respectively.

The index of the ratio of lymphocytes and eosinophils (ISLE) was calculated according to the formula (10):

$$ISLE = L/E, \quad (10)$$

where E – eosinophils, L – lymphocytes.

To determine the informativeness of changes in indicators of the immune system as possible prognostic factors, the degree of immunological disorders (SIP) was determined. In the presence of immunodeficiency, the indicator was negative "–", the sign "+" indicated hyperfunction of the immune system.

The value of the result in the range of 1-33% was interpreted as the I degree of immunological disorders, 34-66.7% – the II degree, more than 66.7% – the III degree [35].

The obtained digital results were processed by methods of variational statistics. The significance of the differences between the average values was determined by the Student's t-test, the differences were considered significant at $p<0.05$.

Research results and their discussion. To assess the adaptive and general reactive immunological potential of chickens under the influence of the size of the grouping, integral immunohematological indices of intoxication, inflammatory activity and non-specific reactivity were determined (Table 2)

Table 2. *Integral immunohematological indices of chickens*

Index, units	A group of chickens			
	1	2	3	4
Indices of intoxication				
Leukocyte shift index	0.31±0.015	0.39±0.029*	0.55±0.015**°	0.66±0.023**°°''
Indices of inflammatory activity				
Index of the ratio of heterophils and lymphocytes	0.29±0.016	0.35±0.033	0.54±0.021**°	0.65±0.023**°°''
Lymphocyte-granulocyte index	30.51±1.595	30.52±0.323	17.04±0.491**°°	14.68±0.489**°°''
Index of ratio of leukocytes and ESR	2.97±0.026	3.02±0.026	3.21±0.016**°	3.57±0.021**°°''
General index	33.48±1.826	33.54±0.223	20.25±0.526**°°	18.26±0.439**°°''
Indices of non-specific reactivity				
Index of immunoreactivity	8.89±0.624	12.85±0.856**	13.98±1.005**	16.58±0.808**'
Index of the ratio of heterophils and monocytes	2.30±0.107	4.71±0.553**	7.42±0.703**°	10.18±0.489**°°''
Index of the ratio of lymphocytes and monocytes	8.52±0.582	12.18±0.837**	13.49±1.001**	16.16±0.820**°°''
Lymphocyte index	3.84±0.217	3.06±0.263*	1.96±0.087**°°	1.61±0.053**°°''
Index of the ratio of lymphocytes and eosinophils	24.64±0.796	27.37±0.899*	37.23±0.538**°°	38.94±0.607**°°'

Notes: **p<0.05, **p<0.001 – compared to the first group; °p<0.01, °°p<0.001 – compared to the second group; 'p<0.05, 'p<0.01, 'p<0.001 – compared to the third group*

It was found that the lymphocyte index (LI), lymphocyte-granulocyte index (ILG) and total index (GI) decreased with decreasing group size, while the leukocyte shift index (LESI), heterophil-to-lymphocyte ratio index (HLRI), leukocyte ratio index and ESR (ILSHOE), immunoreactivity index (IIR), lymphocyte-monocyte ratio index (ILM), heterophil-monocyte ratio index (ISGM) and lymphocyte-eosinophil ratio index (ILLE) – on the contrary, increased.

The index of leukocyte shift (ILK), which characterizes the ratio of granulocytes and agranulocytes and does not depend on the number of leukocytes in the blood [36], increased with a decrease in the size of the grouping of chickens. Chickens of the 4th group had

