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### **REPRODUCTIVE FUNCTION IN HYBRID POULTRY. IV. AN IMPACT OF MATERNAL HORMONES ACCUMULATED IN EGG (review)**

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#### **Abstract**

Deposit of maternal hormones in the egg yolk is shown to significantly change the pattern of ontogenesis in descendants. Accumulation of maternal sexual steroids in yolk influences behavior, growth, morphology, immune function and viability of descendants (T. Groothuis et al., 2005). Testosterone and androstenedione cause changes in postnatal growth (H. Schwabl, 1996), immunocompetence (M. Tobler et al., 2010), models of competitive and agonistic behavior in non-reproductive relationships between individuals (Müller W. et al., 2009) and sexual intercourse (C. Eising et al., 2006). Such consequences develop as a result of regulation of corresponding functions in the descendant body, including indirect influence through other systems. Stress simulation in females by administration of corticosterone (K) led to a dose dependent change in growth and development in the chicken. Imbalance in fatty acids' ratio and assimilation in descendant embryo occurred in the yolk (S. Yalçın et al., 2011) reduce fertility and shell quality, and embryo mortality and death of chicks increase (M. Eriksen et al., 2003; Saino N. et al., 2005; Y.-H. Kim et al., 2014). Similar effects were found in the offspring of hens lines divergently selected by growth rate (A. Abdelkareem et al., 2013). In the yolk of white shell eggs of unstressed layers the corticosterone level is almost two times higher than that in brown shell eggs (K. Navara et al., 2010). Under the influence of different stress factors the activity of the hypothalamic-pituitary-gonadal axis alters, resulting in an inadequate kinetics of sex hormones and inhibition of the reproductive function. Increased concentration of blood corticosterone in the mother hens is accompanied by changes in the content of gonadal hormones in the egg yolk (A. Janczak et al., 2009; F. Guibert et al., 2013), productivity (A. Bertin et al., 2008; E. de Haas et al., 2013) and the sex ratio (S. Correa et al., 2005; T. Pike et al., 2005; S. Pryke et al., 2011). Migration of the hormones from a mother hen to the egg and the embryo, and their interference in metabolism regulation in the descendant occur during early ontogenesis, when the functions of organs and systems are the most labile. Changes in ontogenesis caused by accumulated maternal hormones can be regarded as an adaptive response in the descendants to be ready to a shift in environmental conditions (T. Mousseau et al., 1998; Z. Kankova et al., 2012). Due to egg-deposited maternal hormones the offspring can form phenotypic traits which are inherited epigenetically (T. Groothuis et al., 2008; D. Ho et al., 2011). All these finding should be taken into account at poultry commercial reproduction. When using technological methods and veterinary measures, it is necessary to appreciate possibility of transovarial transfer of signal information about outer conditions mediated by the maternal hormones to cause adaptations in the descendants.

Keywords: bird, egg, maternal hormones, accumulation, stress, ontogenesis descendants

During ovogenesis, maternal biologically active substances accumulate in the egg deutoplasm, determining the character of ontogeny in descendants. Accumulated hormones significantly affect the metabolism of a developing organism, forming phenotypic characters inherited epigenetically in individuals of the next generation [1-3]. Due to various stress factors in the layers, stress-realizing systems are activated, thus the hormones concentration in eggs increases.

This review is focused on summarizing and analyzing features of reproductive function of the poultry breeding stock caused by the maternal hormones

deposited in the egg deutoplasm.

Influence of maternal sex steroids. Accumulation of maternal hormones in egg yolk (deutoplasm) affects behavior, growth, morphology, immunofunction, and viability of the offspring [4]. Thus, testosterone and androstenedione cause changes in postnatal growth [5], immunocompetence [6], models of competitive and agonistic behavior in non-reproductive relationships between individuals [7] and sexual interactions [8]. The consequences develop due to direct regulation of the corresponding functions by these hormones, or under indirect influence through other systems [2, 9, 10].

The content of sex steroids in the egg yolk depends on the genotype, nature and the impact of stress factors on the female organism during egg-laying. Thus, in quails, unstable communities lead to an increase in testosterone level, whereas the amount of progesterone and androstenedione remains the same [11]. In quails, testosterone and androstenedione decreased and progesterone increased in response to the presence of a person [12]. To study testosterone accumulation in yolk as influenced by social status of the layer, white Leghorn males and females were grouped together, five hens and a rooster per cage. Dominant, two intermediate and subordinate social ranks were studied. The study showed that from dominance to subordination the living weight of individuals and the number of laid eggs decreased from 1862 to 1503 g, and from 66.8 to 63.5 g, respectively, while testosterone increased [13].

