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Morphological characterization of spleen and bursa of Fabricius of Pekin ducks in selenium-deficient area

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SUMMARY

The study was aimed at examination of age-related morphology of spleen and bursa of Fabricius of Pekin ducks with a dietary selenium deficiency and its correction with an organic selenium additive. The experimental study was carried out in 85 day-old ducks divided into two groups, control group and test group, 40 ducks per group, the experiment lasted for 120 days. Control group was fed with standard mixed feed for meat-type poultry. The test group of ducks was fed with the feed supplemented with DAFS-25k organic selenium additive, 1.3 mg/kg of feed, that fully compensated selenium deficiency. The study showed that the dynamics of absolute body weights and relative weight gains in control and test groups correlated to the general biological pattern – increase in absolute parameters and decrease in relative parameters were dependent on age. Therewith, maximum relative weight gain intensity was reported at the age of 15 days and maximum increase in relative spleen and bursa of Fabricius weights was reported in at the age of 30 days. Weight gain parameter drastically decreased on day 75 and remained low up to the age of 120 days. Changes in the relative spleen and bursa of Fabricius weights were non-linear throughout the study. Therewith, in ducks of all ages tested spleen parameters remained approximately at the same level but bursa of Fabricius parameters changed – relative weight of bursa of Fabricius decreased by the age of 45 days and then increased again by the age of 75 days. Relative weight gains and relative spleen weights of ducklings in test group were higher than that ones of ducklings in control group during the examined ontogenesis periods. The opposite pattern was observed for bursa of Fabricius: the above-mentioned parameters in test group were lower than that ones in control group. It was concluded that organic selenium additive had a positive effect on development of the immune system organs and reduced the stress factor impact on duckling organism.

Keywords: Pekin ducks, spleen, bursa of Fabricius, organic selenium additive.

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Морфологическая оценка селезенки и клоакальной бурсы уток пекинской породы в селендефицитном регионе

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РЕЗЮМЕ

Целью научно-исследовательского опыта стало изучение возрастной морфологии селезенки и клоакальной бурсы уток пекинской породы при дефиците селена в рационе и его корректировке селеноргани́ческим препаратом. Экспериментальное исследование проводили в течение 120 дней на 85 утках суточного возраста, разделенных на контрольную и опытную группы по 40 голов в каждой. Контрольная группа получала стандартный комбикорм для выращивания мясной птицы, а в рацион уток опытной группы добавляли селеноргани́ческий препарат ДАФС-25к в количестве 1,3 мг/кг корма, что полностью восполняло дефицит селена. В ходе исследований установлено, что динамика абсолютной массы тела и ее относительного прироста в контрольной и опытной группах подчиняется общей биологической закономерности – повышение абсолютных показателей и снижение относительных показателей изменяются с возрастом. При этом максимальная интенсивность относительного прироста массы тела отмечается в 15-суточном возрасте, а относительная масса селезенки и клоакальной бурсы – в 30-суточном. Значение показателя прироста массы тела резко снижается на 75-е сутки и остается на низком уровне до 120-суточного возраста. Изменения относительной массы селезенки и клоакальной бурсы на всем протяжении исследования носят нелинейный характер. При этом исследуемые показатели селезенки у птиц всех возрастных групп остаются примерно на одном уровне, а показатели клоакальной бурсы претерпевают ряд изменений – к 45-суточному возрасту относительная масса органа снижается, а затем к 75-м суткам вновь возрастает. В изучаемые периоды онтогенеза показатели относительного прироста массы тела и относительной массы селезенки утят опытной группы превышали аналогичные показатели птиц контрольной группы. В отношении клоакальной бурсы наблюдается обратная картина – указанные значения

в опытной группе были меньше, чем в контрольной. Сделан вывод, что селенорганический препарат оказал положительное влияние на развитие органов иммунной системы и нивелировал воздействие стресс-фактора на организм утят.

Ключевые слова: Утки пекинский породы, селезенка, клоакальная бурса, селенорганический препарат.