the highest EILK – by 0.35 units. or 112.9% ($p<0.001$) compared to the 1st group and by 0.27 units. or 69.2% ($p<0.001$) and 0.11 units. or 20.0% ($p<0.001$) compared to the 2nd and 3rd groups, respectively. At the same time, in the chickens of the 2nd group, the ICP was higher by 0.08 units. or 25.8% ($p<0.05$) compared to the 1st group, and in chickens of the 3rd group – by 0.24 units. or 77.4% ($p<0.001$) and 0.16 units. or 41.0% compared to groups 1 and 2, respectively. An increase in ILC with a decrease in the size of a group of chickens indicates a shift in the leukocyte formula of their blood to the left, which indicates a violation of immunological reactivity [37] and the entry into the peripheral blood of a large number of "young" forms of leukocytes [36].The index of the ratio of heterophils to lymphocytes (ICHL or Krebs index), which is classically a marker of stress and reflects the ratio of cells of specific and non-specific immunity [14; 22], increased with an increase in the size of the grouping of chickens. The highest ICHL was found in chickens of the 4th group – by 0.36 units. or 121.4% ($p<0.001$) compared to the 1st group, and by 0.3 units. or 85.7% ($p<0.001$) and 0.11 units. or 20.4% ($p<0.001$) compared to the 2nd and 3rd groups, respectively. In the chickens of the 3rd group, ICG was higher by 0.25 units. or 86.2% ($p<0.001$) and 0.19 units. or 54.3% ($p<0.05$) compared to the 1st and 2nd groups, respectively. The difference between the 1st and 2nd groups was only 0.06 points. or 20.7% and was not statistically confirmed. ICHL characterizes the activity of phagocytic reactions and factors of specific immunity, as well as their participation in maintaining the general reactivity of the body [36], therefore, its increase with a decrease in the size of the group of chickens indicates the superiority of non-specific protective cells, which occurs as a result of a functional increase in the proliferative activity of the bone marrow and is expressed in increasing the number of heterophiles [38].

The lymphocyte-granulocyte index (ILH), which allows to differentiate auto-intoxication caused by a malfunction of the immune or enzymatic system, and infectious intoxication, and also expresses in numbers the degree of shift in the leukocyte formula of the blood [33; 39], decreased with a decrease in the size of the grouping of chickens. The lowest ILH was found in chickens of the 4th group – by 15.8 units. or 107.4% ($p<0.001$), 15.8 units. or 107.9% ($p<0.001$) and 2.36 units. or 16.1% ($p<0.001$) compared to the 1st, 2nd and 3rd groups, respectively. In chickens of the 1st and 2nd groups, ILH was at the same level – 30.51-30.52 units, and in the 3rd group it was lower by 13.5 units. or 79.0% ($p<0.001$) compared to the 1st group. A decrease in ILH indicates a shift of the leukocyte formula to the left and confirms the presence of autoimmune intoxication [19; 34; 39]. A decrease in ILH can also be considered as a violation of the factors and mechanisms of immunological reactivity [40].

A simultaneous increase in ILP and a decrease in ILH indicates the development of endogenous intoxication and a violation of immunological reactivity due to auto-intoxication of the body during the destruction of its own cells [34].

The index of the ratio of leukocytes to ESR (ILSHOE), changes in which indicate the presence of intoxication associated with an infectious (decrease in ILSHOE) or autoimmune (increase in ILSHOE) process [41], increased with a decrease in the size of the grouping of chickens. The highest ILSHOE was observed in chickens of the 4th group - by 0.6 units. or 20.2% ($p<0.001$) compared to the 1st group and by 0.55 units. or 18.2% ($p<0.001$) and 0.36 units. or 11.2% ($p<0.001$) compared to the 2nd and 3rd groups, respectively. At the same time, ILSHOE in chickens of the 1st and 2nd groups differed by only 0.05 units.or 1.7% without statistical confirmation, while in chickens of the 3rd group it was higher by 0.24 units. or 8.1% ($p<0.001$) and 0.19 units. or 6.3% ($p<0.001$) compared to the 1st and 2nd groups, respectively. A decrease in ILSHOE with a decrease in the size of a group of chickens indicates the presence of a pronounced systemic inflammatory response in their body with a high level of endogenous intoxication and a violation of immunological reactivity [19], and also confirms the autoimmune nature of the pathological process [18; 42].

The general index (GI), which is the sum of lymphocyte-granulocyte (ILG) and the ratio of leukocytes and ESR (ILSHOE) indices and allows to distinguish the nature of intoxication in the early stages of the development of the pathological process [34], decreased with a decrease in the size of the grouping of chickens. The lowest CI was found in chickens of the 4th group – by 15.22 units. or 45.5% ($p<0.001$) than in chickens of the 1st group and by 15.28 units. or 45.6% ($p<0.001$) and by 1.99 units. or 9.8% ($p<0.01$) than in chickens of the 2nd and 3rd groups, respectively. It should be noted that the difference in CI between the 1st and 2nd groups was only 0.06 units. or 0.2% and was not statistically confirmed, and in chickens of the 3rd group, the CI was lower by 13.23 units. or 39.5% ($p<0.001$) and 13.29 units. or 39.6% ($p<0.001$) than in chickens of the 1st and 2nd groups, respectively. A decrease in CI indicates the presence of an intoxication process in the body of chickens [43].

