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# REPRODUCTIVE FUNCTION IN HYBRID POULTRY. II. AN IMPACT OF BREEDING FOR TRAITS OTHER THAN PRODUCTIVITY*
(review)

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Abstract

Herein, the data are summarized on the impact of such selection criteria as poultry cannibalism, ascites resistance, stress responsiveness, and primary immune response to reproductive function in poultry. The selection for one of these signs changes the productivity and other body functions. High-productive meat crosses differ from slow-growing chicks in a susceptibility to ascites (R. Wideman, 2001). Broilers' mortality because of ascites makes 5-10 %, and at the lowered temperature of the environment can reach 50 % calculated from world production (H. Pavlidis et al., 2007). Prerequisites to development of the disorder are formed during embryogenesis (E. Decuypere et al., 2000). In the embryos who are the descendants of ascite resistant poultry ($L^-$), a relative heart weight is reliable higher, and pipping shells and a hatching occur earlier, than in $L^+$ genotype lines for which the hypothyroidism and tachycardia are characteristic (D. Luger et al., 2002). An observed increase in egg incubation period in $L^+$ lines can be caused by lower activity of thyroid gland and an increased $pCO_2$ in egg air camera, and as a result, the embryos suffered from hypoxia. A positive correlation is revealed between the development of lungs and the thyroid gland activity during embryogenesis, i.e. the lungs volume is the larger the higher thyroidal hormone rate, and vice versa (M. Hassanzadeh et al., 2008). In the chickens with better developed lungs, grown up under chronic hypoxia, the mortality from ascites was reliably lower. In $L^+$ and $L^-$ broilers the mortality was 93.2 and 9.0 %, respectively (S. Druyan, 2009). The heart beating in $L^+$ and $L^-$ 1-day chickens differed, being on average 435 and 404 beats per minute, respectively, but to the day 17 the difference practically leveled (419 and 417 beats per minute, respectively) due to a decreased rate in $L^+$ and an increased rate in $L^-$. Divergent selection for the feather pecking behavior causes differentiation in reactivity of the neuro-endocrine and immune systems (A. Buitenhuis, 2006). There are the evidences that the optimized incubation protocols for meat hens can prevent broiler chicks from ascites and improve safety of the poultry. Feather pecking reduced in the course of selected is associated with improvements in egg production (number and weight of eggs), but the deterioration in the quality of hatching eggs, the results of incubation, the state of derived chickens and changes of stress responsiveness and(or) immune response. So, the feather pecking rate was reliable lower in $L^-$ than in $L^+$ poultry, and the number and weight of eggs laid during a month are higher (i.e. 0.38 and 2.01 feather pecking per hour, 1223 and 1132 g, 24.4 and 18.3 eggs, respectively). However, the egg quality in $L^+$ hens was better compared to $L^-$, with the Haugh units of 73.0 and 64.9, shell thickness of 38.1 and 37.0 mm, and yolk ration of 30.6 and 29.5 %, respectively (G. Su, 2006). Selection for humoral immune response causes the metabolic changes and influences on the synthesis of proteins which are key factors for both immune protection and ensuring reproductive function and egg production, so there is an imbalance between a potential of antibody response, growth, development and reproductive function. Under the influence of divergent selection for primary immune response, body weight, time of puberty and egg production were higher in the $L^-$ layers compared to $L^+$ hens, while the $L^+$ hens surpassed them in egg quality, such as height and pH of the egg white, Haugh units, the number of two-yolk eggs. The changes in reproductive function due to poultry targeted selection should be compensated by genotype-specific optimization of feed rations and rearing technologies for adult hens, and by an adjustment of egg incubation conditions.

Keywords: poultry, genotype, selection, breeding, traits, ascytes, stress responsiveness, feather pecking, antibody response, egg's quality and incubation, embryo metabolism.

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Poultry breeding for the increase in productivity has led to the dysfunction of reproductive capacity, resulting in a decrease in the quality of hatching eggs, embryo metabolism disorders, deterioration of the results of incubation and the state of young poultry [1, 2]. Changes are observed in chemical composition and the ratios of egg ingredients, shell permeability, deviations in development and integration of life support body systems (neuroendocrine, cardiovascular, immune systems, etc.), as well as in the duration of individual stages of development, particularly in the terminal period of embryogenesis.