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INTRODUCTION

Poultry farming is one of high-technology and profitable agricultural industries in the Russian Federation and supplies consumers with meat, eggs, as well as technical raw materials – down and feathers. Duck farming is a promising trend in poultry industry along with chicken farming owing to high growth rate of this poultry species [1]. Currently, special attention is paid to the meat-type duck farming, where the significant share belongs to Pekin duck farming [2]. Pekin ducks are easy to raise and can reach body weight of 3 kg at the age of 6 weeks when they are fed with a balanced diet [3].

It is impossible to realize animal and bird potential without understanding of development pattern for organs and systems thereof, where the immune system plays the key role, conferring protection from diseases of various etiologies. Several studies have been devoted to examination of the development of the poultry immune system organs [4–10], but the data on development of Pekin duck immune system organs are non-systematic and fragmented [2, 11, 12].

Feed additives fortifying poultry diet with the required microelements and vitamins as well as reducing product losses have an impact on internal organ growth and development [13, 14]. Selenium is currently recognized as one of the most important elements [15], it stimulates efficient utilization of feed metabolic energy, enhances nutrient digestibility and intake and thereby contributes to poultry performance improvement [16].

Thus, the study goal was to examine age-related morphology of spleen and bursa of Fabricius of Pekin ducks with a dietary selenium deficiency and its correction with an organic selenium additive.

MATERIALS AND METHODS

Clinically healthy Pekin ducks obtained from OOO PPK "Romashino", Moscow Oblast, were used for the study. The ducks were raised on a backyard farm located in the Gus-Khrustalny Raion, Vladimir Oblast, in accordance with requirements and standards laid down in the Methodical Guidelines for poultry establishment technological designing, RD-APK1.10.05.04-13.

All experiments were carried out in poultry in strict accordance with the International Standard, GOST 33215-2014, adopted by the Interstate Council for Standardization, Metrology and Certification as well as in accordance with Directive 2010/63/EU of the European Parliament and Council of 22 September 2010 on protection of animals used for scientific purposes.

Experimental study was carried out in 85 day-old ducks for 120 days. The ducks were randomly divided into two groups, control group and test group, 40 birds per group. Five ducklings were subjected to diagnostic killing before the experiment to determine syntopy of immune system organs and their absolute and relative weights. Control group was fed with standard mixed feed for meat-type poultry and test group was fed with the feed supplemented with organic selenium additive, DAFS-25k, 1.3 mg/kg of the feed. The amount of feed additive was estimated based on the test of the feed for actual selenium content performed in the Kostroma Oblast Veterinary Laboratory. The poultry were provided with the free access to drinking water. The ducks were daily examined for their appearance, mobility, feed intake. Five ducks from each group were weighed and killed with generally accepted methods at a 15 day-interval.

Spleen and bursa of Fabricius were dissected and examined for their topography, colour, form, size and integrity. The ducks were weighed with a 1.0 g precision torsion balance. Spleen and bursa of Fabricius were weighed with Pocket Scale MH-200 0.01 g precision electronic balance immediately after necropsy. Relative weight was calculated in accordance with the formula proposed by G. G. Avtandilov:

$$w_0 = w_n / W \times 100\%,$$

where w_0 and W – absolute spleen (or bursa of Fabricius) weight and live body weight, respectively. Dynamics of relative weight gain in ducks was calculated in accordance with Brodi formula:

$$K = \frac{W_t - W_0}{0{,}5 \times (W_t + W_0)} \times 100\%,$$

where K – relative weight gain (%) during for a specified period of time;

W_t – weight at given age;

W_0 – initial weight.

Estimated numerical values were processed biometrically as proposed by G. F. Lakin (1990).

RESULTS AND DISCUSSION

Our studies showed that use of organic selenium feed additive at the recommended dose had no negative effect

on the Pekin ducks: birds in both groups willingly ate feed, were motile and adequately responded to external stimuli. Analysis of absolute body weight and relative body weight gain dynamics in control and test groups has indicated that it correlates to the general biological pattern – increase in absolute parameters and decrease in relative parameters depend on age (Table 1, Fig. 1). The weights of ducks in both groups changed synchronously, however, ducks of test group significantly outperformed their counterparts in control group throughout the study.