Z. Kankova et. al. [14] studied the effect of divergent selection of Japanese quails for the testosterone content in yolk on the immune system activity under limited feeding and weight loss. In the  $L^+$  individuals (here and below,  $L^+$  and  $L^-$  are the lines of poultry that underwent contrast selection on a definite trait), the body weight and IgY content were greater, and the ratio of heterophiles and lymphocytes was less than that in  $L^-$ . The immune response to the administration of phytohemagglutinin and the corticosterone concentration did not depend on the genotype. An increase in testosterone content in yolk stimulated cell-mediated immune response in *Carpodacus mexicanus* individuals and humoral-mediated immune response in adult *Taeniopygia guttata* individuals [6]. The androgens suppressed both the humoral and cellular immune responses in black-headed gull (*Larus ridibundus*) [15] and western jackdaw (*Corvus monedula*) [16] at different stages of the early ontogenesis

Thus, under the impact of stress factors on the female organism during egg formation, the amount of sex steroids in yolk changes. Concentrations of testosterone, progesterone and androstenedione depend on nature (hierarchical dominance or subordination, fright, feeding regime, etc.) and intensity of a stressor. The author discovered that maternal body weight and the weight of the eggs which the hen laid depend on the maternal social rank. Sexual dimorphism is observed according to the testosterone content in yolk. The immunomodulating effect of maternal androgens varies according to the type of response, depending on the type of bird, the stage of development, and the environmental conditions.

Influence of maternal glucocorticoids. In commercial poultry farming, there is a high probability of stress resulted from some technological factors [17-23]. The risk of developing a metabolic stress is typical of both the egg crosses showing increased aggression, tending to pecking, plucking feathers (PPF), fatty liver syndromes and the sudden cessation of egg laying, and for broiler chickens predisposed to ascites and a reduced thermotolerance [24, 25]. Metabolic stress in birds is realized through the stimulation of sympathetic-adrenomedullary and hypothalamic-pituitary-corticoadrenal (HPCA) systems as a result of activity of noradrenaline, adrenaline and corticosterone secreted into

the blood [26, 27]. These hormones, regulating the metabolism intensity, prepare the body for a common “fight or run” reaction [28, 29]. Circulating corticosterone changes the endocrine function of gonads [30], protein metabolism and lipid metabolism [31, 32], vitellogenesis in liver [33], and eventually inhibits reproductive function [34, 35]. These events occur when increasing activity of the hypothalamic-pituitary-gonadal axis which regulates the realization of the genetic potential of egg production with the participation of testosterone, progesterone, androstenedione, and estradiol [36].

Maternal corticosterone deposition in yolk is associated with changes in the characteristics of hatching eggs. In particular, decreased indicators of fertility and shell quality, higher mortality (prior and post hatching), immunodeficiency are developed [37, 38]. These processes are accompanied by a depression of the reproductive function caused by genetic breeding for productive and/or unproductive traits, or by parents' aging [24, 25, 39]. Some authors report that the bird's stress response decreases with age, depends on the genotype, and is higher in hybrids than in specialized lines [40].

Reproductive function during breeding for identical but different productive and unproductive traits or during divergent selection for the same trait differs [24, 25]. The content of maternal glucocorticoids in the deutoplasm of eggs from highly productive poultry of different crosses is different [41-46]. In case of divergent breeding, the differences are revealed in the corticosterone content in egg yolk and white, as well as in the expression of enzymes that regulate the intracellular metabolism of glucocorticoids (11- $\beta$  and 20- $\beta$ hydroxysteroid dehydrogenase) in liver of embryos-descendants of meat hens [41]. In eggs, more corticosterone was accumulated in  $L^+$  individuals compared to  $L^-$  ones. The same regularity (i.e. an increase or decrease in blood corticosterone in response to short-term immobilization) was established in Japanese quails under divergent selection [42]. The concentration of corticosterone was significantly higher in eggs of  $L^+$  than in  $L^-$  hens, regardless of they were intact or stressed.

