

## Original researches

### Study of anatomical, histological and cytological characteristics of the thymus of lambs

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**Abstract.** Thymus of lambs of the Ouled-Djellal breed from eastern Algeria, aged one to 10 months, were used to study the anatomical, histological and cytological characteristics of these organs. Modern techniques have been used to demonstrate the morphometric parameters and masses of the thymus at different ages, a regression of the morphometric and mass indexes has been visualized according to the age of the lambs. Staining techniques with Hematoxylin and eosin revealed the normal structure of the thymus with its tissue components. The thymus is bilobed. The lobe is surrounded by a thin capsule and subdivided into lobules separated by septae, the cortical and medullary areas were clearly visible, the interlobular blood vessels enter the lobule in all its aspects to continue its way as interlobular blood vessels. From the changes observed in the involution of the thymus according to the age of the animals which occur relatively late, the percentage of the surface found for the capsule was very variable, which increases from the first to the tenth month, the demarcation of the cortex and the medulla beginning during the second month of age of the animal. The interlobular connective tissue (ILC) presents sums, the maximum of which was found in the fourth month of age of the animal, while the minimum was found in the thymus of ninth month lambs Concerning the Hassal corpuscles, their sums are in high extension until the tenth month, rich in T lymphocytes, whose use of immunohistochemistry, the anti-CD 157+ antibody allowed us to visualize to locate them clearly, which invade and form most of the thymus cortex. In conclusion, the significant changes in thymus development in sheep of the Ouled-Djellal breed are similar to those of other species.

**Keywords:** capsule; Hassal corpuscles; immunohistochemistry; lambs; mass; cortex; medulla; morphometric; T-lymphocytes.

### Анатомічні, гістологічні та цитологічні характеристики тимуса ягнят

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**Анотація.** Досліджено анатомічні, гістологічні і цитологічні особливості структурно-функціональної організації тимуса ягнят від 1- до 10-місячного віку породи Ouled-Djellal зі східної частини Алжиру. Сучасними методами визначено динаміку морфометричних параметрів і маси органа та процес його інволюції протягом раннього постнатального періоду онтогенезу. Мікроскопічну будову і співвідношення тканинних компонентів тимуса ягнят вивчали на тонких гістозрізах, забарвлених гематоксиліном і еозином. Тимус ягнят представлений двома частками, оточеними тонкою сполучнотканинною капсулою. Від капсули всередину органу відходять сполучнотканинні перетинки, які поділяють паренхіму на окремі часточки. У кожній часточці візуалізуються кіркова і мозкова зони. Ознаки інволюції у тимусі ягнят з'являлися відносно пізно, але посилювалися з віком. Відносна площа сполучнотканинної капсули тимуса поступово зростала з першого по десятий місяці життя тварин, проте значно варіювала. У часточках тимуса поділ на кіркову і мозкову зони відмічено починаючи з другого місяця. Відносна площа міжчасточкової сполучної тканини була максимальна у 4-місячних тварин, а мінімальна у 9-місячних. Кількість і відносна площа тимусних тілець поступово зростала протягом періоду дослідження. Імунгістохімічними методами з використанням анти-CD 157+ дозволило візуалізувати та чітко встановити розміщення Т-лімфоцитів. Установлено, що вони переважно формують кіркову зону часточок тимуса. Отже, морфогенез тимуса в овець породи Ouled-Djellal багато у чому аналогічний такому інших видів тварин, проте має свої особливості.

**Ключові слова:** капсула; тимусні тільця; імуногістохімія; ягнята; маса; кіркова і мозкова зона; морфометрія; Т-лімфоцити.

## Introduction

In mammals, the lymphatic system is made up of organized lymphoid structures, as cited by the authors (Datta et al., 2000), the thymus consists of two separate lobes, connected by an isthmus of connective tissue. This thin capsule surrounds each lobe and, in most species, gives rise to partitions which partially subdivide the thymus into interconnected lobules of varying size and orientation, the lobules are often of geometric shape. A dark peripheral area, the cortex, surrounds a paler central area, the medulla. Thin connective septa from the capsule pass through the cortex. In the medulla, globular multi cellular formations are often noted, the Hassal corpuscles. (Klenerman et al., 2017). The thymic frame consists of cross-linked epithelial cells between which evolve maturing T lymphocytes and macrophages (Moticka et al., 2016), in the superficial cortex, reticular epithelial cells or feeder cells are distinguished from lymphocytes only by their paler, ovoid nucleus, in the deep cortex, the reticular epithelial cells are involved in lymphocyte selection, the Hassal corpuscles, characteristic of the thymic medulla, consist of epithelial cells arranged concentrically in a bulb and undergoing a keratinization process from the periphery to the center, the outermost cells are less mature than the central cells loaded with keratin (Dijkstra et al., 1990). The immune system is thus able to respond to external stimuli intervening anywhere in the body.