Therewith, weight gains were the highest in 15 day-old ducks and then sharply decreased at the age of 30 and 75 days that could be accounted for the onset of critical development periods – embryonic down replacement by first feathers and juvenile molting, respectively. Further, relative body weight gains in ducks remained low up to 120 days of age. Absolute weight gains in ducks of tests group were consistently higher as compared to that ones in ducks of control group owing to favourable organic selenium additive effect on body weight gain in ducks. Obtained data on dynamics of absolute and relative body weights in ducks of control and tests groups are consistent with the data provided by other authors [13], however there are insignificant differences in absolute values [2].

Table 1
Live weights and relative weight gains of Pekin ducks in control and test groups

Таблица 1
Показатели живой массы и относительного прироста уток пекинской породы контрольной и опытной групп

Age, days	Live body weight, g		Relative weight gain, %	
	Control group	Test group	Control group	Test group
1	83.60 ± 3.62		–	–
15	261.48 ± 15.59	274.50 ± 17.48*	103.09	106.62
30	458.29 ± 17.49	484.58 ± 33.56*	54.69	55.35
45	887.34 ± 32.60	971.28 ± 40.56*	63.77	66.86
60	1,512.62 ± 15.28	1,751.26 ± 28.38*	52.11	57.30
75	1,698.39 ± 16.04	2,014.49 ± 29.31*	11.57	13.98
90	2,047.27 ± 18.54	2,439.82 ± 15.49*	18.63	19.10
105	2,429.49 ± 17.74	2,950.48 ± 20.36*	17.08	18.95
120	2,670.28 ± 17.88	3,250.43 ± 14.36*	9.44	9.67

* $P \leq 0.05$ as compared to control ($P \leq 0,05$ в сравнении с контролем).

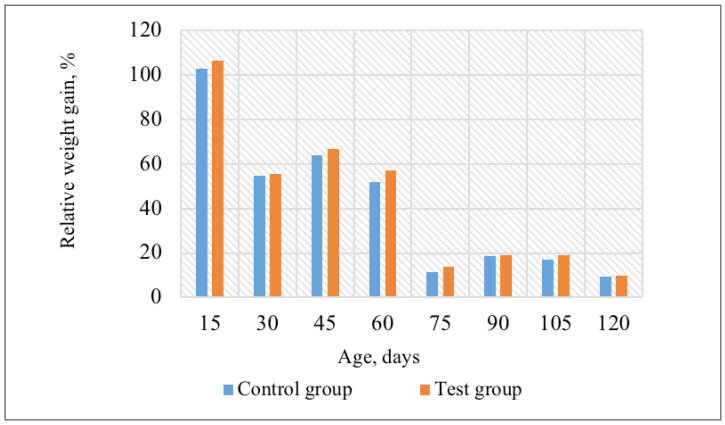

Fig. 1. Dynamics of relative weight gains of Pekin ducks in control and test groups

Рис. 1. Динамика относительного прироста массы тела уток пекинской породы контрольной и опытной групп

Examination of immune system organs of Pekin ducks showed that spleen was oval, of reddish-brown colour and located on the left side in phrenic cavity between proventriculus and gizzard (Fig. 2). Bursa of Fabricius was an elongated-oval unpaired cavity organ in the form of diverticulum of the dorsal wall of proctodeum of the cloaca and connected with it by a duct. Its dorsal surface lied close to lumbosacral bone, its ventral surface was in contact with the dorsal wall of the cloaca. Findings on syntopy and shape of the examined organs are consistent with the data obtained by other authors [9, 11].

Changes in absolute and relative spleen weights were consistent with general biological pattern: absolute spleen weight increased and relative spleen weight decreased with age. It should be noted that changers in relative spleen weights in ducks of control and test groups were non-linear (Table 2, Fig. 3).

Thus, the relative spleen weight gain was the highest at the age of 15 days and 30 days in both groups. Then, this parameter synchronously decreased in ducks by the age of 45 days that could be accounted for completion of the period of embryonic down replacement with first feathers that was stressful for birds. More drastic decrease in relative spleen weight in ducks of test group could be indicative of pronounced adaptive processes associated with selenium in the duck body. Relative spleen weights remained stable up to the age of 120 days, therewith, relative spleen weights were higher in ducks of test group. Other authors also noted that critical periods and technogenic factors had an impact on the immune system organ development [10].