In contrast to the initial genotypes, aggressiveness is manifested [3, 4], stress resistance and to infection is reduced [5, 6] in highly productive hybrid poultry. In addition, it is susceptible to so-called technological diseases — new metabolic disorders, including the sudden cessation of egg production syndrome, hysteria, ascites syndrome, sudden death, etc. [7]. Predisposition to them in different genotypes varies. Selection for reduction of the severity of these disorders provides a positive result [8-10], but has an effect on the reproductive function.

This article provides a review of studies on the reproductive function in different genotypes of highly productive poultry when breeding was performed for traits other than productivity. Particular attention is paid to the early period of ontogenesis in the offspring with different susceptibility to metabolic disorders.

A s c i t e s  s y n d r o m e. Broilers' mortality because of ascites makes 5-10 %, and at the lowered temperature of the environment it can reach 50 %, calculated from world production [11, 12]. High-productive meat crosses differ from slow-growing chicks in their susceptibility to this syndrome [13-16].

According to G. Havenstein [17], the visceral system organs have not changed as much as the vegetative system organs in such hybrids as a result of many years of breeding in their parents. Broilers of modern crosses having a live weight of 2 kg or more by the 40-42-day-old age need more oxygen for their growth and activity, so their heart must work inadequately for its capabilities [18]. Hypoxia developing on the back action scheme causes compensatory increase in the intensity of heart function. Hypertrophy of cardiomyocytes and thickening of the muscular wall arise. Due to the lack of oxygen, some of them die, and the remaining ones become elongated and thin, which ultimately leads to heart failure and paralysis of the heart with ascites symptoms [19]. Chronic heart failure is the main cause of hypoxemia and hypertension of pulmonary circulation and the resulting ascites syndrome in broilers [20].

Prerequisites to development of the disorder are formed during embryogenesis [21, 22]. In the embryos who are the descendants of ascite resistant poultry, the relative heart weight is significantly higher, and pipping shells and a hatching occur earlier, than in the susceptible genotype of the embryos of which hypothyroidism and tachycardia are typical [23]. The interval between the perinatal period stages I and II is identical in them, and the interval between stages II and III is shorter in the emryos not susceptible to ascites. At the incubation day 18, reduced $pO_2$ and increased $pCO_2$ in egg air chamber in birds susceptible to ascites compared to these parameters in hens not susceptible to ascites was recorded. According to the authors, a longer incubation of eggs from hens susceptible to ascites can provoke hypothyroidism and increased value of $pCO_2$ in the air chamber which results in embryo hypoxia. These data are consistent with the features of thyroid gland functioning in chickens with ascites [24].

The degree of prenatal hypoxia affects the development of ascites in the postnatal period [14, 25]. Moreover, embryo hypoxia even in the genotypes of the same production type (egg or meat poultry) varies due to different shell permeability and, consequently, the value of $pO_2$ and $pCO_2$ in the egg air chamber [12, 26].

In the environment with high $CO_2$ in the last week [27, 28] and/or first 10 days of incubation [29, 30] embryos displayed earlier than under the standard $CO_2$ level.

