UKRAINIAN JOURNAL OF VETERINARY SCIENCES

2026. Volume 17, No. 1 P. 11-30

ISSN 2663-967X;
e-ISSN 2663-9688

Journal homepage: https://veterinaryscience.com.ua/en

DOI: 10.31548/veterinary1.2026.11 UDC 619:612.315/.325:636.598

Received: 27.10.2025 Revised: 30.01.2026 Accepted: 26.02.2026 Published: 23.03.2026

Patterns of formation of the lymphoid tissue of the oesophageal tonsil in ducks at the early stages of the postnatal period of ontogenesis

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Abstract. The relevance of studying the oesophageal tonsil of ducks at the early stages of the postnatal period of ontogenesis is linked to the need to analyse how the levels of structural organisation of its lymphoid tissue are established. In this context, the aim of the research was to determine the localisation and form of the lymphoid tissue of the oesophageal tonsil in Blagovarsky cross broiler ducks from 1 to 240 days of age. Morphometric investigations were carried out and

Suggested Citation:
Usenko, S., Mazurkevych, T., Kuropka, P., & Stegney, Zh. (2026). Patterns of formation of the lymphoid tissue of the oesophageal tonsil in ducks at the early stages of the postnatal period of ontogenesis. *Ukrainian Journal of Veterinary Sciences*, 17(1), 11-30. doi: 10.31548/veterinary1.2026.11.

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the topography of the oesophageal tonsil was determined in ducks of the studied age groups. Biological material was fixed in a 10% solution of neutral formalin. For histological examination, paraffin blocks were prepared on a sledge microtome and histological sections were obtained, which were stained to reveal the structural features and area of the tissue components of the oesophageal tonsil. It was established that in ducks, the oesophageal tonsil was macroscopically visualised at the transition of the mucous membrane of the caudal part of the oesophagus into the glandular part of the stomach. Changes in its length and width were asynchronous. Up to 5 days of age, the lymphoid tissue of the oesophageal tonsil was represented only by the diffuse form. In ducks aged 10 days and older, primary and secondary nodules appeared. By 15 days of age, the oesophageal tonsil had reached morphofunctional maturity and was characterised by fully developed lymphoid tissue. In day-old ducklings, an infiltration of the glandular portions of the oesophageal glands and the excretory ducts by lymphocytes was observed. With increasing age, intensive colonisation of the epithelium of the oesophageal glands and the excretory ducts by lymphoid cells was recorded. As a result, the lumina of the glands narrowed and transformed into crypt-like openings that opened into the lumen of the oesophagus. The data obtained on the development of the lymphoid tissue of the oesophageal tonsil in broiler ducks during the initial age phases can be used to optimise rearing processes, improve productive performance and refine vaccination strategies to prevent dangerous infectious diseases

Keywords: immune formations; lymphoid nodules; morphometric investigations; poultry; mucous membrane of the oesophagus

Introduction

In phylogeny, the organs of haematopoiesis and lymphopoiesis of birds occupy a special place. In birds, lymphoid tissue is for the first time separated from myeloid tissue, although both branches remain closely connected, forming a single haematopoietic system (Pendl & Schmidt, 2024). The formation of lymphoid tissue in ontogenesis takes place in direct contact with blood vessels, which mirrors its phylogenetic development and its dependence on the vascular bed (Hantusch, 2024). A characteristic feature of birds is the presence of another central organ of haematopoiesis and lymphopoiesis – the cloacal bursa (bursa of Fabricius), which is not found in other cloacal animals. In the course of phylogeny, birds also developed the Harderian gland, typical of vertebrates except for primates and humans, which has been described in detail in the works of I.R. Tizard (2024) and A. Jamil *et al*. (2024). An oesophageal tonsil has likewise been identified, which is unique for this class and is not found in other vertebrate species (Capotă *et al*., 2025).

Another important sign of the transition of the immune system to a higher level of structural and functional organisation is the formation in waterfowl of structures similar to the lymph nodes of mammals. These were studied by C. Ceccopieri & J.P. Madej (2024) and H. Pendl & R.E. Schmidt (2024). As shown by these authors, in birds, due to the absence of classical lymph nodes, the diffuse lymphoid tissue is extremely well-developed. It forms in places of potential antigen penetration and sites of antigenic stimulation. An example of such tissue is the lymphoid tissue associated with mucous membranes (MALT – mucous associated lymphoid tissue), which includes

bronchus-associated lymphoid tissue (BALT – bronchus associated lymphoid tissue), nasal-associated lymphoid tissue (NALT – nasal associated lymphoid tissue) and gut-associated lymphoid tissue (GALT – gut associated lymphoid tissue). Additional, though less described, components of MALT include conjunctiva-associated lymphoid tissue (CALT – conjunctiva associated lymphoid tissue), larynx-associated lymphoid tissue (LALT – larynx associated lymphoid tissue) and lymphoid tissue associated with the excretory ducts of the salivary glands (DALT – salivary duct associated lymphoid tissue). According to the conclusions of C. Ceccopieri & J.P. Madej (2024), owing to the activity of immunocompetent cells – dendritic cells, T- and B-lymphocytes – MALT contributes to the formation of long-term local immunity.

The bodies of waterfowl are exposed to increased antigenic load, which is determined by the habitat. Therefore, the immune system of these birds includes both lymph nodes and MALT. The oesophageal tonsil in birds belongs to the peripheral organs of haematopoiesis and lymphopoiesis and is part of the group of lymphoid formations associated with mucous membranes (MALT – mucous associated lymphoid tissue). According to H.M. Ali *et al*. (2023), this organ plays a key role in shaping the local immune response to pathogens entering the body through the digestive tract.

For this reason, investigation of the morphofunctional features of the oesophageal tonsil in ducks is an important task for a deeper understanding of the immune mechanisms in these birds. Analysis of age-related changes in its structure makes it possible to identify stages in the development of the immune system and to optimise housing conditions, feeding, and vaccination to ensure high health status and productivity. The aim of the study was to determine the patterns of formation of the lymphoid tissue of the oesophageal tonsil in ducks from hatching to the onset of sexual maturity. To achieve this aim, the following tasks were set: to determine the macroscopic indices and features of the microstructure of the lymphoid tissue, its interrelations with the oesophageal glands and the surface epithelium of the mucous membrane; to determine the area of the lymphoid tissue, the levels of its organisation and its interrelations with the components of the mucosa.

Literature Review

Current scientific research points to the leading role of the organs of haematopoiesis and lymphopoiesis in maintaining immune homeostasis in animals. Peripheral lymphoid formations, which are the first to come into contact with environmental antigens, are particularly important in this respect. The organs of haematopoiesis and lymphopoiesis in animals are divided into central and peripheral. In the central organs, blood cells develop; in the peripheral organs, under the influence of antigens, lymphocytes differentiate into effector cells that ensure immunity and the elimination of foreign agents from the body (Akhand & Ahsan, 2023).

The central organs are situated in regions of the body protected from the direct action of antigens, whereas the peripheral organs are located at the sites where antigens enter the organism. As noted by J.I. Park *et al*. (2023) and L.V. Kadirova (2024), most antigens enter with feed and water through the digestive tract, in the wall of which about 70% of the lymphoid tissue of the body and 80% of its immunocompetent cells are concentrated. It is lymphoid tissue that forms the functional basis of the peripheral organs of haematopoiesis and lymphopoiesis.