The stock of genotypes with white eggshell is shyer than the one with brown eggshell [43]. The study of manifestation of two associated traits (anxiety and PPF syndrome in chicks of egg crosses Dekalb White and ISA Brown) showed [44] that the first one, being aged 7 weeks, made 16.9 peckings, the second one made only 11.4 peckings during 20 min. The permissible distance to the human observer at 10 weeks of age was at least 153 and 58 cm respectively. In the egg yolk of the Hy-Line W-36 cross layers kept individually, the corticosterone concentration was 2 times as much as that in Hy-Line Brown layers, i.e. 1.6 and 0.8 ng/g, respectively [45]. The author recorded identical corticosterone concentrations in blood and manure of the intact white Leggorne and Hy-Line Brown layers [46]. However, when captured, the Leggorne layers showed higher concentration of this hormone and higher duration of tonic immobility as compared to the Hy-Line Brown layers. Therefore, chickens laying eggs with white and brown eggshells differ in stress responsiveness. The first deposits more maternal corticosterone in yolk, which causes increased aggression.

The correlations were justified between the indices of the immune and endocrine systems in the ISA Brown cross layers due to the divergent selection for the primary antibody production [47]. Under the impact of stress factors of different nature (blood sampling and the number of individuals per cage) in  $L^+$  birds (freely mated control group, initial population) and  $L^-$ , the blood corticosterone concentration differed. For example, in blood samples this figure was 46, 28 and 81 ng/ml, respectively. Differences in the HPCA reaction for the studied genotypes were also expressed in coping behavior strategy (reactive style in the livestock of  $L^-$ , and proactive in  $L^+$ ). Thus, divergent selection for primary

immune response caused unequal changes in HPCA reactivity. All this let it possible to differentiate the population by sensitivity to stress factors, which manifests itself in different coping styles [48].

Dose-dependent changes in pre- and postnatal growth and development of chicken were found in the stress modeling by using corticosterone as an additive to feed. Observations of the stress markers kinetics, including the concentration of uric acid and the blood ratio of heterophyll to lymphocytes, made it possible to determine that the severity of this state is in direct proportion to the dose of the hormone (1.0, 1.5 or 2 mg/head per day) [49]. Only 3 days after the feeding with corticosterone started, the changes of these markers were registered, as well as the accumulation of corticosterone in yolk. Feeding broiler chicken with feeds enriched with corticosterone (2 mg/head per day) for 14 days [50] resulted not only in the accumulation of corticosterone in yolk, but also in a change in the ratio of many fatty acids and their assimilation by embryos. Before the incubation, the content of docosahexaenoic acid in yolk (C 22:6 n3) decreased, and the content of the stearic (C 18:0) and cis-8,11,14-eicosatrienoic (C 20:3 n6) acids increased as compared to the control, whereas in the yolk sac of embryos, the amount of stearic (C 18:0), trans-octadecenoic (C 18:1tr n9), and arachidonic (C 20:4 n6) acids was higher. The content of myristinic (C 14:0), palmitoleic (C 16:1 n7) and linoleic (C 18:2 n6) acids was below the control. Consequently, the development of stress in mothers caused changes in fat metabolism in embryos.

Feeding the egg chicken with a diet containing 30 mg/kg of corticosterone for 14 days led to an increase in the amount of feed intake by 39 %. The body weight changed insignificantly, but the productivity sharply decreased compared to the control [51, 52]. The weight of eggs and shells, as well as the strength of the latter, practically remained the same. The thickness of eggshell increased from 0.41 to 0.47 mm, the height of the protein decreased from 7.8 to 5.5 mm, and the Haugh units diminished from 87 to 69. Moreover, the action of corticosterone decreased the content of calcium and triglycerides in blood, and the concentration of albumin, glucose, uric acid and the activity of a number of enzymes increased.

In the experiment with introduction of 0.2 or 1 µg of corticosterone into eggs, chicks from these eggs formed respectively group 1 and group 2 [53, 54]. The rate of growth from the 8 week age in chickens in group 2 was suppressed more than in group 1 and group 3 (control). The same dependence was noted for the duration of tonic immobility and the frequency of aggressive behavior due to changes in the HPCA response and the serotonergic system, which may be associated with the DNA methylation. In blood and yolk produced by chickens in group 2 the corticosterone concentration was greater than that in groups 1 and 3. The expression of luteinizing hormone receptors and the content of follicle-stimulating hormone in the cells of follicle membranes have decreased in the phases F<sub>1</sub>, F<sub>2</sub> and F<sub>3</sub> of their development. In addition, oviposition in the second group began 1 week later, and the egg productivity and quality were worse than that in groups 1 and 3. In Japanese quails with implanted corticosterone-containing capsules and without hormone (control) blood corticosterone contents were 11.7 ng/ml and 1.3 ng/ml, respectively [55]. During a week after the operation, they laid an equal number of eggs with corticosterone level in the yolk of 2.1 ng/ml and 0.9 ng/ml, respectively. The offspring of the experimental group grew slower only during the first week of life. The HPCA response after capture and restriction of movement at puberty at 8 weeks of age was higher than in control. When corticosterone was injected directly into the egg [56] in an amount that causes almost twofold increase in the concentration of this hor-

mone in yolk thus reaching the level obtained after implantation [55], there was sexual dimorphism of the response to corticosterone. Growth slowed in males, but not in females, and stress response decreased in adult female quails, but not in males.