Half of eggs from commercial Cobb cross flock and paternal SAS-Hybro line with a tendency to the development of ascites was incubated for 10 days in non-ventilated (NV) setters which resulted in an increase in air $CO_2$ concentration from 0.05 to 0.7 %, the rest eggs were incubated in the setters at standard ventilation (SV) regimen, when the content of this gas was less than 0.1 % [30]. In both genotypes, from incubation day 11 to day 14 $pCO_2$ in the air chamber was significantly higher with NV than at SV. For example, it was 17.9±1.1 and 15.1±0.9 mmHg, respectively, at day 13 in Cobb and 16.2±1.1 and 13.2±0.9 mmHg in SAS-Hybro. Hatchability in SAS-Hybro-NV was 88.00 %, while in SAS-Hybro-SV it was just 76.84 %. The period from the start of incubation to each of the three stages of perinatal period was shorter in Cobb than in SAS-Hybro in all versions of the experiment: Stage I with the NV mode lasted for 7.33±0.46 and 13.29±0.50 hours, respectively, while with the SV mode it was 10.49±0.41 and 11.54±0.45 hours. Hatching in Cobb-NV was completed 2.5 hours earlier than in Cobb-SV, and 0.5 hours earlier than in SAS-Hybro. From day 17 to hatching, plasma $T_3$, $T_4$ and corticosterone levels in Cobb were significantly higher compared to SAS-Hybro under both incubation modes. In Cobb and SAS-Hybro, dependence of thyroid hormones concentration from pCO2 was not found, but the dynamics of corticosterone level was significantly defined by both incubation regime and genotype. While a sharp increase in this hormone level was observed at SV from day 11 to day 17 in both genotypes followed by its further decrease, at NV maximum corticosteroid level was reached at day 15. The latter was lower in Cobb-NV compared to SAS-Hybro-CB, while the dependence on $pCO_2$ was not found in SAS-Hybro.

N. Buys et al. [31] incubated two groups of eggs from two parent forms of meat hens susceptible (AS) and resistant to ascites (AR). During days 1-13, the $CO_2$ content of 0.2 % was maintained in all setters, and during days 14-19 it was increased to 0.4 % in one of them as a result of less active ventilation. AS embryos reached the perinatal stage I significantly later compared to AR embryos in both experimental versions. At 0.2 % $CO_2$, it was reached after 470.67±0.78 and 464.17±0.70 hours of egg incubation. AR embryos that were developing at 0.2 %, hatched significantly earlier than AS (in 492.52±1.11 and 500.97±1.17 hours, respectively), but this difference leveled at 0.4 % (494.12±0.58 and 493.47±0.70 hours). A significantly lower decrease in $T_4$ and $T_3$ was observed in AS genotypes than in AR. In embryos of both genotypes incubated under 0.4 %, plasma $T_3$ concentration was higher and mortality from ascites lower than under 0.2 %. The ratio of the right ventricle weight to the total ventricle weight in AS and AR embryos was greater at 0.2 % $CO_2$ than at 0.4 %.

Heterochrony of internal organs was identified in the embryos of Arbor Acres meat hens compared to the freely mate Athens-Canadian population, which was expressed, inter alia, in a decreased relative heart weight [32].

In embryo offspring of the Ross × Cobb cross chickens heart heterochrony was shown to be not only due to the genotype and hypoxia in embryos, but also to an increase in incubation temperature [33]. Control group of eggs was incubated at the shell temperature of 37.8 °C, experimental group was incubated at 38.9 °C from incubation day 7 until the end of incubation. Egg hatching was almost similar (94.5±0.57 and 92.5±1.04 %). Heart, body, and residual yolk weights at hatching were significantly lower in the experimental group compared to control (by 26 %, 3.4 and 0.5 g, respectively). Total mortality and mortality from ascites were significantly greater in the experiment than in control

(12.5±1.16 against 8.4±1.28 %; and 6.6±1.02 against 2.8±0.65 %, respectively) for the 42-day growing period. Therefore, incubation of eggs at a temperature increased from incubation day 7 by 1.1 °C compared with the standard, provokes heterochrony of heart development and an increase in overall chicken mortality by 4.1 %, and in mortality from ascites by 3.8 %.

As a result of successful divergent selection of maternal livestock for ascites resistance, S. Druyan et al. [9, 34] obtained offspring lines susceptible ($L^+$) and resistant ($L^-$) to ascites. Under provocative conditions, mortality of broilers was 93.2 and 9.0 %, respectively. The heart rate in $L^+$ and $L^-$ 1-day chickens differed, being on average 435 and 404 beats per minute, respectively, but to the day 17 the difference practically leveled (419 and 417 beats per minute, respectively) due to a decreased rate in $L^+$ and an increased rate in $L^-$. Moderate hypoxia is known to initiate the acceleration of the heart rate in birds [35], as evidenced by increased $pCO_2$ in $L^+$ egg air chamber in the terminal period of incubation.