The index of immunoreactivity (IIR), which reflects the state of the main cytokine-producing cells and the imbalance in the cytokine profile [44], increased with a decrease in the size of the grouping of chickens. The highest IIR was observed in chickens of the 4th group – by 7.69 units. or 86.5% ($p<0.001$) than in chickens of the 1st group and by 3.73 units.or 29.0% ($p<0.01$) and by 2.60 units. or 18.6% ($p<0.05$) than in chickens of the 2nd and 3rd groups, respectively. At the same time, in chickens of the 2nd group, the IIR was

higher by 3.96 units. or 44.5% (p<0.001), and in chickens of the 3rd group – by 5.09 units. or 57.3% (p<0.001) compared to the 1st group. The differences between the 2nd and 3rd groups were only 1.13 units. or 8.8% and were not statistically confirmed. An increase in IIR with a decrease in the size of the group (up to 25 units) indicates the compensation of endogenous intoxication [45].

The index of the ratio of heterophils and monocytes (ISGM), which indicates the ratio of the components of the microphage-macrophage system [19], increased with a decrease in the size of the grouping of chickens. The highest ISGM was observed in chickens of the 4th group – by 7.88 units. or 342.6% (p<0.001) compared to the 1st group, and by 5.47 units. or 116.1% (p<0.001) and 2.76 units. or 37.2% (p<0.01) compared to the 2nd and 3rd groups, respectively. At the same time, hens of the 2nd group were characterized by a higher ISGM by 2.41 units. or 104.8% (p<0.001) compared to the 1st group, and chickens of the 3rd group – by 5.12 units. or 222.6% (p<0.001) and 2.71 units. or 57.5% (p<0.01) compared to the 1st and 2nd groups, respectively. An increase in ISGM with a decrease in the size of the chicken group indicates an increase in the activity of heterophils in the microphage-macrophage system of the immune response [46].

The index of the ratio of lymphocytes and monocytes (ILM) reflects the relationship between affective and effector links of the immunological process [4], increased with a decrease in the size of the grouping of chickens. The highest ISLM was observed in chickens of the 4th group – by 7.64 units. or 89.7% (p<0.001) compared to the 1st group, and by 3.98 units. or 32.7% (p<0.001) and 2.67 units. or 19.8% (p<0.01) compared to the 2nd and 3rd groups, respectively. At the same time, in chickens of the 2nd group, ISLM was higher by 3.66 units. or 43.0% (p<0.001), and in chickens of the 3rd group – by 4.97 units. or 58.3% (p<0.001) compared to the 1st group. The differences between the 2nd and 3rd groups were 1.31 units. or 10.8% and were not statistically confirmed. An increase in ISLM indicates the predominance of the effector link of a non-specific immunological process over the affective one [43].The lymphocyte index (LI), which reflects the relationship between the humoral and cellular links of the immune system [34], decreased with a decrease in the size of the grouping of chickens. Thus, LI in chickens of the 2nd was lower by 0.78 units. or 25.5% (p<0.05) compared to the 1st group, and in chickens of the 3rd group – by 1.88 units. or 95.9% (p<0.001) and 1.1 units. or 56.1% (p<0.001) compared to the 1st and 2nd groups, respectively. In chickens of the 4th group, LI was lower by 2.23 units. or 138.5% (p<0.001) compared to the 1st group and by 1.45 units. or 90.1% (p<0.001) and 0.35 units. or 21.7% (p<0.001) compared to the 2nd and 3rd groups, respectively. A decrease in LI with a decrease in the size of a group of chickens indicates the dominance of the activation of the cellular link of the immune system, and also indicates an active adaptive response of white blood and a decrease in non-specific anti-infective protection due to intoxication [43].

