Method of Increasing Bird Adaptation in the Early Stages of Embryogenesis

Tatyana Kolokolnikova
Department of breeding, genetics and biotechnology of poultry
Siberian Scientific Research Institute of Poultry Farming – Branch of the Omsk Agrarian Scientific Center
Omsk, Russia
kotani2009@mail.ru

Andrei Dymkov
Department of breeding, genetics and biotechnology of poultry
Siberian Scientific Research Institute of Poultry Farming – Branch of the Omsk Agrarian Scientific Center
Omsk, Russia
dymkov65@mail.ru

Sergey Borisenko
Department of Animal Science
Omsk State Agricultural University named after P. A. Stolypin
Omsk, Russia
svb_777@mail.ru

Alexey Kavtarashvili
Laboratory of the Technology of Egg Production
All-Russian Research and Technological Poultry Institute of Russian Academy of Sciences
Sergiyev Posad, Russia
alexk@vnitip.ru

***Abstract*—The article is devoted to the study of birds' adaptation in the early development stages through the stress factor impact. To carry out the adaptation, eggs of meat and egg-laying crosses were cooled down to the chosen temperature at certain incubation periods. The developed egg cooling scheme of meat and egg-laying crosses during the incubation period allowed us to increase the hatchability rate by reducing the amount of incubation waste – the blood rings, dormant embryos (7.5-18.5 days) and dead-in-shell chicks. This scheme application has a positive effect on poultry growth, it allows to increase meat yield (by 3.2-3.4%) and egg yield (by 1.5-4.3% for the initial laying hen), which in turn increases the profitability of broiler meat production by 4.1% and 7.7%, and table eggs by 2.6-3.4%, and also confirms the birds' adaptation to subsequent stresses during the incubation period. According to the research results, patent No. 2613282 "A method for incubating chicken eggs of meat and egg-laying crosses" was obtained. This method is recommended for implementation in production of poultry farms.**

Keywords—stress, adaptation, claw trimming, egg cooling, incubation, hatchability rate, poultry production performance.

I. Introduction

Birds in production face stress every day. It is impossible to create ideal conditions without a single stress factor. But is it necessary to do so? One cannot disagree with H. Selye – stress is the organism's defense, in a certain sense. And in order for the organism to be always fully armed, it needs to be prepared, namely, trained to exercise by stressful loads, just as athletes are trained to exercise physically.

Adaptation to the usual, constantly manifesting environmental factors occurs throughout the life and is carried out using various neuro-humoral mechanisms. The doctrine of stress has received broad theoretical and practical justification in biology, medicine and veterinary. In conditions of intensive husbandry and poultry farming, stress began to be recorded more often than the diseases. Stressful situations can be forced (vaccination, transportation, limited feeding, overcrowding, etc.) and undesirable (high temperatures, gas contamination, breakdowns in drinking water system, equipment repair, etc.). Farm specialists should strive to minimize the negative effect of stress by any available means to maintain fowl's safety and yield [1-3]. One way is to prepare the chicken for the production stress.

Any stress factor affects simultaneously all body systems. The effects of stress depend on the strength and duration of exposure to the stress factor, as well as on the body's readiness to withstand these factors. The most unfavorable is the combined action of several stress factors, which can often be observed under industrial conditions of poultry farming [4].

There is no concrete answer to the question: "What stressful effects should be used to adapt the bird and how stressful they must be?" It is important to consider that in the life of a bird there are age periods and production moments (the process of hatching, the beginning of oviposition), which are stress factors themselves for the body.

There is an understanding that it is necessary to start in the early stages of development. Active postnatal adaptive reactions are manifested at the age of one day; the reactions of reserve adaptation are observed at the 7-day age, which corresponds to the phase of the nonspecific adaptation reaction and preparation for forced physiological loads [5].

Where are the limits when the stress level is already sufficient for adaptation, but not yet excessive for the bird's health? These limits will differ for birds of different species, breeds, production areas, not to mention the age and veterinary well-being of the flock. Frequent, strong and prolonged stressful effects will simply destroy the body; the weak effects are not able to improve, since homeostasis (the body's ability to maintain a constant internal environment) can easily cope with them.

A number of stressful effects are used in poultry farming purposefully to improve zootechnical indicators – forced molting, vaccination, debeacking, dubbing, artificial insemination, changing the diet, etc. However, these are not used to adapt birds, but to solve various zootechnical and veterinary issues.

In claw trimming studies at the age of one day, the objective was to find the optimal trimming option to reduce harming of laying hens when kept in battery cages, since they do not have the ability to grind the claws and by the end of the productive period the claws can reach to 8-10 cm. Having such a "weapon", the hens are injuring themselves; injure each other, as well as personnel when they take birds out from cages. Bird has fewer injuries with no claws, they seem calmer and the yield is higher. In addition, bird's catching time is reduced.