The below data make it possible to conclude that the reasons and conditions for ascites development arise in the incubation period, and embryogenesis in egg from $L^+$ and $L^-$ hens differs (Table 1).

**1. Features of embryogenesis in meat hens genotypes with different susceptibility to ascites syndrome** [23, 27, 30, 34]

| Parameter | Genotype | |
|---|---|---|
| | susceptible | resistant |
| Relative heart weight | Reduction | Increase |
| Egg air chamber at incubation day 18: | | |
| $pO_2$ | Reduction | Increase |
| $pCO_2$ | Increase | Reduction |
| Plasma $T_3$, $T_4$ level | Reduction | Increase |
| Duration of incubation | Increase | Reduction |
| Heart rate in 1-day old chicks | Increase | Reduction |

N o t e. The absolute values of the embryogenesis parameters in compared genotypes published by independent researchers vary but a regularity in the changes of these parameter related to one another can be identified. For example, the $pCO_2$ value in susceptible genotype was lower compared to that in resistant.

Hypothyroidism typical of the meat hens genotype predisposed to ascites [23, 24, 36, 37] also develops due to the breeding for the increase in growth rate and feed [22]. Apparently, it is the decreased thyroid functional activity that determines the processes resulting in the deficit of oxygen in the tissues of broilers which causes myocardial hypertrophy due to the intensified heart function, the lack of cardiovascular efficiency, and development of ascites syndrome as a consequence.

A direct correlation was found in the parameters characterizing lung development and thyroid function in embryogenesis, i.e. the lungs volume is the larger the higher thyroidal hormone rate is, and vice versa [7, 15]. In the chickens with better developed lungs grown under chronic hypoxia, mortality from ascites was significantly lower.

The impact of prenatal hypoxia on the manifestation of ascites syndrome in postnatal period has been proven. Embryogenesis at rather high air $CO_2$ is completed earlier than at its standard and low levels which is due to the increased thyroid under hypoxic conditions [22, 23, 31, 36]. Paradoxically, in chickens hatched from eggs incubated under hypoxic conditions, a decrease in the incidence of ascites has been recorded [28, 27]. One reason for this phenomenon can be a reduction of the period of embryogenesis which results in an earlier change of allantoic respiration to pulmonary respiration, transition to active life and improvement of tissue supply with oxygen.

There are the evidences that the optimized incubation protocols for meat hens appropriate for their genotype can prevent broiler chicks from ascites and improve safety of poultry.

S t r e s s  r e s i s t a n c e  a n d  a g g r e s s i v e n e s s. An increase in corticosterone content in egg white and yolk of eggs produced by stressed laying hens has been proven [38, 39]. The egg white in the eggs produced by hens after immobilization was reported to contain a significantly increased concentration of corticosterone from 1.4-1.5 to 1.7-2.0 ng/g [40]. Same regularity was found under different regimes of hyperthermia, as well as under the transfer of chickens in new types of cells and changes in the stocking density.

Hormones accumulated in eggs affect embryogenesis adversely [41-43]. Thus, corticosterone injections (10 or 20 ng/ml) into an egg result in increased embryo mortality, reduction of embryogenesis duration, and development bilateral asymmetry in tarsus length [44].

In stress simulation in Japanese quail (*Coturnix coturnix japonica*) by introducing implants with or without corticosterone, a correlation of the amount of the hormone entering the body and accumulating in the yolk of laid eggs was found [45]. Growth parameters in the offspring from the mothers with such implants appeared to be worse compared to control, and the reactivity of hypothalamic-pituitary-adrenocortical system (HPA) in response to immobilization was more significant.

Age and sex dimorphism was identified in Japanese quails in the parameters of growth and stress reactivity in response to corticosterone injections in egg yolk prior to incubation [46]. A growth slowdown was seen in males but not females, and a reduction in stress reactivity was found in adult quail females, but not quail males.