One of the key components of the immune system of birds is the oesophageal tonsil, which belongs to the lymphoid formations associated with mucous membranes (MALT – mucous

associated lymphoid tissue) and functions as a peripheral organ of haematopoiesis and lymphopoiesis. According to F. Davison (2022), because representatives of this class lack the pharyngeal lymphoid ring of Pirogov-Waldeyer, the oesophageal tonsil is the first organ to respond to antigens entering with feed and water. It is located in the mucous membrane of the caudal part of the oesophagus, at the boundary with the glandular part of the stomach, and is represented by diffuse and nodular forms of lymphoid tissue (Zeinali *et al*., 2024). M. Rochman *et al*. (2025) confirmed that this formation actively responds to antigenic stimuli entering via the oesophagus and plays an important role in the local immune response to pathogens that penetrate the organism through the digestive tract.

The morphofunctional features of the oesophageal tonsil in birds, particularly in ducks, as indicated by J. Mehrzad *et al.* (2024), are of considerable scientific interest, since the study allows a deeper understanding of the mechanisms of immune response to external stimuli. Analysing age-related changes in the structure and function of this organ helps to identify critical periods in the development of the immune system, to optimise the conditions of housing and feeding, and to improve vaccination strategies aimed at increasing productivity and maintaining health. The oesophageal tonsil in ducks, as shown by N.I. El-Naseery *et al*. (2021), begins to form as early as the fifth day after hatching, which underlines its important role in the early development of the immune response. During the development of the organ, significant changes occur in the total amount of lymphoid tissue and in the levels of its structural organisation. The total amount of lymphoid tissue reaches a maximum at 30 days of age and then gradually decreases. According to J. Mehrzad *et al.* (2024), this may be related to adaptation to constant antigenic stimuli and the establishment of a stable immune response. With age, a redistribution of lymphoid tissue takes place, with a decrease in its diffuse form and an increase in the proportion of connective tissue, which points to changes in the lymphopoietic processes of the organ.

A crucial indicator of the function of the oesophageal tonsil is the presence of a substantial number of immunocompetent cells. C. Ceccopieri & J.P. Madej (2024) noted that the presence of T- and B-lymphocytes, plasma cells, macrophages, and monocytes ensures the development of cellular and humoral immunity. In older birds, the number decreases, which, in the opinion of J. Mehrzad *et al*. (2024), may be associated either with the achievement of a stable immune response or with general changes in the functioning of the immune system.

External factors, vaccination in particular, also influence the morphogenesis of the oesophageal tonsil. S. Guralska *et al*. (2023) reported that in vaccinated birds, its morphofunctional maturity occurs earlier, which confirms the role of antigenic stimulation in the development of the immune system. This also highlights the importance of the organ as an indicator of the effectiveness of vaccination strategies (Lestari *et al*., 2023). In turn, N. Yıldırım (2024) showed that age-related changes in the structure and function of the tonsil have practical significance for adjusting vaccination methods, treating infections and conducting immunological monitoring, since the regenerative capacity of the organ declines with age. Thus, studying the morphofunctional changes in the oesophageal tonsil in ducks is necessary for a better understanding of the mechanisms of immunity formation in this species. Knowledge of age-related changes in the oesophageal tonsil will help to optimise methods of housing, feeding and vaccination, as well as to improve disease prevention strategies in poultry farming.

Materials and Methods

The research was carried out from September 2023 to March 2025 in the Teaching-Scientific-Production Laboratory "Centre of Biomorphological Technologies" of the Department of Vertebrate Biomorphology named after Academician V.H. Kasyanenko. The present work continues investigations performed in 2012-2013, the results of which were partly published in scientific articles by V.T. Khomych & S.I. Usenko (2012; 2013). In the publication by V.T. Khomych & S.I. Usenko (2012) information was presented on the localisation of the lymphoid tissue of the oesophageal tonsil in the lamina propria and submucosa of the oesophageal mucosa in ducks aged 1-20 days. The age of the ducks at which different levels of structural organisation of lymphoid tissue (diffuse form, prenodules, primary and secondary lymphoid nodules) appear and its area in the mucous membrane were determined. In the publication by V.T. Khomych & S.I. Usenko (2013) the investigation of the lymphoid tissue of the oesophageal tonsil in ducks aged 25-120 days was continued and morphometric indices of the oesophageal tonsil, the area of its lymphoid tissue and the levels of its development were provided. For a full understanding of the patterns of development of the oesophageal tonsil in ducks from hatching to the onset of sexual maturity (180 days) and its subsequent development, the present study used the findings of the investigations from 2012 to 2013 and extended the examination of this immune formation in ducks aged 150-240 days. In addition, the studies from 2012 to 2013 were supplemented. Specifically, in ducks aged 1-25 days, macroscopic indices of the oesophageal tonsil were determined; in ducks aged 1-120 days, changes in the linear measurements of the mucosal folds of the oesophagus in the region of the oesophageal tonsil and in adjacent areas, and the relationships between the lymphoid tissue and the oesophageal glands, were examined.

Material for the study was taken from 68 Blagovarsky cross broiler ducks aged 1 day, 5, 10, 15, 20 and 25 days (six birds in each age group) and 30, 60, 90, 120, 150, 180, 210 and 240 days (four birds in each age group). Preventive vaccinations were not carried out in these birds. After ether anaesthesia, euthanasia was performed by acute exsanguination in accordance with the general ethical principles of O.H. Reznikov (2003). The authors state that the provisions of the Law of Ukraine No. 3447-IV (2006) were compiled with and the ARRIVE recommendations (n.d.) were taken into account. As this research was post-mortem, the standards of OIE/WOAH (n.d.) were followed.

After opening the carcasses of the ducks, the caudal part of the oesophagus and the cranial part of the glandular stomach were dissected in the thoraco-abdominal cavity and cut longitudinally with fine-pointed scissors. In the caudal part of the oesophagus, the topography, relief, and colour were recorded. The length and greatest width of the oesophageal tonsil were measured with callipers and a ruler (DSTU EN ISO 13385-1:2018, 2018). After sampling material for histological examination, it was labelled and fixed in a 10% aqueous solution of neutral formalin. The next stage was the preparation of histological sections. For this purpose, the fixed material was washed in tap water, dehydrated in ethanol solutions of increasing concentration and then embedded in paraffin. Histological sections 5-10 μm thick were cut on an MPS-2 sledge microtome (Tochmedpribor, Ukraine). The obtained histological slides were stained with Carazzi haematoxylin and eosin, according to Mallory, Van Gieson and Weigert (Horalskyi *et al.*, 2015). The structural components of the lymphoid tissue (reticular fibres) were demonstrated by

impregnating the sections with a 1% aqueous solution of silver nitrate. After staining and impregnation, the histological preparations were examined using Olympus (Japan) and Levenhuk (China) light microscopes.

The results obtained were recorded in protocols, and the numerical indices were processed statistically on a personal computer using Excel and Statist software. Statistical processing of the data included calculation of the mean value, the standard error of the mean and the P-value for testing the statistical significance of the results, in accordance with the requirements of morphological studies. A P-value of less than 0.05 was considered statistically significant. These methods made it possible to identify patterns in changes in lymphoid tissue in the different age groups of ducks and to assess the statistical significance of the findings obtained.

Results and Discussion

In conformity with the results of the investigations, the anatomically defined location of the oesophageal tonsil in ducks is the mucous membrane of the caudal part of the oesophagus in the region where it passes into the glandular part of the stomach. The mucous membrane of the oesophagus forms folds, owing to which the lumen of the oesophagus widens as the bolus of feed passes through. The position of the lymphoid tissue of the oesophageal tonsil is closely related to the longitudinal folds of the oesophagus. In the age groups of ducks studied, the mucous membrane forms 7-12 folds, in which the tonsil is localised (Fig. 1).