We studied the following trimming options on both legs: only third toes; first and third toes; all toes. The best option was where the claws were trimmed on the first and third toes of one day old chickens of the final hybrids of the Rodonit and Hisex Brown crosses. This technique contributed to increasing the flock uniformity at 16 weeks of age by 3.0-11.0%, compared to the younger age. And in the productive period, this technique allowed to increase egg production in the middle and initial layers by 4.3-6.3% and 2.9-8.9%, while reducing the feed cost for 10 eggs and 1 kg of egg weight by 3.9-5.6% and 3.7-4.9%, respectively. A production audit confirmed the results. The total economic effect per 1000 animal units of the initial livestock during the sale of table eggs and laying hens amounted to 13374.18 rubles [6-7].

It was noted that the more toes were cut off, the earlier the sexual maturity occurred, the live weight of young and laying hens was higher, the egg-laying peak was earlier, and the yield declined more slowly.

Perhaps this depended on the stress level when trimming claws in the age of one day? The more toes were cut off, the stronger and longer the exposure to the stress factor was, the more adapted the bird became to the production conditions.

And what if you start the process of adaptation during the incubation period, when all body systems are still developing?

Numerous studies have proven the positive effects of both cooling and heating eggs during incubation [8]. Both are stressful for the embryo.

In nature, bird embryos undergo periodic cooling during natural incubation. Why not bring temperature fluctuations into the artificial incubation mode in order to adapt the bird to production stresses in the early stages of development?

II. Research Methodology

The objective was to increase the output of younglings and subsequent yield by cooling developing embryos at certain periods.

We developed a scheme for cooling chicken eggs of meat and egg crosses during the incubation period. The novelty of the developed cooling scheme consists in the adaptation of a developing organism by a significant periodic decrease in egg temperature, starting from 6.5th day of incubation. With an increase in the incubation period, the cooling time increases as the embryo begins to generate heat itself. Egg cooling had a positive effect on both incubation results and adult bird yield.

The studies were conducted on eggs of experimental broiler chicken cross meat at the Siberian Research Institute of Poultry and on eggs of chicken crosses Hisex White and Hisex Brown at "Irtyshskoye" farm.

The Universal-55 incubators were used, using a differentiated incubation regime, both in the control and in the experimental groups. The eggs of the control groups were not cooled down. In the experimental groups, cooling was carried out once a day: by 6.5th; 8.5th and 11.5th day of incubation down to 32 °C on the surface of the eggs, then the cooling was preformed every day until transfer to the hatching machines – down to 30 °C. When these temperatures were reached, cooling was stopped and incubation continued as usual.

Cooling was carried out by opening the doors of the incubator machine, turning off the heating element and active ventilation of the incubator ventilation system. The temperature on the surface of the eggs during cooling was measured by TP-1 and DS18S20 sensors.

In the first study, two control and two experimental groups were formed, differing in egg weight, with the eggs of the final hybrid of the experimental meat cross. 200 chickens were randomly selected from each group and placed in the rearing house on deep bedding up to 42 days of age (Table I).

TABLE I. Research 1 scheme

Group	Egg weight, g	Eggs selected for study	Rearing flock, animal units
1(control)	60.0-64.9	3128	200
2(control)	65.0 and more	5488	200
1(experimental)	60.0-64.9	3128	200
2(experimental)	65.0 and more	5480	200

TABLE II. Research 2 scheme

Group	Cross	Egg weight, g	Eggs selected for study
1(control)	Hisex White	60.0-64.9	689
2(control)	Hisex Brown		689
3(control)	Hisex White	65.0 and more	646
4(control)	Hisex Brown		663
1(experimental)	Hisex White	60.0-64.9	686
2(experimental)	Hisex Brown		690
3(experimental)	Hisex White	65.0 and more	649
4(experimental)	Hisex Brown		656

In the second study, two control and two experimental groups of eggs of Hisex White and Hisex Brown crosses, differing in egg mass, were selected for incubation. Groups of the same name were formed with 120 of hatched chickens in each. Fowl up to 64 weeks of age was kept in Zucami battery cages (Table II).

III. Research Results

The developed cooling scheme made it possible to increase the hatchability rate by 1.09-1.52% (the difference between the 2k and 2o groups was significant at $P < 0.01$) in the first study by reducing the amount of incubation waste – the blood rings by 0.43-1, 67% ($P < 0.001$), dormant embryos (7.5-18.5 days of age) by 0.28-0.17%, dead-in-shell by 0.68-1.61% ($P < 0.001$) (Table III).