A reduction of embryogenesis period arises as a result of selection for the trait of stress resistance in quails, particularly young $L^+$ hatch 3.7 hours earlier than $L^-$ [47]. This was confirmed in experiments with implantation of empty (control) and containing corticosterone implants (experiment) with $L^-$ (control) 397.8±0.5 hours > $L^-$ (experiment) 395.9±0.7 hours > $L^+$ (control) 393.8±0.3 hours > $L^+$ (experiment) 391.2±0.4 hours [48].

The feather-pecking (FP) behavior is one of the most common defects of egg hen behavior recorded in 40-80 % of industrial poultry livestock [49, 50]. There are mild (ignored by a recipient) and severe forms of FP [4, 51]. FP intensity increases with the start of egg laying due to increased release of sexual hormones. Cases of FP are more common under poultry selection for productivity [52].

As a result of selection of 5 generations of White Leghorns for FP, plasma serotonin levels in $L^+$ became significantly higher than in $L^-$ (0.059 and 0.037 mmol/l, respectively) [53]. These data are consistent with the results obtained by H. Cheng et al. [54] who have proved that high levels of this neurotransmitter in chickens showing a tendency to FP is associated with low safety due to cannibalism.

Selection for the FP decrease is effective [51, 55, 56], but its effects on reproductive and other functions are not clear enough. Comparison of stress reactivity in the 6$^{th}$ generation of White Leghorn hens selected for FP traits and freely mate control line (CL) that originated from the same population revealed the average plasma corticosterone of 1.6 ng/ml at rest [52]. In males, it was significantly higher than in females (1.9 and 1.5 ng/ml, respectively). In response to the stress factor (immobilization), corticosterone level in $L^+$ hens with severe defects of FP behavior and in $L^-$ individuals increased unevenly and was 11.0 and 7.9 ng/ml with the intermediate value of this parameter (10.2 ng/ml) in CL.

A negative phenotypic correlation of mild FP and stress reactivity (–0.11±0.03), weight of eggs from 44- (–0.18±0.07) and 50-week (–0.16±0.06) hens, and egg shell deformation in eggs from 50-week individuals (–0.16±0.07) was found in White Leghorn hens [57]. For such behaviors as soil eating, a direct correlation with the deformation of the shell of eggs obtained from 50-week-old chickens ($r$ = 0.63±0.26), and a reverse correlation with the strength of the shell ($r$ values for the eggs from 35-, 44- and 50-week-old chickens was –0.86±0.29, –0.81±0.20, and –0.76±0.24, respectively) were found.

G. Su et al. studied the reproductive function in five generations of White Leghorn hens selected for FP trials [58]. The feather-pecking rate was significantly lower in $L^-$ than in $L^+$ poultry, and the number and weight of eggs laid during a month were higher (0.38 and 2.01 feather pecking per hour, 1223 and 1132 g, 24.4 and 18.3 eggs, respectively). However, the egg quality in $L^+$ was better compared to $L^-$ due to the Haugh units of 73.0 and 64.9, shell thickness of 38.1 and 37.0 mm, and yolk ration of 30.6 and 29.5 %. The parameters of CL egg quality were of intermediate values. Hence, the egg quality parameters dropped as a result of breeding for FP reduction which caused a statistically significant decrease in pecking in the 5th generation along with an increase in some quantitative parameters of egg production.

Selection for FP traits determines the differentiation of livestock related to the degree of sympathicoadrenal system (SA) and HPA reactivity. Selection for the increase in stress reactivity results in a reduced embryogenesis period [47, 48]. The positive effect of hen selection for FP reduction causes the deterioration of egg quality [58]. In addition, the state of immune system changes [53]. Thus, a significant increase in the response to the vaccination against the Gumboro disease virus compared to $L^-$ and CL was observed. WBC was greater in $L^-$ compared to $L^+$ and CL. Consequently, such divergent selection affects the poultry health.

This should be considered in industrial poultry when as a result of high livestock crowding infectious diseases and stress due to the so-called technological stress factors are likely, as well as the propensity of chickens for FP.