A B

Figure 1. Oesophageal tonsil of ducks of different ages
***Note**: A – at 5 days of age; B – at 120 days of age. Macroscopic specimen*
***Source**: V.T. Khomych & S.I. Usenko (2012; 2013)*

Macroscopically, the oesophageal tonsil was identified in ducks at 5 days of age and appeared as a pale band. The width of the band corresponded to the perimeter of the oesophagus and measured 1.97 ± 0.02 cm, while its length was 0.9 ± 0.06 cm. By 10 days of age, the oesophageal tonsil had the form of a yellowish ring-shaped, nodular band. This appearance remained the same in ducks of all older age groups, and only its linear dimensions (length and width) changed. V.R. Indu & K.M. Lucy (2021) reported that in hens, the oesophageal tonsil appeared as isolated pale patches located at the base of the folds.

Changes in the linear dimensions (length and width) of the oesophageal tonsil of ducks with age were asynchronous and periodic. The most intensive increase in the length of the oesophageal tonsil was observed in ducks aged 5-10, 10-15 and 60-90 days, by 37.8% ($P < 0.01$), 33.1% ($P < 0.001$) and 31.1% ($P < 0.001$) respectively, while the width increased most noticeably between 20 and 25 days, by 48.54%

(P < 0.001). The greatest values of length and width of the oesophageal tonsil were recorded in 120-day-old ducks, at 3.78 ± 0.25 cm and 0.84 ± 0.11 cm respectively (Fig. 2).

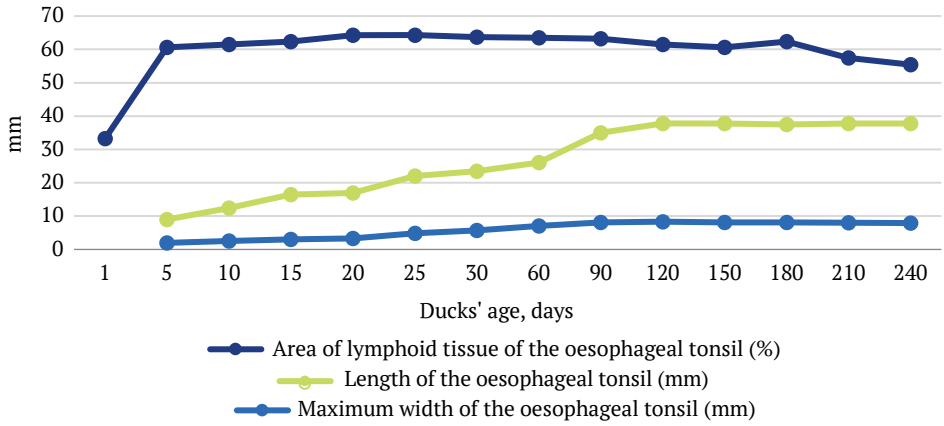


Figure 2. Morphometric indices of the oesophageal tonsil at the early stages of the postnatal period of ontogenesis and the area of its lymphoid tissue
***Note**: different colours indicate the area, length, and width of the oesophageal tonsil*
***Source**: developed by the authors*

Subsequently, a tendency towards a decrease in the width of the oesophageal tonsil was observed. The most marked reduction in this index, by 2.4% (P < 0.001), was found in ducks aged 120-150 days, when the width of the tonsil decreased to 0.81 ± 0.14 cm. In the age groups of 180 and 210 days, the width of the oesophageal tonsil remained almost unchanged (0.81 ± 0.8 cm and 8 ± 0.1 cm respectively). By 240 days of age it decreased by a further 1.25% (P < 0.001) and was 0.79 ± 0.02 cm. In ducks aged 150-240 days, the length of the oesophageal tonsil remained almost unchanged and ranged from 3.79 ± 0.21 cm to 3.78 ± 0.38 cm. L.O. Buhai (2008), who examined this immune formation in Muscovy ducks from the first day of life to sexual maturity, also reported periodic and asynchronous growth and development of the oesophageal tonsil.

Analysis of the relationship between the development of the area of lymphoid tissue of the oesophageal tonsil and its macroscopic indices showed that the area of lymphoid tissue of the oesophageal tonsil in the mucous membrane of the oesophagus reached its maximum values in ducks at 20 days of age and remained almost unchanged in 25-day-old ducks. In contrast, the linear dimensions reached the maximum values only in 120-day-old ducks. In older age groups (150-240 days), as noted above, the length and width of the oesophageal tonsil remained almost unchanged. The area of lymphoid tissue (Fig. 2), however, tended to decrease, except in the group of ducks aged 180 days, in which a slight increase in this index was recorded (by 2.9%, P < 0.001). Thus, quantitative changes in the area of lymphoid tissue of the oesophageal tonsil did not influence changes in its macroscopic indices.

In the region where the oesophageal tonsil is located, thickening of the wall of the oesophageal mucosa relative to adjacent areas was also noted. According to the results obtained, this is related to an increase in the height and maximum width of the folds of the mucous membrane in the region of the oesophageal tonsil

compared with those in neighbouring parts of the oesophagus. In day-old ducks, the linear measurements of the mucosal folds in the area of the oesophageal tonsil already substantially exceeded the corresponding indices for folds in adjacent portions of the oesophagus (Fig. 3).

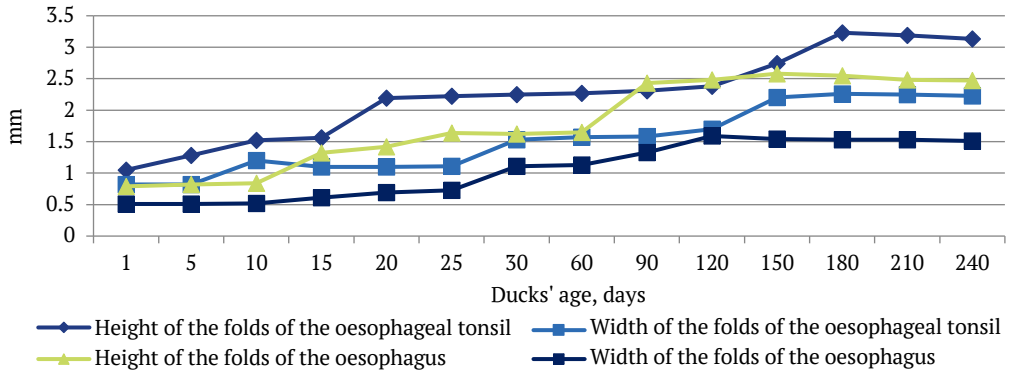


Figure 3. Linear measurements of the folds of the mucous membrane of the oesophagus and the oesophageal tonsil of ducks
***Note**: different colours indicate the height of the folds of the oesophageal tonsil and of the oesophagus*
***Source**: developed by the authors*

The height of the folds in the region of the oesophageal tonsil was 28% greater and the width 54.1% greater than in the adjacent part of the oesophagus. Changes in these indices with age were uneven and asynchronous. During the first 5 days of life, the height, and maximum width of the folds increased by 28% (that is, doubled) ($P < 0.05$) and 5.2% ($P < 0.05$) respectively. In the same period, the area of lymphoid tissue of the oesophageal tonsil increased most markedly – by 82% ($P < 0.001$). The maximum increase in the height of the folds of the oesophageal tonsil compared with adjacent parts of the oesophagus was recorded in ducks aged 15-20 days (by 99%, $P < 0.001$) and remained unchanged up to 25 days of age. In other age groups, this index fluctuated between 18.8% ($P < 0.001$) and 56% ($P < 0.001$). The width of the folds in the region of the oesophageal tonsil compared with the folds in adjacent areas of the oesophagus increased most intensively at 10-15, 15-20 and 20-25 days of age, by 116% ($P < 0.001$), 106% ($P < 0.001$) and 125% ($P < 0.001$) respectively. In the other age groups, this index also fluctuated, between 46% ($P < 0.001$) and 82.7% ($P < 0.001$).