The index of the ratio of lymphocytes and eosinophils (ISLE), which reflects the ratio of the processes of hypersensitivity of the immediate and delayed type [34], increased with a decrease in the size of the grouping of chickens. The highest ISLE was found in chickens of the 4th group, namely by 14.3 units. or 58.0% (p<0.001) compared to the 1st group and by 11.57 units. or 42.3% (p<0.001) and 1.71 units. or 4.6% (p<0.05) compared to the 2nd and 3rd groups, respectively. ISLE in chickens of the 2nd group was higher by 2.73 units. or 11.1% (p<0.05), and in chickens of the 3rd group – by 12.59 units. or 51.1% (p<0.001) and 9.86 units. or 36.0% compared to groups 1 and 2, respectively. An increase in ISLE reflects the predominance of immediate-type hypersensitivity reactions over delayed-type reactions [47], which indicates an increase in autointoxication and a violation of immunological reactivity [48] in chickens with a decrease in the size of the grouping.

Determining the informativeness of changes in integral immunohematological indices as indicators of the immune system showed that all of them to one degree or another reflected the reaction of the chickens' body to the influence of changes in group size (Table 3).

Thus, the informative immunohematogolic indices that responded to the decrease in the size of the group of chickens, that is, to the degree of intensity of the stress factor, turned out to be ISK, ISGL (IC), ZI, IIR, ISLM, LI and ISLE. Whereas ILH did not respond to the reduction of the group from 93 to 52 goals, and ISGM and ILSHOE showed the same degree of immunological disturbances for the reduction of the group from 93 to 9 goals.

Table 3. *The degree of immunological disorders according to blood indices of chickens*

Index, units	A group of chickens		
	2 (52 pcs.)	3 (17 pcs)	4 (9 pcs.)
Indices of intoxication			
Leukocyte shift index	+I	+III	+III
Indices of inflammatory activity			
Index of the ratio of heterophils and lymphocytes (Krebs index)	+I	+III	+III
Lymphocyte-granulocyte index	–	-II	-II

Table 3, Continued

Index, units	A group of chickens		
	2 (52 pcs.)	3 (17 pcs)	4 (9 pcs.)
The index of the ratio of leukocytes and ESR	+I	+I	+I
General index	+I	-II	-II
Indices of non-specific reactivity			
Index of immunoreactivity	+II	+II	+III
Index of the ratio of heterophils and monocytes	+III	+III	+III
Index of the ratio of lymphocytes and monocytes	+II	+II	+III
Lymphocyte index	-I	-II	-II
Index of the ratio of lymphocytes and eosinophils	+I	+II	+II

CONCLUSIONS

The optimal group size of laying hens of modern white-egg crosses during their keeping in cages of 12-tier cage batteries is 52-93 head. For reducing the size of the grouping of chickens to 17 and 9 heads. there is an increase in the leukocyte shift index, the index of the ratio of heterophils and lymphocytes (Krebs index), the index of immunoreactivity, the index of the ratio of heterophils and monocytes, the index of the ratio of lymphocytes and monocytes, the index of the ratio of leukocytes and ESR, and the index of the ratio of lymphocytes and eosinophils. This indicates a shift of the leukocyte formula to the left, the predominance of nonspecific protective cells, which occurs as a result of a functional increase in the proliferative activity of the bone marrow and is expressed in an increased number of heterophils, an increase in their activity in the microphage-macrophage system of the immune response, and indicates the presence of a high level of endogenous intoxication in the body of chickens and violation of immunological reactivity, and can also inform about the autoimmune nature of the pathological process. At the same time, there is a decrease in the lymphocyte-granulocyte index, the total index, and the lymphocyte index, which confirms the shift of the leukocyte formula to the left and indicates the dominance of activation of the cellular link of the immune system, indicating an active adaptive reaction of white blood. A simultaneous increase in the leukocyte shift index and a decrease in the lymphocyte-granulocyte index indicates the development of endogenous intoxication in chickens and a violation of their immunological reactivity due to autointoxication of the body during the destruction of its own cells.

REFERENCES:

[1] Hemsworth, P.H. (2021). Cage production and laying hen welfare. *Animal Production Science*,. 61, 821-836. doi:10.1071/AN19609.

[2] Guide to the content of the final hybrid Hy-Line W-36, 2019. 32 p. Retrieved from https://www.hyline.com/userdocs/pages/36_COM_RUS.pdf.