It should be noted that in implantation of capsules with corticosterone to mothers, the adult offspring showed increased response to the identical stress factors. According to the authors' opinion [55, 56], this contradiction was due to the peculiarities of the corticosterone distribution when injected into layers and directly into the egg. Despite the fact that steroids are liposoluble, their distribution over the layers of yolk is not the same [57]. This may cause the corticosterone impact on the metabolism of embryos at different stages of development, which will lead, for example, to unequal impact of the hormone on the integration of HPCA elements. Thus, rodents showed that the nature of the consequences in descendants after prenatal stress in their mothers was determined by the stage of embryogenesis during which the effect of stress factors and, accordingly, the release of glucocorticoids occurred [58]. HPCA activity increased in guinea pigs, if glucocorticoids were administered at early luteinization phase during the ovarian cycle, but having the hormones introduced during the late phase, this system was depressed [59].

Sexual dimorphism of the dynamics of some blood hormone levels during pre-egg-laying period and sexually active period is described in black-legged kittiwake (*Rissa tridactyla*) by using corticosterone through implants [60]. The blood concentration of luteinizing hormone, released in response to induction by the releasing factor, decreased in females, while the amount of this hormone and testosterone, and the intention to mate did not change in males.

After the implantation of corticosterone (30 mg/head) or placebo (control) under the skin of the white Leghorn and ISA Brown chickens [61], the testosterone and progesterone concentration in blood and egg yolk of test birds decreased, but in different ways. In ISA chickens in the control group for progesterone it was 3654 ng/g, whereas in the experimental group it was 9.3 % less. In white Leghorn it was 3127 ng/g and 4.9 % less, respectively. Egg productivity in the control hens of both genotypes averaged 17.5-18.5 pcs/head for 19 days after the corticosterone implantation. However, the experimental group of white Leghorns for this period showed a 31.4 % decrease in this indicator, while in ISA it almost did not change and amounted to 18.0 pcs/head. In layers of both genotypes from experimental groups, the testosterone and progesterone in blood and yolk decreased if compared to the control. This is consistent with data on the antigonadotropic effect of glucocorticoids which ensures the dominance of physiological functions responsible for survival. It is especially important in case of chronic stress of various nature [62], including hyperthermia [63-66], hypodynamia [67], etc.

Thus, the modeling of stress in female precocial birds and altricial birds, as well as in mammals, with different methods of corticosterone administration made it possible to establish dose-dependent disturbances in ontogenesis of offspring, which is manifested in changes in egg productivity, hatching egg quality, embryo metabolism, and development of young animals. Sexual dimorphism was revealed according to hormonal state, stress reactivity and growth of descendants. Different genotypes of egg hens show an unequal response to the administration of corticosterone, both in the concentration of hormones in the egg yolk and in the parameters of egg productivity [61].

Role of maternal hormones in sex inversion of the offspring. In response to the impact of stressors of different nature, females optionally affect the sex ratio in offspring [68]. This phenomenon is discovered not

only in the natural habitat, but also in experimental conditions and in commercial poultry farming. Two races of Gouldian finch (*Erythrura gouldiae*), red-headed and black-headed, co-exist within one habitat. Females prefer to mate with males of the same coloring, because daughters from mixed crosses have lowered viability due to genetic incompatibility of parents [69, 70]. In females, mating with unpreferable phenotype leads to stress, the marker of which is the increased blood corticosterone (an average of 68 ng/ml), whereas in females from pairs of the same race it is 19 ng/ml. Among the descendants of mixed pairs, males predominate (82 %), while in the offspring of homogeneous pairs their number is lower (about 46 %). The phenomenon of sex inversion in the descendants of peacocks (*Pavo cristatus*) was found as a result of removing a part of feathers, which have the spots typical of the species, from the tails of father birds prior to mating [71]. In the yolk of eggs laid by female partners the corticosterone increased, and there was a tendency to a decrease in the testosterone level with an unchanged  $17\beta$ -estradiol. In the offspring of the experimental group, there were more females, and the ratio of ♂:♀ significantly decreased if compared to the control (0.35 and 0.54, respectively). Interesting, there are similarities and differences in the reproduction in Gouldian finch [69, 70] and peacocks [71] determined by the male phenotype. In both species when mating females with the males belonging to another race or having a modified feathering patterns the corticosterone concentration in the egg yolk increases. However, the sex ratio in the finch offspring shifts toward the males, which reduces the adverse effect of the low viability of daughters of heterogeneous pairs on the population, while in peacocks this proportion shifts towards the females.