S e l e c t i o n  f o r  i m m u n e  r e s p o n s e. Selection for humoral immune response causes the metabolic changes and influences the synthesis of proteins which are the key factors for both immune protection and ensuring reproductive function and egg production [59]. For example, selection in 14 hen generations for the primary antibody response impacts the growth rate and egg production [60]. Young $Ls^-$ have greater body weight and mature individuals have lower body weight and lay their first egg earlier, while the number of produced eggs (and the number of two-yolk eggs) is greater compared to that in $L^+$.

Selection in 22 hen generations for the change in antibody response has a significant impact on the quality of hatching eggs [61]. Egg weight in laying hens of the same age was 59.44 g in CL, 55.50 g in $L^-$, and 54.15 g in $L^+$. The relative weight of egg shell, its thickness, egg white height and pH were lower in $L^-$, intermediate in CL and the greatest in $L^+$. Egg white height decreased with age in all laying hens, and the regularities of these changes were dependent on the genotype.

As a result of successful divergent selection for primary immune response in 37 generations in $L^+$ and $L^-$ White Leghorn chickens from the same population, growth and reproductive functions changed for which selection was not conducted [62]. Thus, in the 16th to 37th $L^+$ generations, the antibody titer (log 2) increased from 8.27±1.64 to 18.20±6.10, and decreased in $L^-$ from 4.12±2.07 to 2.0±1.30, respectively. In 24th generation, the first egg was laid by the individuals of the $L^+$ and $L^-$ in the age of 181.0±20.9 days and 161.1±6.5 days, respectively. $L^+$ chickens had lower body weight in the age of 1 month compared to $L^-$ of the same age. The body weight and antibody titers correlation depends on the genotype and was direct in $L^-$ and inverse in $L^+$.

Egg laying in $L^-$ was proved to start 11.67±3.53 days earlier and layers had a lower body weight (–169.46±40.20 g) than in $L^+$ as a result of selection in 36 generations of White Leghorn hens for antibody response [63, 64]. At this, egg parameters were significantly greater in $L^+$ (shape index by 4.12±0.55 %, egg white height by 0.27±0.12 mm and egg white quality in Haugh units by 1.89±0.91 %). Egg weight and yolk coloration were similar in both genotypes, but the shell quality was better in $L^-$, its weight and thickness were 0.66±0.09 g and 0.03±0.01 mm greater compared to that in $L^+$.

Data on the regularities of the weight and shell thickness changes in eggs from $L^+$ and $L^-$ published by A. Martin et al. [60] and H. Albrecht et al. [64] are contradictory. Probably, the reasons are the unequal duration of selection (22 and 36 generations respectively) and the differences between the genotypes of initial populations.

Human serum albumin (HSA) and lipopolysaccharides were simultaneously administered in the 30th generation chickens aged 7 and 12 weeks in the selection for the humoral immune response to sheep erythrocytes [65]. A rise in plasma antibodies specific to HSA and natural antibodies binding keyhole limpet hemocyanin and greater susceptibility to immune modulation by lipopolysaccharides were reported in $L^+$ individuals compared to $L^-$. A delayed puberty and lower egg productivity was found in $L^+$ livestock.

The above data suggest that selection of highly productive poultry for humoral immune response causes an imbalance between the potentials of antibody genesis, growth and development, and reproductive functions. Table 2 shows that layers $L^-$ are superior to $L^+$ in body weight, puberty age (first egg) and egg production. However, $Ls^+$ are superior to $Ls^-$ in egg quality (height and pH of egg white, Haugh units, number of two-yolk eggs). The main parameters that characterize the quality of hatching eggs are regulated by the industry standard OST 10 321-2003 [66].