[3] Abrahamsson, P., & Tauson, R. (1997). Effects of group size on performance,health and birds' use of facilities in furnished cages for laying hens. *Acta Agriculturae Scandinavica – Section A: Animal Science*, 47, 254-260. doi: 10.1080/09064709709362394.

[4] Appleby, M.C. (1998). The Edinburgh modified cage: effects of group size andspace allowance on brown laying hens. *Journal of Applied Poultry Research*,7, 152-161. doi: 10.1093/japr/7.2.152

[5] Sierzega, M., Lenart, M., Rutkowska, M., Surman, M., Mytar, B., Matyja, A., Siedlar, M., & Kulig, J. (2017). Preoperative Neutrophil-Lymphocyte and Lymphocyte-Monocyte Ratios Reflect Immune Cell Population Rearrangement in Resectable Pancreatic Cancer. *Annals of Surgical Oncology*, 24(3), 808-815. doi:10.1245/s10434-016-5634-0.

[6] Shimmura, T., Azuma, T., Eguchi, Y., Uetake, K., & Tanaka, T. (2009). Effects ofseparation of resources on behaviour, physical condition and production oflaying hens in furnished cages. *British Poultry Science*, 50, 39-46. doi: 10.1080/00071660802613260.

[7] Kryzhanovsky, G.N., Magaeva S.V., & Makarov S.V. (1997). *Neuroimmunopathology*. Moscow: Medicine.

[8] Fedorov, B.M. (1990). *Stress and circulatory system*. Moscow: Medicine.

[9] Sellier, G.(1969). *Essays on the Adaptation Syndrome.* Moscow: Medgiz.

[10] Miftahutdinov, A.V. (2014). Experimental approaches to the diagnosis of stress in poultry (review). *Agricultural Biology*,. 2, 20-30. doi: 10.15389/agrobiology.2014.2.20eng.

[11] Gupta, S.K., Behera, K., Pradhan, C.R., Acharya, A.P., Sethy, K., Behera, D., Lonel, S.A., & Shinde, K.P. (2017). Influence of stocking density on the performance, carcass characteristics, hemato-biochemical indices of Vanaraja chickens. *Indian Journal of Animal Research*, 51(5), 939-943. doi: 10.18805/ijar.10989.

[12] Hetland, H., Moe, R.O., Tauson, R., Lervik, S., & Svihus, B. (2004). Effect of includingwhole oats into pellets on performance and plumage condition in laying henshoused in conventional and furnished cages. *Acta Agriculturae Scandinavica – Section A: Animal Science*, 54, 206-212. doi: 10.1080/09064700410010026.

[13] Kholodkovskaya, V.D., & Barabanov A.L.(2015). Using integral hematological indices to assess severity of endogenous toxicosis in chronic dermatoses. *International Scientific and Practical Conference "World Science"*, 3(2), 69-72.

[14] Maxwell, M.H., Hocking, P.M., & Robertson, G.W. (1992). Differential leucocyte responses to various degrees of food restriction in broilers, turkeys and ducks. *British Poultry Science*, 33(1), 177-187. doi: 10.1080/00071669208417455.

[15] Heidt, T., Sager, H.B., Courties, G., Dutta, P., Iwamoto, Y., Zaltsman, A., von Zur Muhlen, C., Bode, C., Fricchione, G.L., Denninger, J., Lin, C. P., Vinegoni, C., Libby, P., Swirski, F.K., Weissleder, R., & Nahrendorf, M. (2014). Chronic variable stress activates hematopoietic stem cells. *Nature Medicine*, 20(7), 754-758. doi: 10.1038/nm.3589.

[16] Nwaigwe, C.U., Ihedioha, J.I., Shoyinka, S.V., & Nwaigwe, C.O. (2020). Evaluation of the hematological and clinical biochemical markers of stress in broiler chickens. *Veterinary World,* 13(10), 2294-2300. doi: 10.14202/vetworld.2020.2294-2300.

[17] Vits, A., Weitzenburger, D., Hamann, H., & Distl, O. (2005). Production, egg quality,bone strength, claw length, and keel bone deformities of laying hens housed infurnished cages with different group sizes. *Poultry Science*, 84, 1511-1519. doi:10.1093/ps/84.10.1511.