Analysis of relative bursa of Fabricius weight dynamics showed that this parameter was non-linear similar to the relative spleen weight parameter (Table 3, Fig. 4).

Relative bursa of Fabricius weight drastically increased in ducks of control and test group by the age of 15 days and kept increasing and reached maximum by the age of 30 days; however this parameter decreased by the age of 45 days. Relative bursa of Fabricius weight increased in both groups at the age of 60 to 75 days probably due to the onset of the next critical period of the duck development. However, this parameter tended to decrease in ducks of both groups already from the age of 90 days. It should be noted that relative bursa of Fabricius weight in control group within the all tested age periods were higher than that one in test group that was associated with higher body weight of ducks in test group. Available literature data on bursa of Fabricius size during postnatal ontogenesis are quite contradictory. Findings on the dynamics of the relative organ weight obtained during the study are consistent with the data of some authors [17–21], but differ from the data on maximum absolute mass of the organ [17–20, 22, 23].

CONCLUSION

The maximum relative weight gain of Peking ducks was observed at the age of 15 days, then this parameter decreased with a sharp drop on day 30 and day 75. The relative weight gains in ducks of test group were higher

than in ducks of control group during all tested periods of ontogenesis.

Dynamics of changes in relative spleen weight showed that the development of the organ was almost the same both in control group and test group. Therewith, maximum values were reported in ducks at the age of 15 and 30 days and then those values just slightly and synchronously fluctuated in both groups. Relative spleen weight in ducks of test group was higher than that one in ducks of control group throughout the study.

Relative bursa of Fabricius weight in Pekin ducks intensively increased up to the age of 15 days, but reached the peak level at the age of 30 days both in control and test groups. There were more pronounced wave-like fluctuations in the relative weight of the examined organ, associated with critical periods due to diet changes and moltings in control group.

Thus, it can be concluded that the organic selenium additive had a positive effect on the development of the spleen and bursa of Fabricius, enhancing the adaptive capacity of the duck body during critical periods of its development.

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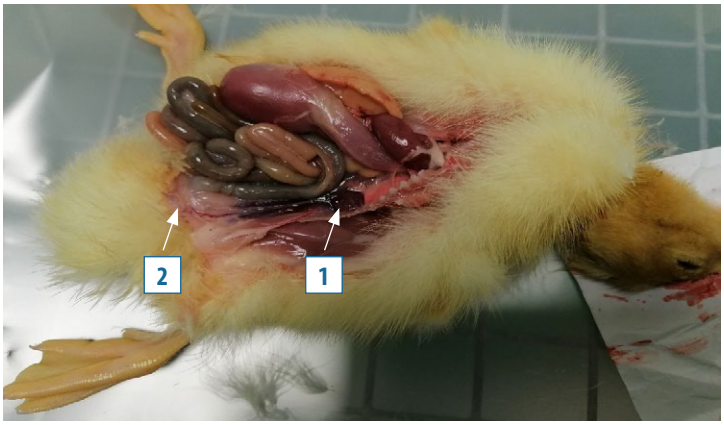

Fig. 2. Phrenic organs of day-old Pekin ducks: 1 – spleen, 2 – bursa of Fabricius

Рис. 2. Органы грудобрюшной полости суточного утенка пекинской породы: 1 – селезенка, 2 – клоакальная бурса

Table 2
Dynamics of absolute and relative spleen weight parameters of Pekin ducks in control and test groups

Таблица 2
Динамика абсолютных и относительных показателей массы селезенки уток пекинской породы контрольной и опытной групп

Age, days	Control group		Test group	
	Absolute spleen weight, g	Relative spleen weight, %	Absolute spleen weight, g	Relative spleen weight, %
1	0.13 ± 0.02	0.16	0.13 ± 0.02	0.16
15	0.62 ± 0.04	0.24	0.63 ± 0.30	0.23
30	1.15 ± 0.05	0.25	1.23 ± 0.04	0.25
45	1.73 ± 0.11	0.19	1.84 ± 0.12	0.19
60	3.00 ± 0.22	0.20	3.50 ± 0.14	0.20
75	3.23 ± 0.12	0.19	3.95 ± 0.21	0.20
90	3.99 ± 0.14	0.19	5.10 ± 0.16*	0.21
105	4.76 ± 0.17	0.20	6.40 ± 0.19*	0.22
120	5.26 ± 0.21	0.20	7.20 ± 0.18*	0.22

* $P \leq 0.05$ as compared to control ($P \leq 0,05$ в сравнении с контролем).