As a result, the output of young animals increased by 1.49% and 2.74% (the difference between the 2 control and 2 experimental groups was significant ($P < 0.001$)).

One day old chickens of the experimental groups had a more developed hearts (by 0.081-0.062%), lungs (by 0.009%), and also had a higher weight of chest muscles (by 0.011-0.038%), thighs (by 0.150-0.546%) tibia (0.215-0.220%). With an equal live weight, the one day old chickens of both experimental groups had a lower weight of the yolk sac with a residual yolk by 2.283-2.378% ($P < 0.05$), in comparison with the control group, which indicates its better assimilation during the incubation period (Table IV).

TABLE III. RESULTS OF INCUBATION OF MEAT CROSS EGGS, %

Indicator	Group			
	1c	*1e*	*2c*	*2e*
Fertilized eggs	88.91	89.01	88.83	88.12
Hatchability rate	90.63	91.72	89.11	90.63[a]
Hatchability of live chicken	80.12	81.61	77.81	80.55[в]
Incubation waste:				
unfertilized	11.09	10.99	11.17	11.88
dormant embryos (48 hours before incubation)	0.35	0.37	0.42	0.43
blood rings	3.83	3.38	5.33	3.65[в]
dormant embryos (7.5-18.5 days before incubation)	1.11	0.83	1.12	0.95
dead-in-shell	3.50	2.82	4.15	2.54[в]

The difference with the 2c group is significant at: P <0.01 - a; P <0.001 - c.

TABLE IV. RELATIVE ORGANS' WEIGHT OF ONE DAY OLD CHICKEN, %

Indicator	Group			
	1c	*1e*	*2c*	*2e*
Hearts	0.541	0.622	0.550	0.612
Lungs	0.768	0.777	0.751	0.760
Muscles:				
breast	2.029	2.040	1.859	1.897
thighs	4.794	4.944	4.862	5.408
tibia	3.963	4.178	4.038	4.258
Spleens	0.024	0.030	0.026	0.035
Bursas	0.093	0.102	0.104	0.111
Yolk sac with residual yolk	10.301	8.018	10.736	8.358

An indirect confirmation of the better development of immune system is the superiority of the chickens of the experimental groups in terms of spleen weight by 0.006-0.009% and bursa by 0.009-0.007%.

The avian spleen is an exclusively immunocompetent organ. Its formation as a whole is completed by the time the chicks are hatched, i.e. an exceptional role in this process is played by the egg incubation period [9].

One of the important functions of bursa is to control the maturation of B lymphocytes and the formation of humoral immunity. In addition, it is capable of synthesizing antibodies. This property is most actively manifested during the first few months of the chickens' life [10].

The use of the developed scheme for eggs cooling during the incubation period further contributed to an increase in body weight at 42 days of age by 3.2-3.4%, 1st quality meat yield – by 3.5-7.3%, while reducing feed costs by 1 kg gain in live weight by 2.9-4.3%. The profitability of meat production in the experimental groups was greater than the control ones by 4.1% and 7.7% (Table V).

TABLE V. RESULTS OF REARING OF MEAT CROSS CHICKEN

Indicator	Group			
	1c	*1e*	*2c*	*2e*
Live weight at 42th day of life, g	1930.4	1991.8	1954.4	2020.5
Meat yield, %:				
I quality	85.7	89.2	81.2	88.5
II quality	2.3	0.8	2.9	0.7
for processing	12.0	10.0	15.9	10.8
Profitability of production, %	42.9	47.0	42.6	50.3

In the second study, the use of a new egg cooling scheme during the incubation period allowed us to increase the hatchability rate and hatchability of live chickens of all experimental groups, in comparison with the control groups by 1.17-2.35% and 1.05-2.35%, respectively. This is due to a decrease in the incubation waste: the blood ring by 0.19-1.05%; dorment embryo (7.5th-18.5th day) by 0.07-0.68%; dead-in-shell by 0.20-2.02% (Table VI).

TABLE VI. RESULTS OF INCUBATION OF EGG-LAYING CROSS EGGS, %

Indicator	Group							
	1c	*1e*	*2c*	*2e*	*3c*	*3e*	*4c*	*4e*
Fertilized eggs	92.11	92.33	92.12	92.15	93.10	92.95	92.45	92.42
Hatchability rate	91.15	93.41	92.15	94.50	92.52	94.62	89.95	91.12
Hatchability of live chicken	83.95	86.24	84.88	87.23	86.16	87.94	83.16	84.21
Incubation waste:								
unfertilized	7.89	7.67	7.88	7.85	6.90	7.35	7.55	7.58
dormant embryos (48 hours before incubation)	2.81	2.91	2.21	2.31	2.31	2.49	2.55	2.84
blood rings	1.55	0.50	1.85	1.32	1.21	1.02	1.71	1.22
dormant embryos (7.5-18.5 days before incubation)	0.89	0.82	0.85	0.52	0.85	0.65	1.82	1.14
dead-in-shell	2.91	1.86	2.33	1.77	2.57	0.55[a]	3.21	3.01

The difference with the 3c group is significant at: P <0.01 - a.