In female Japanese quail, implantation of corticosterone-containing capsules allowed the authors [72] to establish that it is namely the increased concentration of this hormone that causes sex inversion in the offspring and leads to an increase in the female number. Some authors describe other examples of participation of sex hormones in offspring sex ratio regulation [73]. A dose-dependent sex inversion was found in chicken that resulted from injections of progesterone (2.0 and 0.25 mg). The number of cockerels was 25 and 61 % respectively, whereas in control (placebo administration) this figure was 63 % [74]. Differences in social rank among mother hens also lead to sex inversion in offspring [13]. Thus, in the offspring of the dominant and subordinate layers, the ratio of ♂: ♀ was 0.6 and 0.4. Egg yolk testosterone level correlated with the social rank of hens, as well as the sex of developing embryo-descendants, this index varied from dominating hens to subordinate ones from 1.1 to 2.3 pg/mg for female chicks, and only from 1.7 to 1.9 pg/mg for cockerels.

A change in the sex ratio in the offspring of stressed females was found in different birds [75], horses [76], and humans [77]. This phenomenon is widely viewed as the manifestation of adaptive response to changes in environmental conditions, the character of the relationships in the community, and a hierarchy in the population. The mechanism of sex inversion in chickens hatched from eggs with the increased concentrations of deposited hormones in the deutoplasm is not clarified yet. The introduction of corticosterone into the females of chestnut-eared finch (*Taeniopygia guttata*) during meiotic division caused a significant increase in the number of males among the chicks [78]. The same results were obtained on quails and chickens when introduction of corticosterone and testosterone, respectively [79, 80]. However, 5-minute long bag handling of females of this species in about the same period (5 hours prior ovulation), which caused a physiological increase in the concentration of corticosterone, did not affect the primary sex ratio [81]. Such a contradiction may be due to different strength and nature of the acting factor. Moreover, the research results may be affected by the

unequal viability of embryos of different sex [82].

Maternal hormones participation in the formation of epigenetic adaptations in descendants. An increase in the content of androstenedione and  $17\beta$ -estradiol in yolk from hens kept on the floor was registered if compared to that in layers kept in cages [83]. As the authors believe, the concentration of these hormones may be due to the mechanism by which mothers inform descendants on the state of the environment or living conditions.

Under a chaotic change of illumination in the experimental group of egg hens, in contrast to regular illumination in the control (12 h/12 h), subject to free accessible standard feed and mealworms [84], the individuals from the experimental group preferred feed, had a larger weight and pecked much more often compared to the control (595 and 322 movements for 15 minutes, respectively). The test for pair dominance was negative, and there was no difference between the groups. The descendants of both groups were grown at 12/12 hours lighting regime. The daughters, but not sons, in the experimental group were more likely to peck the feed than in the control. In the pair dominance test, the offspring of the experimental group also pecked the feed more often, and the intervals between the movements were shorter than those of the control groups (199 and 470 seconds, respectively). The former preferred worms and had a larger body weight, and their survival by the 40-week-old age was 65 %, while that of the latter was only 39 %. The egg yolk  $17\beta$ -estradiol in experimental group was 1.04 mmol/l vs. 0.87 mmol/l in the control. Corticosterone, testosterone and androstenedione concentrations were identical. The individuals of both groups had differences in hypothalamus cells; there also were differences in the expression of 9 genes which was preserved in the descendants. The differences were particularly pronounced for several immunoglobulin genes. The data obtained demonstrates the participation of maternal  $17\beta$ -estradiol in providing the epigenetic adaptation of offspring to environmental conditions (unpredictable regime of illumination) which was unusual for parents.