Uneven and asynchronous changes in the indices of height and width of the mucosal folds of the oesophagus in the region where the oesophageal tonsil is located were also observed when analysed by age. In day-old ducks, the height of the folds in the area of the oesophageal tonsil was 1.05 ± 0.04 mm and the width 0.79 ± 0.01 mm. By 5 days of age, the height of the folds had increased by 22% ($P < 0.001$), while the width remained unchanged. The area of lymphoid tissue in the mucosa increased by 82% ($P < 0.001$). With age, these indices changed unevenly. The most intensive increase in the height of the folds, by 40.4%, occurred in birds between 15 and 20 days of age. At this time, the content of lymphoid tissue of the oesophageal tonsil increased by 3.1% ($P < 0.001$). The width of the folds in the region of the oesophageal tonsil increased maximally in ducks aged 10-15 days and 60-90 days, by 57.1% ($P < 0.01$)

and 53.3% (P < 0.001) respectively. The area of lymphoid tissue of the oesophageal tonsil in ducks aged 10-15 days decreased by 2% (P < 0.001), while in those aged 60-90 days it increased by 0.8% (P < 0.001). The greatest values of the height of the mucosal folds in the region of the oesophageal tonsil were reached in ducks at 180 days of age and amounted to 3.23 ± 0.06 mm, while the greatest width was found in 150-day-old ducks and was 2.58 ± 0.05 mm. In ducks aged 150-180 days, the area of lymphoid tissue increased by 2.9% (one of the highest indices) (P < 0.001). In older birds, these indices decreased slightly (height by 1.2-1.9%, width by 0.4-2.7%), and in 240-day-old ducks, the indices were 3.13 ± 0.05 mm and 2.47 ± 0.05 mm respectively. At the same time, a decrease in the area of lymphoid tissue was observed in ducks aged 210 and 240 days, by 7.9% (P < 0.001) and 3.6% (P < 0.001) respectively.

Thus, the uneven increase in the linear measurements of the folds of the mucous membrane of the oesophagus in the region of the oesophageal tonsil, both with age and in comparison with adjacent parts of the oesophagus, is related not only to the growth of the body of the ducks but also to the development of lymphoid tissue in the mucosa. Asynchronous development of the lymphoid tissue of the oesophageal tonsil was observed, influencing increases in the height and width of oesophageal folds oriented in different planes. Such changes in the linear indices of the folds in the region of the oesophageal tonsil compared with adjacent parts of the oesophagus indicate that the development of its lymphoid tissue proceeded unevenly and was oriented in different planes. Thickening of the oesophageal wall in the region of the oesophageal tonsil has also been reported in hens by I. Oláh *et al.* (2003) and C. Casteleyn *et al.* (2010), and in ducks by H.H. Donmez *et al*. (2012).

Microscopic examination confirmed that the general plan of the structure of the oesophageal wall in the region of the oesophageal tonsil is characteristic of ducks of all age groups studied. The wall of the oesophagus consists of mucosal, muscular and serous coats. The mucous membrane forms longitudinal folds involving all its components: epithelium, lamina propria, muscularis mucosae and submucosa. The epithelium covering the mucosa of the oesophagus is stratified squamous; immediately adjacent to the glandular part of the stomach it is replaced by the simple columnar glandular epithelium characteristic of this part of the stomach. In ducks of all age groups, the muscularis mucosae is poorly developed and represented by individual smooth muscle cells. In the lamina propria and submucosa, which consist of loose fibrous connective tissue, the oesophageal glands are located. These glands produce a mucous secretion that is discharged onto the surface of the mucosa through the excretory ducts. Near the glandular part of the stomach, lobules of the deep glands of this part of the stomach were also found in the submucosa of the oesophagus (Fig. 4).

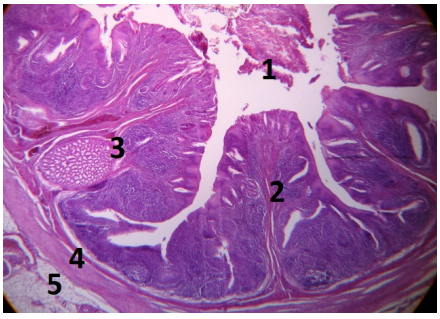
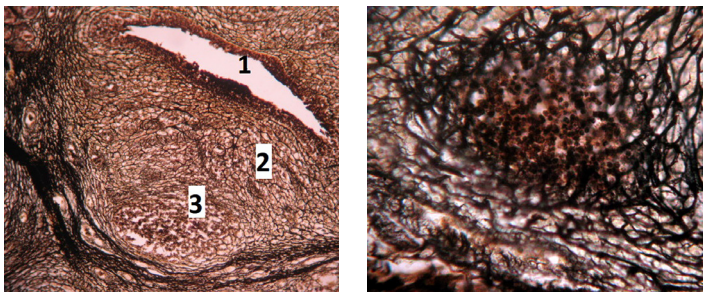


Figure 4. Oesophageal tonsil of a duck aged 15 days
***Note**: 1 – lumen of the oesophagus; 2 – fold of the mucous membrane; 3 – lobule of the deep glands of the glandular part of the stomach; 4 – muscular coat of the oesophagus; 5 – serous coat of the oesophagus. Haematoxylin and eosin stain, ×40*
***Source**: authors' own data*

The excretory ducts of the glands open on the surface of the mucosa of the glandular part of the stomach. The muscular coat of the oesophagus is formed by smooth muscle tissue arranged in three layers. The inner and middle layers are well-developed. In the inner layer the smooth muscle cells run longitudinally, and in the middle layer, these cells run circularly. The outer layer of the muscular coat is poorly developed and represented by small bundles of longitudinally oriented smooth muscle cells. In older ducks, the inner layer of the muscular coat locally projects into the folds of the mucosa. The serous coat of the oesophagus in the region of the oesophageal tonsil is formed by loose fibrous connective tissue covered externally by mesothelium.

The lymphoid tissue that provides the functional features of the oesophageal tonsil is represented by diffuse and nodular forms. It is based on reticular tissue, the arrangement of whose fibres depends on the level of development of the lymphoid tissue. In diffuse lymphoid tissue, the reticular fibres lack a definite orientation, are closely packed and form a network with small meshes containing lymphoid cells (Fig. 5).



A B

Figure 5. Architectonics of reticular fibres in the oesophageal tonsil of a duck
***Note**: A: 1 – excretory duct of an oesophageal gland; 2 – diffuse lymphoid tissue; 3 – lymphoid nodule; ×100. B – formation of a lymphoid nodule, ×400. Impregnation with silver nitrate*
***Source**: authors' own data*

The architectonics of the reticular fibres in the lymphoid nodules has specific features. In lymphoid nodules without germinal centres, the reticular fibres are arranged more loosely and form a meshwork with large spaces. In lymphoid nodules with pale germinal centres, the reticular fibres are usually absent. The nodules are bounded by a capsule composed of densely arranged reticular fibres together with isolated collagen and elastic fibres.