[18] Raznatovskaya, E.N. (2012). Integral indicators of endogenous intoxication in patients with chemoresistant pulmonary tuberculosis. *Actual Problems of Pharmaceutical and Medical Science and Practice*, 2(9), 119-120.

[19] Rekalova, O.M., Panasyukova, O.R., & Koval, N.G. (2017). Application of leukocyte indices in immunological assessment of inflammatory process activity in patients with chronic obstructive pulmonary disease. *Asthma and Allergy,* 1, 27-33.

[20] Siplyvyi, V.A., Kon, E.V, & Yevtushenko, D.V. (2009). The use of leukocyte indices to predict the outcome of peritonitis. *Clinical Surgery*, 9, 21-26.

[21] Belyaeva, E.Yu., & Buslovskaya, L.K. (2012). Adaptive reactions and biochemical indicators of chicken blood in different conditions of illumination. *Scientific Journal. Series of Natural Sciences*, 21(140), 143-148.

[22] Letkin, A.I. (2020). Leukocytic blood parameters of laying hens with nonspecific stress syndrome. *Bulletin of the Altai State Agrarian University*, 2(184), 102-108.

[23] Derho, M.A., & Samoilova, E.S. (2011). Integral indices of intoxication as a criterion for evaluating the level of endogenous intoxication in babesiosis. *Scientific Notes of KGAVM Named After N.E. Bauman*, 207, 170-177.

[24] Croney, C.C., & Newberry, R.C. (2007). Group size and cognitive processes. *Applied Animal Behaviour Science*, 103(3-4), 215-228. doi:10.1016/j.applanim.2006.05.023.

[25] Bas Rodenburg, T., & Koene ,P. (2007). The impact of group size on damaging behaviours, aggression, fear and stress in farm animals. *Applied Animal Behaviour* Science, 103(3-4), 205-214. doi:10.1016/j.applanim.2006.05.024.

[26] Wood-Gush, D.G.M. (1971). *The Behaviour of the Domestic Fowl*. London: Heinemann Educational Books Ltd.

[27] Estevez, I., Andersen, I.-L., & Nævdal ,E. (2007). Group size, density and social dynamics in farm animals. *Applied Animal Behaviour Science,* 103(3-4), 185-204. doi:10.1016/j.applanim.2006.05.025.

[28] Appleby, M.C. (1998). Modification of laying hen cages to improve behavior. *Poultry Science*, 77, 1828-1832. doi: 10.1093/ps/77.12.1828.

[29] Appleby, M.C., Walker, A.W., Nicol, C.J., Lindberg, A.C., Freire, R., Hughes B.O., & Elson, H.A. (2002). Development of furnished cages for laying hens. *British Poultry Science*, 43, 489-500. doi: 10.1080/0007166022000004390.

[30] Hemsworth, P.H. (2021). Cage production and laying hen welfare. *Animal Production Science*,. 61, 821-836. doi:10.1071/AN19609.

[31] Guo, Y.Y., Song, Z.G., Jiao, H.C., Song, Q.Q., & Lin, H. (2012). The effect of group size and stocking density on the welfare and performance of hens housed in furnished cages during summer. *Animal Welfare*, 21, 41-49. doi: 10.7120/096272812799129501.

[32] Kang, H.K., Park, S.B., Kim, H.S., & Kim, C.H. (2016). Effects of stock density on the laying performance, blood parameter, corticosterone, litter quality, gas emission and bone mineral density of laying hens in floor pens. *Poultry Science*, 95, 2764-2770. doi: 10.3382/ps/pew264.

[33] Levandovsky, R.A. (2014). Cellular and immunological reactivity of the body in patients after resection of the upper and lower jaws to remove malignant tumors. *Clinical and Experimental Pathology*, 2(48), 83-87.

[34] Ostrovska, L.Y., Moshel, T.M., & Ivanitsky, I.O. (2016). Analysis of hemogram parameters in patients with inflammatory and inflammatory-dystrophic changes of periodontal tissues. *Bulletin of Problems of Biology and Medicine*, 1(126), 360-363.