When adult Japanese quails were exposed to different stressors (blowing, shaking cages, noise) (group 1), and the control population was left intact (group 2) [85], sexual behavior in male  $F_1$ -1 changed compared to their fathers, i.e. the numbers of copulation attempts (2.4 and 4.2, respectively) and of completed sexual acts (1.2 and 2.2) decreased. The eggs from  $F_1$ -1, when compared to those from their mothers, had lower yolk content (27.5 and 29.3 %, respectively) and fertilization (46.3 and 66.2 %), but not hatchability. However, the yolk of eggs from  $F_1$ -1 contained more progesterone and testosterone compared to yolk from eggs from mothers.

Therefore, the embryos' assimilation of maternal steroids from the deuteroplasm is the cause of the formation of both short-term phenotypic characters and their long-term programming in offspring [86, 87]. The possibility of such regularities is also justified by the data that maternal  $17\beta$ -estradiol affects brain development in embryos, causing an increase in anabolism and masculinized behavior in offspring [88].

The phenomenon of maternal hormones impact on the phenotype of descendants is revealed in different classes of animals, like reptiles [89], altricial birds [60], precocial birds [67], and horses [76]. According to L.K. Trofimova [90], the influence of various stress factors changes locomotor and orienting-research activities, anxiety, heart rhythm variability, functions of stress realizing and stress limiting systems in pregnant rats and their offspring. Moreover, physical development is disturbed. Changes in ontogenesis in the offspring under the influence of maternal hormones may be considered as an epigenetic adaptive response to parent's signals about the need to be ready for a change in environ-

mental conditions [1, 91]. The study of the regularities of these processes offers prospects of a better understanding variability in animal populations during phenotypic evolution. It should be noted that the influence of parents on the ontogenesis of their descendants is realized not only through the parent hormone accumulation in the deutoplasm, but also via other signaling systems. For example, the parents of chestnut-eared finch use sounds to inform embryos in incubated eggs about an increase in the ambient temperature above 26 °C (92).

In natural conditions, the signals about changes in environment transmitted to descendants via maternal hormones seem to serve as a mechanism that ensures the preservation of the species. However, in commercial poultry farming, the adaptive response which results in a decrease in the reproductive function should be regarded as undesirable, especially with regard to a shortage of hatching eggs for highly productive broiler chickens [93]. Breeding for increased performance of the latter has negative consequences as well resulting in a decrease in the reproductive function and efficiency of vital systems, including the cardiovascular problems, e.g. ascitic syndrome [24, 25, 94].

Routine technological and preventive measures in commercial poultry farming can also cause metabolic stress in livestock of breeding studs. Thus, in egg hens, when the feed is changed, aggression increases, and signs of PPF become more severe [95]. Feeding quails with a seed mixture instead of the usual mixed feed causes an increase in HPCA activity and corticosterone response [96]. As a result of limited feeding, ovarian tissue of hens excreted *in vitro* more progesterone and less testosterone while secretion of 17 $\beta$ -estradiol and arginine vasotocin did not change [97]. In the hypothalamus and ovary of 23-week-old individuals, expression of grehlin and its receptors was activated. In the ovaries of 7-week-old females, the first one decreased, the second one remained the same [98]. Therefore, limited feeding can affect sex hormone production, as well as age-related changes in the function of grehlin which has the properties of gonadotropin releasing hormone. These data proves the need to use limited feeding of the parent herd cautiously because of a possible disruption in the metabolism of hormones that regulate reproductive function. It also seems to influence the storage of hatching eggs. With a 6-fold increase in the ammonia content in air, blood corticosterone in egg hens increased more than twice, 17 $\beta$ -estradiol and progesterone decreased, egg productivity significantly decreased [99]. Obviously, such eggs are not suitable for incubation.

Thus, as a result of stresses, including those developing in female birds due to technological factors, the concentration of maternal hormones in eggs increases. Stress response and the amount of hormones accumulated in the deutoplasm are not the same in genotypes. Selection for productive and/or non-productive characteristics also changes stress response. The migration of hormones along the mother—egg—embryo chain and their participation in the regulation of metabolism in offspring occur in early ontogenesis, when the functions of organs and systems are most labile. Testosterone accumulation in yolk causes changes in postnatal growth, immunocompetence and behavior patterns. In the offspring, sexual dimorphism is revealed in the manifestation of the effects of increased mother hens' hormone deposition in yolk due to unusual housing conditions and feeding during egg production period. When carrying out technological and veterinary preventive measures, the role of the parent hormones in the transovarial transmission of signals about the acting stressors from a mother hen to the offspring should be taken into account, for it leads to metabolic disorders, suppression of the reproductive function, and reduces the efficiency of commercial poultry farming.



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