In ducks of all age groups, the lymphoid tissue of the oesophageal tonsil is located in the lamina propria and submucosa of the oesophageal mucosa (Fig. 4). Lymphoid cells surround blood vessels, the secretory portions of the oesophageal glands and the ducts. These cells locally infiltrate the epithelium of the glands and the mucosa. Near the glandular part of the stomach, lymphoid tissue is localised around the lobules of its deep glands, some of which are infiltrated by lymphoid cells. In older ducks, small accumulations of lymphoid cells were also found in the lumina of some glands. In the regions where the oesophageal tonsil is located, the structure of the components of the mucosa changes. In the lamina propria and submucosa, in addition to collagen and elastic fibres, local accumulations of reticular meshwork typical of diffuse lymphoid tissue and lymphoid nodules were observed (Fig. 5).

The development of the lymphoid tissue of the oesophageal tonsil takes place gradually. In day-old and 5-day-old ducks, the lymphoid tissue is represented only by the diffuse form (Fig. 6). In ducks aged 10 days, lymphoid nodules without germinal centres appeared in the oesophageal tonsil. Lymphoid nodules with pale (germinal) centres were found in ducks aged 15 days, which is a sign of an immune response to antigenic stimulation (Fig. 7). This is consistent with the conclusions of V. Logvinova & A. Oliyar (2021) and N. Mazur & N. Dyshliuk (2025), who determined that the formation of lymphoid tissue associated with the mucosa of the digestive organs takes place in four stages: diffuse lymphoid tissue, prenodules, primary and secondary lymphoid nodules.

Figure 6. Lymphoid tissue in the mucous membrane of the oesophagus in the region of the oesophageal tonsil of a day-old duck

***Note**: 1 – fold of the mucous membrane of the oesophagus; 2 – oesophageal glands; 3 – lymphoid tissue in the lamina propria and submucosa of the mucous membrane; 4 – lumen of an oesophageal gland; 5 – lobule of the deep glands of the glandular part of the oesophagus; 6 – muscular coat of the oesophagus. Impregnation with silver nitrate, ×100*

***Source**: authors' own data*

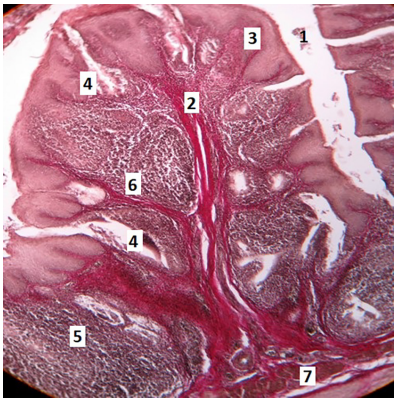


Figure 7. Formation of lymphoid nodules with germinal centres in the oesophageal tonsil of a 15-day-old duck

***Note**: 1 – lumen of the oesophagus; 2 – fold of the mucous membrane of the oesophagus; 3 – epithelium; 4 – oesophageal glands and the ducts; 5 – lymphoid tissue in the lamina propria and submucosa of the mucous membrane; 6 – lymphoid nodule with a germinal centre; 7 – muscular coat of the oesophagus. Van Gieson staining, ×100*

***Source**: authors' own data*

Diffuse and nodular forms of lymphoid tissue of the oesophageal tonsil in ducks occupy different areas. The area of diffuse lymphoid tissue is the largest, whereas that of the nodular forms is considerably smaller. The ratio of these indices changes with increasing age of the ducks (Fig. 8). In day-old and 5-day-old ducks, the lymphoid tissue is 100% represented by the diffuse form. As the ducks grow older, its content decreases unevenly. By 180 days of age, the area of the diffuse form of lymphoid tissue was 63.77 ± 0.51%. In older age groups, its area increased: in 210-day-old ducks by 7.8%, and in 240-day-old ducks by a further 1%, reaching 71.14 ± 0.23% of the area of the mucous membrane. These changes in the content of diffuse lymphoid tissue of the oesophageal tonsil are partly related to the development within it of lymphoid nodules.

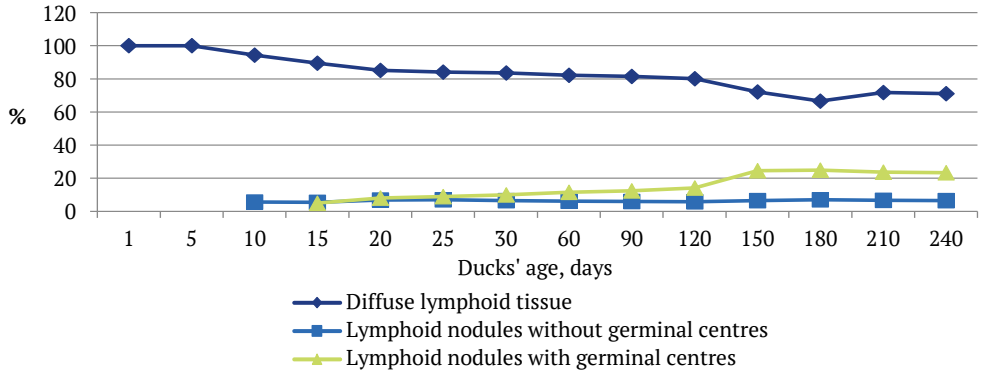


Figure 8. Content of structural components of lymphoid tissue of the oesophageal tonsil in ducks at different ages
***Note**: different colours indicate the content of lymphoid nodules at different ages of ducks*
***Source**: developed by the authors*

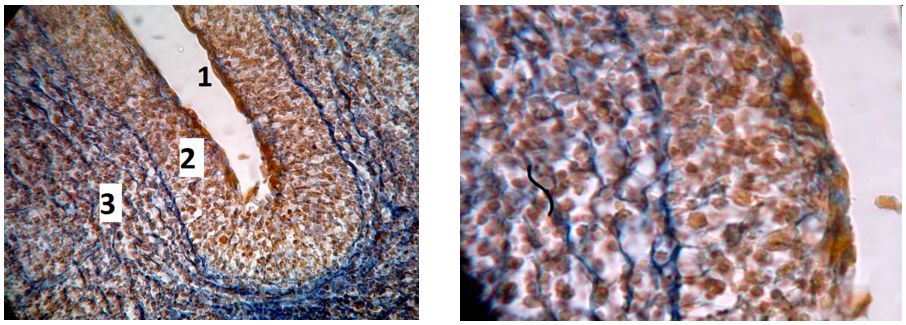
In ducks at 10 days of age, lymphoid nodules without germinal centres occupied 5.7 ± 0.24% of the area of the lymphoid tissue of the oesophageal tonsil. The amount increased markedly up to 20 days of age. With increasing age of the ducks, only slight changes in this index were recorded. In older age groups (150-240 days), the area of lymphoid nodules without germinal centres reached its highest values at 180 days of age, at 6.96 ± 0.32%. Afterwards it decreased evenly by 2.6% ($P < 0.01$) and in 240-day-old ducks was 6.52 ± 0.41%.

Lymphoid nodules with germinal centres in the oesophageal tonsil of ducks aged 15 days occupied 5.00 ± 0.64% of the area of lymphoid tissue. The area of these nodules in the lymphoid tissue of the oesophageal tonsil increased unevenly up to 180 days of age and amounted to 24.90 ± 0.38%. The most active formation of lymphoid nodules with germinal centres was observed in ducks aged 20 and 150 days: the area increased by 62% and 73.7% respectively. The maximum value (24.90 ± 0.38% of the area of lymphoid tissue of the oesophageal tonsil) was reached in ducks aged 180 days. In the older age groups (210 and 240 days), the area of these nodules decreased slightly, by 4.5% and 1.2% respectively, and in 240-day-old ducks it was 23.39 ± 0.19%. From 20 days of age, the content of lymphoid nodules with germinal centres clearly exceeded the content of nodules without germinal centres. A similar pattern of development of the lymphoid tissue of the oesophageal tonsil in hens at different ages was reported

by N.V. Dyshliuk (2009). In day-old hens, the author identified diffuse lymphoid tissue; at 10 days of age, primary lymphoid nodules appeared, and by 20 days secondary lymphoid nodules were present, while the content of diffuse lymphoid tissue increased with age.