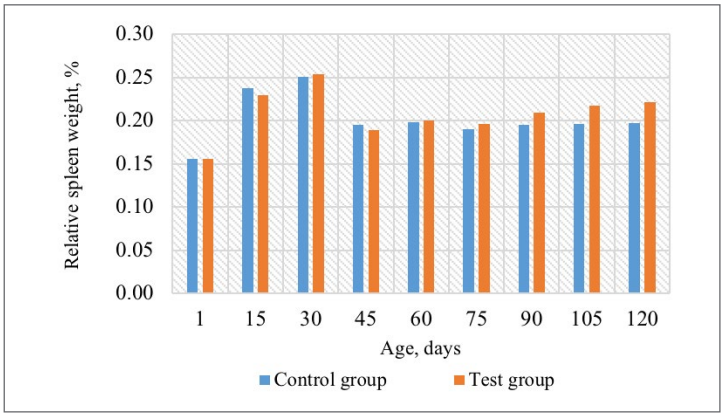

Fig. 3. Dynamics of relative spleen weight of Pekin ducks in control and test groups

Рис. 3. Динамика относительной массы селезенки уток пекинской породы контрольной и опытной групп

Table 3
Dynamics of absolute and relative bursa of Fabricius weight parameters of Pekin ducks in control and test groups

Таблица 3
Динамика абсолютных и относительных показателей массы клоакальной бурсы уток пекинской породы контрольной и опытной групп

Age, days	Control group		Test group	
	Absolute bursa of Fabricius weight, g	Relative bursa of Fabricius weight, %	Absolute bursa of Fabricius weight, g	Relative bursa of Fabricius weight, %
1	0.02 ± 0.01	0.02	0.02 ± 0.01	0.02
15	0.26 ± 0.01	0.10	0.25 ± 0.01	0.09
30	0.55 ± 0.01	0.12	0.48 ± 0.01	0.10
45	0.71 ± 0.02	0.08	0.68 ± 0.02	0.07
60	1.65 ± 0.03	0.11	1.58 ± 0.03	0.09
75	1.87 ± 0.03	0.11	2.01 ± 0.03*	0.10
90	1.64 ± 0.05	0.08	1.98 ± 0.06*	0.08
105	1.39 ± 0.05	0.06	1.35 ± 0.05	0.05
120	1.24 ± 0.06	0.05	1.11 ± 0.04	0.03

* $P \leq 0.05$ as compared to control ($P \leq 0{,}05$ в сравнении с контролем).

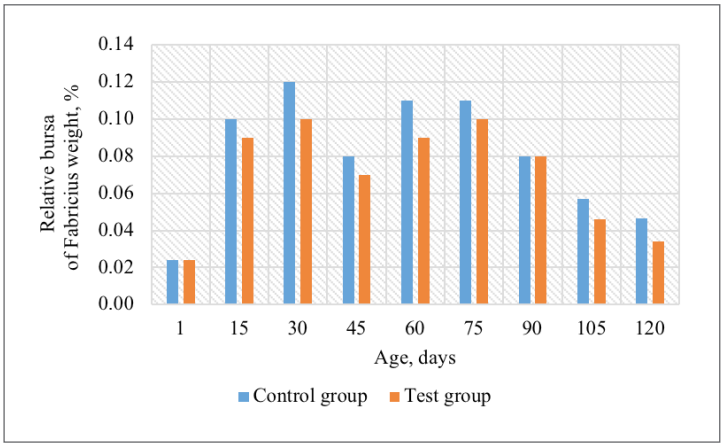

Fig. 4. Dynamics of relative bursa of Fabricius weight of Pekin ducks in control and test groups

Рис. 4. Динамика относительной массы клоакальной бурсы уток пекинской породы контрольной и опытной групп

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