The chickens of experimental groups exceeded the control group in relative weight of hearts (by 0.001-0.043%), gizzards (by 0.027-0.343%), spleens (by 0.006-0.012%), and bursas (by 0.010-0.024%). In this case, in the chickens of the experimental groups, as in the experiment with chickens of meat cross, a smaller mass of the yolk sac with the residual yolk was noted to be 0.308-0.871% (Table VII).

The experimental groups exceeded the control group in live weight of rearing chickens at 16 weeks of age by 12.0-42.0 g, or 1.1-3.0%, with the same feed intake. Production indicators of laying hens are presented in Table VIII.

In the production period of 20-64 weeks, the hens of the experimental groups had a higher preservation by 0.09-2.60%, in comparison with the control group; live weight at 64 weeks of age was higher by 1.5-4.7% (between groups 1c and 1e difference is significant at P <0.05), egg production on the initial one – by 4.0-11.4 units, or 1.5-4.3% (the difference is significant between groups 1c and 1e (P <0.01), 3c and 3e (P <0.001), 4c and 4e (P <0.05)) and the average layer – by 3.3-6.2 units, or 1.2-2.3% (the difference is significant between groups 1c and 1e (P <0.01), 3c and 3e (P <0.01)), the average egg weight – by 0.2-0.6 g, or 0.3-1.0% (the difference is significant between groups 1c and 1e (P <0.01), 3c and 3e (P <0.05)).

TABLE VII. RELATIVE ORGANS' WEIGHT OF ONE DAY OLD CHICKEN, %

Indicator	**Group**							
	1c	***1e***	***2c***	***2e***	***3c***	***3e***	***4c***	***4e***
Hearts	0.827	0.831	0.815	0.858	0.805	0.807	0.833	0.834
Gizzards	6.271	6.568	7.007	7.279	5.843	6.186	7.124	7.151
Spleens	0.048	0.055	0.047	0.053	0.048	0.060	0.041	0.050
Bursas	0.149	0.159	0.127	0.142	0.157	0.181	0.116	0.134
Yolk sac with residual yolk	8.222	7.351	7.691	7.383	9.777	8.923	8.128	7.612

TABLE VIII. LAYING HENS' PRODUCTION DURING 64 WEEKS OF LIFE

Indicator	**Group**							
	1c	***1e***	***2c***	***2e***	***3c***	***3e***	***4c***	***4e***
Viability, %	96.49	96.58	95.76	97.46	96.55	99.15	96.55	98.28
Live weight (g) at 64th week:	1703	1783[a]	1965	2022	1743	1794	1996	2026
Laying capacity (units) per one hen:								
initial	267.5	274.1[в]	269.7	273.7	265.8	277.2[c]	263.6	268.8[a]
average	271.4	277.6[в]	275.1	278.4	271.3	277.5[в]	267.2	271.2
Average egg weight, g	60.1	60.7[в]	63.2	63.5	61.5	62.0[a]	63.6	63.8
Egg weight output, kg:								
of initial hen	16.08	16.64	17.04	17.38	16.34	17.18	16.76	17.15
of average hen	16.31	16.85	17.39	17.68	16.68	17.20	16.99	17.30
Profitability of production, %	9.29	12.71	5.52	8.15	10.5	13.48	3.54	6.13

The difference with the analogue group is significant at: P <0.05 - a; P <0.01 - c; P <0.001 - s.

As a result, the egg weight output was higher in the experimental groups than in the control groups, both of the initial (0.34-0.84 kg, or 2.0-5.1%), and of the average laying hen (0.29- 0.54 kg, or 1.7-3.3%).

When calculating the economic efficiency, it was found that the use of this egg cooling scheme allows increasing the profitability of production by 2.6-3.4%.

IV. CONCLUSION

The developed egg cooling scheme for meat and egg-laying crosses during the incubation period allows to increase the hatchability rate by reducing the amount of incubation waste – the blood ring, dormant embryos (7.5-18.5 days) and dead-in-shell. Scheme's application has a positive effect on chicken growth; it allows to increase meat (by 3.2-3.4%) and egg (by 1.5-4.3% of the initial laying hen) yield, which in turn increases the profitability of production of broiler meat by 4.1% and 7.7%, and table eggs by 2.6-3.4%, and also confirms the birds' adaptation during the incubation period to subsequent stresses.

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