The lymphoid nodules of the oesophageal tonsil in ducks of all age groups studied are mainly round or oval. Nodules with germinal centres are larger than those without these centres. In round nodules, the diameter of the former reached its maximum in ducks aged 150 days, and of the latter in ducks aged 180 days, at 198.82 ± 1.67 μm and 239.7 ± 1.84 μm respectively. Oval nodules reached the greatest size in ducks at 180 days of age. The length and maximum width were 304.56 ± 2.59 μm and 210.09 ± 2.43 μm (without germinal centres) and 349.68 ± 4.20 μm and 252.39 ± 3.16 μm (with germinal centres) respectively. T.A. Mazurkevych & V. Khomych (2017) also observed lymphoid nodules of such shapes in the lymphoid formations of the intestine of ducks.

Oesophageal glands and the excretory ducts deserve particular attention in the formation of the oesophageal tonsil in ducks. With increasing age, considerable changes were observed in the shape, content, and localisation in the mucous membrane of the oesophageal tonsil. In day-old ducks, the oesophageal glands were small and elongated-oval. These glands were located in the lamina propria of the mucous membrane at the base of the folds, on the lateral surfaces and at the tips. By 5 days of age the size had increased, and the glands had become round-oval, sometimes with star-shaped depressions. From the first day of life, lymphocytic infiltration of the secretory portions of the oesophageal glands and the excretory ducts was noted. This process became more intense with age. As a result, the epithelium thickened (Fig. 9) and the lumina of the glands narrowed, although the lumina did not disappear completely. The lumina were transformed into crypt-like openings surrounded by lymphoepithelium, opening onto the surface of the oesophagus.



A B

Figure 9. Formation of lymphoepithelium in the excretory ducts of the oesophageal glands in the oesophageal tonsil of ducks

***Note**: A: 1 – lumen of the excretory duct of an oesophageal gland; 2 – lymphoepithelium; 3 – lymphoid tissue, ×100. B – epithelium of an oesophageal gland infiltrated by lymphoid cells, ×400. Mallory staining*

***Source**: authors' own data*

The altered glands were found at the base of the folds of the mucous membrane and on the lateral surfaces. From 60 days of age, oesophageal glands in the region of the oesophageal tonsil were noted only beneath the epithelium, and from 180 days of age also at the

tips of some folds. In day-old ducks, oesophageal glands occupied 19.1 ± 0.67% of the area of the mucous membrane. With increasing age, up to 120 days, the area of the secretory portions of the oesophageal glands and the excretory ducts steadily decreased. The most intensive decrease occurred at 15, 60 and 90 days of age, by 31.6% ($P < 0.001$), 34.2% ($P < 0.01$) and 52.7% ($P < 0.001$) respectively. This process was due to an increase in the area of lymphoid tissue of the oesophageal tonsil. In ducks aged 120 and 150 days, the oesophageal glands occupied the smallest area, only 3.07 ± 0.06% of the mucous membrane (Fig. 10).

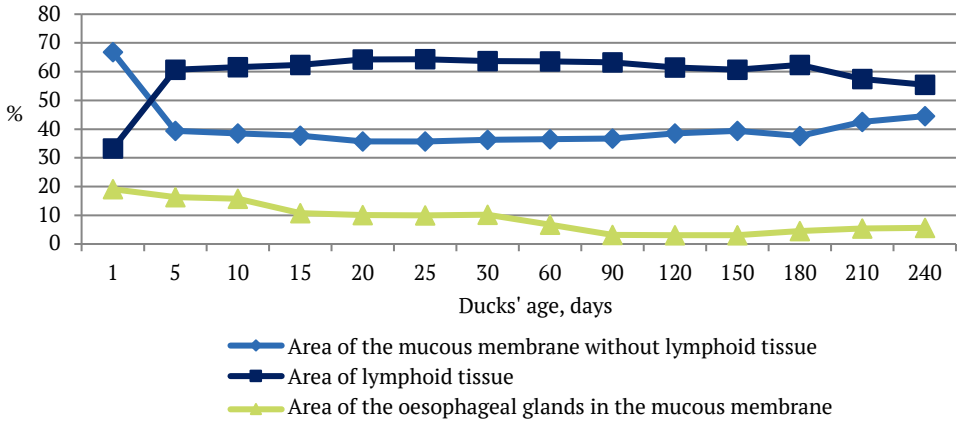


Figure 10. Area of lymphoid tissue and oesophageal glands of the mucous membrane of the oesophagus in ducks aged from 1 to 240 days
***Note**: different colours indicate the areas of different tissues*
***Source**: developed by the authors*

From 150 days of age, an increase in the area of the oesophageal glands was recorded. In ducks aged 180, 210 and 240 days, this index increased by 46.3% ($P < 0.001$), 20.9% ($P < 0.001$) and 4.4% ($P < 0.001$) respectively. In 240-day-old ducks, the area of the oesophageal glands accounted for 5.67 ± 0.07% of the mucous membrane. Conversely, in ducks of this age, the area of lymphoid tissue of the oesophageal tonsil decreased.

The results obtained in this work are consistent with the findings of other authors. The anatomically defined location of the oesophageal tonsil is the mucous membrane of the caudal part of the oesophagus at the transition to the glandular part of the stomach, as noted by V.R. Indu & K.M. Lucy (2021) and N.V. Dyshliuk (2009). The position of the lymphoid tissue of the oesophageal tonsil is closely related to the longitudinal folds of the oesophagus, as also reported by N. Nagy *et al.* (2005) and L.O. Buhai (2008). Thickening of the oesophageal wall in the region of the oesophageal tonsil was described by C. Casteleyn *et al.* (2010). In the present study, it was established that this occurs owing to an increase in the width and height of the mucosal folds during the development of lymphoid tissue. Increases in the linear parameters of the tonsil occur with increasing age of the ducks and are characterised by periodicity and asynchronicity. L.O. Buhai (2008) observed the same phenomenon in Muscovy ducks.

Functional maturity of the lymphoid tissue of the oesophageal tonsil (the presence of lymphoid nodules with germinal centres) was

recorded at 15 days of age. This fully corresponds to the data of A. Friedman *et al*. (2012), who reported that, in hens after hatching, protection against foreign antigens is provided by maternal IgA, and that a specific adaptive immune response matures during the first two weeks after hatching. T.A. Mazurkevych & V. Khomych (2017) established that in Blagovarsky cross broiler ducks full morphofunctional maturity of Peyer's patches of the duodenum, jejunum and caecum occurs at 15 days of age. With increasing age of the ducks, an increase in the content of lymphoid tissue of the oesophageal tonsil and its components was recorded. The formation of lymphoepithelial structures in the mucous membrane of the oesophagus in the region of the oesophageal tonsil is associated with the development of its lymphoid tissue. Colonisation of the oesophageal glands and the ducts by lymphoid cells led to the appearance of crypt-like structures. The presence of crypts in the oesophageal tonsil of hens was observed by V.R. Indu *et al*. (2020).

Thus, the results of the study confirm that in ducks the oesophageal tonsil is located in the mucous membrane of the caudal part of the oesophagus, where it is associated with longitudinal folds that contribute to widening of the oesophageal lumen during the passage of the bolus of feed. With increasing age, asynchronous and periodic changes are observed in the linear parameters of the tonsil, in particular its length, width, and the area of its lymphoid tissue, indicating a complex developmental process in this organ. In addition, changes in the morphology of the oesophageal tonsil, including the development of crypt-like structures, reflect the gradual maturation of this organ, which is important for effective immune protection in the early postnatal period in ducks.