**2. Changes in the parameters characterizing the reproductive function of hens under the influence of divergent selection for traits of the primary immune response**

| Parameter | Direction of change | | Reference |
|---|---|---|---|
| | $L^+$ line | $L^-$ line | |
| Onset of puberty (first egg) | Later | Earlier | [60, 62, 63-65] |
| Egg productivity | Decreased | Increased | [60, 65] |
| Egg-laying intensity | Decreased | Increased | [63, 64] |
| Egg weight | Decreased | Increased | [61] |
| Egg shape index | Increased | Decreased | [64] |
| Height and pH of egg white, Haugh units | Increased | Decreased | [61, 64] |
| Number of two-yolk eggs | Less | More | [60] |

Note. The absolute values of the parameters characterizing the reproductive function in compared genotypes published by independent researchers vary, but a regularity in the changes of these parameter related to one another can be identified. For example, the number of two-yolk eggs in $L^+$ is less compared to this parameter in $L^-$.

Thus, redistribution and the elimination of certain gene pools as a result of poultry selection for the traits other than productivity (ascites syndrome, tendency to FP, stress reactivity and immune defense) cause a reproductive system dysfunction in livestock. It is worth noting that directional selection causes correlated modifications for different trait groups. Thus, in selection for FP, a correlation of stress reactivity, immune response, and egg quality was found [57]. Apparently, under the selection for traits of stress reactivity due to the factors of various nature (social, physical, biological), the changes in reproductive function may have their distinctive features. This assumption is based on the fact that the number of individuals that exhibit different behavior strategies (coping styles) when dealing with stress varies in populations as a result of selection for relevant traits [5, 67]. This type of dichotomy was found in different classes of animals, including birds, fish and mammals [68, 69].

The findings of the studies on the quality of hatching eggs, embryos metabolism, results of incubation and the state of young generations in poultry that were selected for traits other than productivity, prove that such a selection can cause deterioration of not only reproductive, but other functions as well. For example, successful breeding for reduction of feather pecking is associated with improvements in egg production, but with the deterioration of hatching eggs quality and with the changes in stress reactivity and(or) immune response. In ascites-susceptible genotypes, embryo offspring is characterized with heart heterochrony and tachycardia, hypothyroidism, and longer duration of development before hatching. Let us note that these changes are taking place as a result of selection for productive traits [2].

It appears that the identified regularities should be used to develop ways to offset the decline in reproductive function due to selection. Promising techniques include optimizing diet composition [70] and the conditions of the parent stock housing [6, 50], including prevention of the development of stress [71-74] and selection for the improvement of egg quality [84]. Producing the offspring, it is necessary to individualize the regimes of incubation of eggs from each genotype [75-78], regulate embryogenesis through introduction of biologically active substances in the hatching eggs [79] and thermo contrast embryo training [80-83].

Thus, selection of poultry for traits other than productivity (resistance to ascites, pecking, stress factors, and primary immune response) affects the reproductive and other physiological functions. For example, at the tendency to the development of ascites syndrome, the individuals' response to vaccination against the virus that causes the Gumboro increases significantly, and heart heterochrony and tachycardia, hypothyroidism, prolonged time to hatching are observed in embryos. Selection of egg incubation regimes may be one way of prophylaxis of ascites and enhancing the safety of livestock. Corticosterone is accumulated in egg white and yolk of eggs from hens that are under stress that, in particular, adversely affects embryo metabolism and the results of incubation. With the positive effect of selection of chickens for the reduction of their propensity for pecking and plucking, deterioration of egg quality occurs, the state of the immune, sympathicoadrenal and hypothalamic-pituitary-adrenocortical systems changes. Selection for traits of humoral immune response causes changes in energy metabolism and protein synthesis that are critical to both immune defense, and reproductive and productive functions. Under the influence of divergent selection for primary immune response, ascites-susceptible and resistant layers differed in their body weight, time of puberty, and egg quality (height and pH of egg white, Haugh units, the number of two-yolk eggs). It has been noted that highly productive poultry often show aggression, behavior defects, reduced resistance to stress and diseases. This should be considered in poultry industry in the crowded livestock when the probability of infection and the effects of technological stressors increase. Continuing the study of factors affecting the reproductive function in modern genotypes of poultry, we should, in particular, pay attention to the age of the parents and the prevention of stress caused in them by various factors. Conditions of storage of hatching eggs are also of interest as such a factor. Based on our results, the particularities of expression of the genes that determine the pleiotropic effect of selection can be identified.

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