[35] Bondarchuk, R.V., Sydorchuk, L.P., & Sydorchuk, I.Y. (2016). The level of adaptive stress and cellular reactivity of the body in patients with arterial hypertension in combination with coronary heart disease. *Bukovyna Medical Herald*, 20(2), 16-19.
[36] Tkachenko, E.A., & Derho, M.A. (2014). Leukocytic parameters in experimental cadmium intoxication in mice. *Proceedings of the Orenburg State Agrarian University*, 3, 81-83.
[37] Yabluchansky, N.I. (1983). Leukocyte shift index as a marker of reactivity of the organism in acute inflammation. *Laboratory Business*, 1, 60-61.
[38] Gao, S.Q., Huang, L.D., Dai, R.J., Chen, D.D., Hu, W.J., & Shan, Y.F. (2015). Neutrophil-lymphocyte ratio: a controversial marker in predicting Crohn's disease severity. *Journal of Clinical and Experimental Pathology*, 8(11), 14779-14785.
[39] Keeling, L.J., Estevez, I., Newberry, R.C., Correia, M.G. (2003). Production-relatedtraits of layers reared in different sized flocks: The concept of problematicintermediate group sizes. *Poultry Science*, 82, 1393-1396. doi: 10.1093/ps/82.9.1393.
[40] Matolych, U.D (2016). Diagnostic value of hematological indices in phlegmon of the maxillofacial area and neck. *Scientific Bulletin of Uzhhorod University, Series "Medicine"*,1(53), 108-110.
[41] Mustafina, J.G.G., Kramarenko, Y.S., & Kobtseva, V. (1999). Integral hematological parameters in the evaluation of the immunological reactivity of the organism in patients with ophthalmopathology. *Clinical Laboratory Diagnostics*, 5, 47-48.
[42] Zubchenko, S.O., Akimova, V.M., & Lapovets, L.E. (2014). Identification of pre-hospital disorders based on changes in integral hematological indices in patients with the latent stage of chronic Epstein-Barr virus infection. *Herald of Problems of Biology and Medicine*, 4, 1(113), 125-128.
[43] Radzykhovsky, M.L., Goralsky, L.P., Borisevich, B.V., & Dyshkant, O.V. (2018). Integral indices of intoxication of dogs with coronavirus enteritis. *Scientific Bulletin of Veterinary Medicine*, 2, 13-19. doi: 10.33245/2310-4902-2018-144-2- 13-19.
[44] Shabalov, N.P., Ivanov, D.O., & Shabalova, N.N. (2001). Heterogeneity of the systemic inflammatory response in neonatal sepsis. *Medical Academic Journal*, 1(3), 81- 90.
[45] Khabirov, T.Sh. (2002). The level of reactive response of neutrophils as an indicator of the severity of endogenous intoxication in abdominal sepsis. Lugansk: WFUMS.
[46] Rushen, J.(1991). Problems associated with the interpretation of physiological data in the assessment of animal welfare. *Applied Animal Behaviour Science*, 28, 381-386. doi: 10.1016/0168-1591(91)90170-3.
[47] Brodyak, I., & Sibirna, N. (2006). Morphofunctional studies of peripheral blood leukocytes under conditions of experimental diabetes mellitus in rats. *Bulletin of Lviv University. Biological Series*, 42, 117-127.
[48] Mazur, O.A, Olenovych, O.A., Plaksivyi, A.G., Kalutskyi, I.V., Yakovets, K.I., & Bogach, V.A (2017). Indicators of endogenous intoxication in patients with chronic purulent maxillary sinusitis with type 1 diabetes mellitus. *Bukovinian Medical Bulletin*, 1(81), 76-80.

Вплив величини угрупування курей на неспецифічну реактивність їх організму

Ю. В. Осадча

Кандидат сільськогосподарських наук, доцент
https://orcid.org/0000-0003-4126-2456

Національний університет біоресурсів і природокористування України

Анотація. Досліджено неспецифічну реактивність організму курей за впливу величини угрупування з однаковою щільністю посадки несучок в клітках-аналогах за конструкцією. Виявлено, що за зменшення величини угрупування курей спостерігається зсув лейкоцитарної формули вліво, перевага неспецифічних захисних клітин, що відбувається внаслідок функціонального підвищення проліферативної активності кісткового мозку і виражається у збільшенні кількості гетерофілів та підвищенні їх активності у мікрофагальномакрофагальній системі імунної відповіді

Ключові слова: кури, стрес, імуногематологічні індекси, неспецифічна реактивність, ендогенна інтоксикація