Conclusions

The development and morphological changes of the oesophageal tonsil in ducks during the postnatal period of ontogenesis are important for understanding the functioning of the avian immune system. This organ in ducks aged 1 to 240 days in the postnatal period of ontogenesis is located in the caudal part of the oesophagus at the border with the glandular part of the stomach. Its site of localisation is the mucous membrane of the oesophagus, namely the lamina propria and the submucosa. Macroscopically, the tonsil was identified in 5-day-old ducks as a pale band. From 10 days of age, it took the form of a yellowish ring-shaped nodular band. The linear dimensions of the oesophageal tonsil increased with age, which is related not only to the physical growth of the ducks but also to the development of the lymphoid tissue of the oesophageal tonsil. In the region of the tonsil, thickening of the longitudinal folds of the oesophageal mucosa was observed in comparison with those in adjacent areas. Lymphoid cells were already found in the mucous membrane of the oesophagus in the region of the tonsil in day-old ducks, forming diffuse lymphoid tissue. Nodular levels of development of the lymphoid tissue appeared gradually. Lymphoid nodules without germinal centres were present in the lymphoid tissue of the tonsil in ducks at 10 days of age, and nodules with germinal centres appeared at 15 days of age, indicating maturity of the lymphoid tissue of the tonsil. The content of the components of lymphoid tissue changed with age. Diffuse lymphoid tissue reached its maximum in 30-day-old ducks and decreased by 240 days of age. The area of lymphoid nodules increased with age, especially that of nodules with germinal centres, but decreased after the onset of sexual maturity (180 days). This may indicate the beginning of involution of the oesophageal tonsil, which is typical of organs of haematopoiesis and lymphopoiesis. In the region of the oesophageal tonsil, structural changes occurred in the oesophageal glands and the excretory ducts. The epithelium was

infiltrated by lymphoid cells, transforming into lymphoepithelium. The secretory portions of the oesophageal glands and the ducts formed crypt-like structures opening onto the surface of the oesophagus. The patterns established – the development of the oesophageal tonsil and the components of its lymphoid tissue, the linear dimensions of the longitudinal folds of the tonsil and adjacent parts of the oesophagus, and the area of the oesophageal glands at different ages (1-240 days) in the early stages of the postnatal period of ontogenesis in Blagovarsky cross ducks – were characterised by asynchronicity and periodicity, which should be taken into account when planning vaccination strategies in poultry farming. To determine the age and characteristics of involution of the oesophageal tonsil, further studies in older ducks are needed. Such work is important for optimising preventive measures aimed at avoiding dangerous infectious diseases.

Acknowledgements

None.

Funding

The study was not funded.

Conflict of Interest

None.

References

[1] Akhand, A.A., & Ahsan, N. (2023). Cells and organs of the immune system. In M.T. Rahman, W. Teughels & J.R. Lamont (Eds.), *Immunology for dentistry* (pp. 1-12). Hoboken: John Wiley & Sons. doi: 10.1002/9781119893035.ch1.

[2] Ali, H.M., Ali, K.A., & Taha, A.M. (2023). Comparative anatomical, histological, and electron microscopical studies on the cervical region of the esophagus in some birds with different diet habits. *Journal of Advanced Veterinary Research*, 13(2), 181-187.

[3] ARRIVE. (n.d.). *ARRIVE guidelines*. Retrieved from https://arriveguidelines.org.

[4] Buhai, L.O. (2008). Peculiarities of the dynamics of macro-microscopic parameters of the esophageal spongy tissue of musk ducks in early postnatal ontogenesis. *Naukovyi Visnyk Lvivskoho Natsionalnoho Universytetu Veterynarnoi Medytsyny ta Biotekhnolohii Imeni S.Z. Gzhytskoho,* 2(37), 16-20.

[5] Capotă, R., Bostănaru-Iliescu, A.C., Ciauşu-Sliwa, D., & Năstasă, V. (2025). Insights into the avian immune system. *Romanian Journal of Veterinary Sciences*, 58(3), 454-462. doi: 10.59463/rjvs.2025.3.13.

[6] Casteleyn, C., Doom, M., Lambrechts, E., van den Broeck, W., Simoens, P., & Cornillie, P. (2010). Locations of gut-associated lymphoid tissue in the 3-month-old chicken: A review. *Avian Pathology*, 39(3), 143-150. doi: 10.1080/03079451003786105.

[7] Ceccopieri, C., & Madej, J.P. (2024). Chicken secondary lymphoid tissues – structure and relevance in immunological research. *Animals*, 14(16), article number 2439. doi: 10.3390/ani14162439.

[8] Davison, F. (2022). The importance of the avian immune system and its unique features. In B. Kaspers, K.A. Schat, T.W. Göbel & L. Vervelde (Eds.), *Avian immunology* (pp. 1-9). New York: Academic Press. doi: 10.1016/B978-0-12-818708-1.00010-5.

[9] Donmez, H.H., Eken, E., Besoluk, K., & Sur, E. (2012). The histological characteristics and localization of ACP and ANAE positive lymphocytes in the oesophageal tonsil of the duck (*Anas platyrhynchos*). *Avian Biology Research*, 5(1), 11-15. doi: 10.3184/175815512X13264771062961.

[10] DSTU EN ISO 13385-1:2018. (2018). *Technical requirements for geometric product parameters (GPS). Linear and angular measuring instruments. Part 1: Calipers. Design and metrological characteristics*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=80498.

[11] Dyshliuk, N.V. (2009). Development of the striated mycosis of chickens in the postnatal period of ontogenesis. *Bulletin of Dnipropetrovsk State Agricultural University*, 1, 115-118.

[12] El-Naseery, N.I., Mohammed, A.A., Abuel-Atta, A.A., & Ghonimi, W.A.M. (2021). Species-specific differences of the avian oesophagus: Histological and ultrastructural study. *Anatomia, Histologia, Embryologia,* 50(5), 788-800. doi: 10.1111/ahe.12721.

[13] OIE/WOAH. (n.d.). *Standarts*. Retrieved from https://www.woah.org/en/what-we-do/standards.

[14] Friedman, A., Elad, O., Cohen, I., & Bar Shira, E. (2012). The gut associated lymphoid system in the post-hatch chick: Dynamics of maternal IgA. *Israel Journal of Veterinary Medicine*, 67(2), 75-81.

[15] Guralska, S., Kot, T., Gryshuk, H., Zaika, S., & Dubovyi, A. (2023). Effect of chicken infectious bronchitis vaccine on morphogenesis and differentiation of cells in caecal tonsils. *Scientific Horizons*, 26(6), 9-21. doi: 10.48077/scihor6.2023.09.

[16] Hantusch, B. (2024). Morphological and functional characteristics of blood and lymphatic vessels. In M. Geiger (Ed.), *Fundamentals of vascular biology. Learning materials in biosciences* (pp. 1-50). Cham: Springer. doi: 10.1007/978-3-031-64591-4_1.

[17] Horalskyi, L.P., Khomych, V.T., & Kononskyi, O.I. (2015). *Fundamentals of histological techniques and morphofunctional methods of studies in norm and pathology*. Zhytomyr: Polissia.

[18] Indu, V.R., & Lucy, K.M. (2021). Histology and histochemistry of the oesophageal tonsils in White Leghorn chicken. *International Journal of Current Microbiology and Appied Sciences,* 10(6), 304-308. doi: 10.20546/ijcmas.2021.1006.032.

[19] Indu, V.R., Biju, S., Lucy, K.M., & Maya, S. (2020). Histological studies on the oesophageal tonsils of broiler ducks. *Journal of Food and Animal Sciences*, 1(1), 53-56. doi: 10.51128/jfas.2020.A010.

[20] Jamil, A., Hameed, I., Rizwan, M.U., Fiaz, M., Usmani, M.T., & Shoaib, M. (2024). Avian immune system unveiled: A comprehensive prospective. *THE PROGRESS: A Journal of Multidisciplinary Studies*, 5(4), 51-64. doi: 10.71016/tp/3d3njw68.

[21] Kadirova, L.V. (2024). Morphofunctional features of intestinal-associated lymphoid tissue. *International Journal of Integrative and Modern Medicine*, 2(6), 522-526.

[22] Khomych, V.T., & Usenko S.I. (2013). Morphology of the ostrich egg of ducks aged 25 to 120 days. *Scientific Bulletin of the National University of Bioresources and Natural Resources of Ukraine. Series: Veterinary Medicine, Quality and Safety of Animal Production,* 188(2), 193-197.

[23] Khomych, V.T., & Usenko, S.I. (2012). Morphofunctional features of the ostrich feathered crest of ducks in the early stages of the postnatal period of ontogenesis. *Bulletin of Zhytomyr National Agroecological University,* 3(2), 412-415.

[24] Law of Ukraine No. 3447-IV "On the Protection of Animals from Cruelty". (2006, February). Retrieved from https://zakon.rada.gov.ua/go/3447-15.

[25] Lestari, D., Murtini, S., Ulupi, N., Gunawan, A., & Sumantri, C. (2023). Flow cytometric evaluation of CD4+ and CD8+ T-cell in IPB-D2 chickens with different Newcastle disease antibody titers level. *Veterinary World*, 16(5), 1161-1164. doi: 10.14202/vetworld.2023.1161-1164.

[26] Logvinova, V., & Oliyar, A. (2021). Histoarchitectonics of lymphoid formations of the mucosa of the small intestine of muscy ducks. *Bulletin of Sumy National Agrarian University,* 1(52), 31-37. doi: 10.32845/bsnau.vet.2021.1.5.

[27] Mazur, N., & Dyshliuk, N. (2025). Morphological features of immune formations of the avian digestive tract. *Scientific Reports of the National University of Life and Environmental Sciences of Ukraine*, 21(5), 28-42. doi: 10.31548/dopovidi/5.2025.28.

[28] Mazurkevych, T., & Khomych, V. (2017). Location features of lymphoid tissue in immune formations of the intestine, meckel's diverticulum and apical diverticula walls in ducks. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Veterinary Sciences*, 19(82), 30-35. doi: 10.15421/nvlvet8207.

[29] Mehrzad, J., Shojaei, S., Keivan, F., Forouzanpour, D., Sepahvand, H., Kordi, A., & Hooshmand, P. (2024). Avian innate and adaptive immune components: A comprehensive review. *Journal of Poultry Sciences and Avian Diseases*, 2(3), 73-96. doi: 10.61838/kman.jpsad.2.3.7.

[30] Nagy, N., Igyárto, B., Magyar, A., Gazdag, E., Palya, V., & Oláh, I. (2005). Oesophageal tonsil of the chicken. *Acta Veterinaria Hungarica*, 53(2), 173-188. doi: 10.1556/AVet.53.2005.2.3.

[31] Oláh, I., Nagy, N., Magyar, A., & Palya, V. (2003). Esophageal tonsil: A novel gut-associated lymphoid organ. *Poultry Science,* 82(5), 767-770. doi: 10.1093/ps/82.5.767.

[32] Park, J.I., Cho, S.W., Kang, J.H., & Park, T.E. (2023). Intestinal Peyer's patches: Structure, function, and *in vitro* modeling. *Tissue Engineering and Regenerative Medicine*, 20(3), 341-353. doi: 10.1007/s13770-023-00543-y.

[33] Pendl, H., & Schmidt, R.E. (2024). Lymphatic and hematopoietic system. In R.E. Schmidt, J.D. Struthers & D.N. Phalen (Eds.), *Pathology of pet and aviary birds* (pp. 307-341). Hoboken: John Wiley & Sons. doi: 10.1002/9781119650522.ch9.

[34] Reznikov, O.H. (2003). General ethical principles of experiments on animals. The first National congress on bioethics. *Endocrinology*, 8(1), 142-145.

[35] Rochman, M., Kellerman, K., Jankowski, M.P., & Rothenberg, M.E. (2025). The oesophagus as an immune organ. *Nature Reviews Gastroenterology & Hepatology*, 22, 657-667. doi: 10.1038/s41575-025-01086-4.

[36] Tizard, I.R. (2024). *Veterinary immunology-E-book* (11th ed.). Amsterdam: Elsevier Health Sciences.

[37] Yıldırım, N. (2024). Histochemical and immunohistochemical investigations on pyloric tonsil in Turkeys (*Meleagris gallopavo*). *Ankara University Faculty of Veterinary Medicine Journal*, 71(3), 259-267. doi: 10.33988/auvfd.1242236.

[38] Zeinali, S., Sutton, K., & Vervelde, L. (2024). Distribution and spatiotemporal development of organised lymphoid tissues in the chicken intestinal tract. *Developmental & Comparative Immunology*, 151, article number 105096. doi: 10.1016/j.dci.2023.105096.

Закономірності формування лімфоїдної тканини стравохідного мигдалика в качок на ранніх етапах постнатального періоду онтогенезу

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Анотація. Актуальність дослідження стравохідного мигдалика качок на ранніх етапах постнатального періоду онтогенезу зумовлена необхідністю проведення аналізу становлення рівнів структурної організації його лімфоїдної тканини. У зв'язку з цим, метою дослідження було виявлення локалізації та форми лімфоїдної тканини стравохідного мигдалика бройлерних качок Благоварського кросу віком від 1 до 240 діб. Проводили морфометричні дослідження та визначали топографію стравохідного мигдалика у качок досліджуваних вікових груп. Фіксацію біологічного матеріалу проводили у 10 % розчині нейтрального формаліну. При проведені гістологічних досліджень виготовляли парафінові блоки на санному мікротомі та отримували гістозрізи, які зафарбовували для виявлення особливостей структури і площі тканинних компонентів стравохідного мигдалика. Встановлено, що стравохідний мигдалик у качок макроскопічно візуалізувався в ділянці переходу слизової оболонки каудальної частини стравоходу в залозисту частину шлунку. Зміни його довжини і ширини характеризувались асинхронністю. Лімфоїдна тканина стравохідного мигдалика до 5-добового віку качок представлена лише дифузною формою. У птахів віком 10 і більше діб з'являлися первинні і вторинні вузлики. На 15 добу стравохідний мигдалик набував морфофункціональної зрілості та характеризувався повністю сформованою лімфоїдною тканиною. У добових качок встановили інфільтрацію лімфоцитами залозистих відділів стравохідних залоз та вивідних проток. З віком

спостерігалося інтенсивне заселення лімфоїдними клітинами епітелію стравохідних залоз та вивідних проток. У результаті просвіти залоз звужувалися та перетворювалися на криптоподібні отвори, що відкриваються в просвіт стравоходу. Отримані дані щодо розвитку лімфоїдної тканини стравохідного мигдалика у бройлерних качок у початкові вікові фази можуть бути використані для оптимізації процесів вирощування, підвищення продуктивних показників і вдосконалення стратегій вакцинації з метою запобігання небезпечним інфекційним хворобам

Ключові слова: імунні утворення; лімфоїдні вузлики; морфометричні дослідження; свійська птиця; слизова оболонка стравоходу