Although current knowledge in immunology is largely based on studies carried out in mice and humans (Bodi et al., 2020), numerous experiments carried out on large domestic species such as sheep have largely contributed to the study of ontogeny and anatomy of the immune system, functioning of the thymus, as well as induction and regulation of the immune response in mammals (Mosby et al., 1997; Motika et al., 2016).

The thymus is essential for the formation and maintenance of the full operation of immunogenic system. Knowledge of the age characteristics of the structure and function of the organs of the immune system is necessary for breeders for the proper organization of preventive and therapeutic measures (Pearse et al., 2006). The need to saturate the market of food and industrial raw materials predetermines a further increase herd of livestock, increased productivity and improved product quality. This in turn requires an in-depth knowledge of the structural and functional organization of the organism as a whole and of its different parts, including the organs of the lymphoid system (Mikušová et al., 2017).

Our research consists in making a histological study of the functional zones of this organ and also its involution. The aim of which is to highlight the immunological status of the sheep of the Ouled Djellel breed in Algeria.

## Materials and methods

Thymus for research were collected from 50 clinically healthy lambs, 1 to 10 months of age, organ harvesting was carried out at the meat packing plant in Souk-Ahras (Algeria). The thymus are weighed with a high-precision Kern KB 0.001g electronic scale, the length and width are taken with the digital measuring ruler «Dasqua Professional IP67 600 mm», the data is entered in the notebook. The selected fragments were excised segmentally and fixed in 10% neutral buffered formalin solution. After fixation, part of the fragments (3 fragments each) of the thymus were embedded in paraffin (histoplast). Paraffin sections 3 to 5  $\mu$ m thick produced by a CUT 4062 microtome with manual rotation, staining with hematoxylin and eosin were also made. Immunohistochemical studies were performed by the direct method. Used CD157 + monoclonal antibodies were used to elucidate T lymphocytes in functional areas of the thymus, according to the technique cited by the author (Resendes et al., 2004). Reviews and data collection were

performed on a personal computer. Determination of histological and cytological features was performed using an eye microscope and an MBS-10 stereo microscope. The quantitative study of the tissue compartments was carried out using the S point system, the measurements of each ocular field were carried out in five fields of view of five histological sections of each histological slide. The data obtained were analyzed with the R program.

## Results

The dissection of the animal carcass at the slaughterhouse revealed that the thymus has two lobes and is located just above the heart, under the trachea. Lobulation is well pronounced in fetuses and newborns; from 6 to 8 months, it is gradually lost. It is relatively large at birth, for older lambs, it begins to decrease and becomes very small, includes the thoracic and cervical lobes connected by an isthmus. The cervical lobe has unpaired and paired parts. The lobulation of the gland depends on the age of the lambs and the degree of organ involution.

In day-old newborn lambs, the thymus has been found to consist of paired and unpaired (intermediate) cervical lobes and thoracic lobes. In 7-day-old lambs, twin cervical parts, the cranial part of which is much thicker, start from the laryngeal thyroid cartilage and are located along the trachea. At the level of 3–4 cervical vertebrae, before entering the thoracic cavity, they merge into an unpaired (intermediate) cervical lobe, which is connected by an isthmus to the unpaired thoracic lobe and has an irregular triangular shape.

The unpaired thoracic lobe is located on the left in the atrial mediastinum, in contact with the base of the heart, as well as with the cranial surface of the handle of the sternum and extends to the third rib. Most of the thymus is closed by the cranial lobes of the lungs. The unpaired cervical and thoracic lobes are larger than the paired cervical thymus lobes.

On the other hand, for older lambs, it was found that the thymus has a paired cervical part, located on the sides of the trachea of the larynx, and an unpaired thoracic, located in the thoracic cavity in front of the heart, more deepened, we were able to determine that the thymus includes the cervical and thoracic sections, connected by a thin isthmus, which was not detected in all subjects. The cervical section is the largest; the pinkish color gives the impression of an unpaired medium lobe. The pairs of cervical lobes that leave it reach the submandibular salivary glands and are differentiated by their color.

Also it has been noticed that the color of the thymus in young animals is pale pink and it is gray-yellow in older lambs. The coloration in the thymus of lambs of the first month of age varies from weak pink to gray yellow (Fig. 1).

It has been noted that the cervical and thoracic border is located between the last cervical segment and the first thoracic segment. The thoracic thymus has a somewhat irregular shape, composed of lobes of different sizes, located in the cranial mediastinum, anterior to the base of the heart, with a ventral side adjacent to the sternum.

The age-related morphological characteristics of the thymus have been well defined, the mass and linear characteristics of the gland in lambs at all times prevail over the same gland indicators in sheep.

Concerning the study of the thymus mass, our results show that the lambs in the thymus of lambs of the first month of age, have a mass of  $7.3 \pm 0.06$  g, this mass begins to decrease around the second month and reaches  $6.4 \pm 0.87$  g, which is significant as results for the third month of lambs, arriving at the mass of  $6.5 \pm 1.36$  g. a drop in the mass figure also found for the fourth and fifth group of lambs, aged 04 and 05 months, from which it reached  $5.3 \pm 0.13$  g and  $4.1 \pm 0.46$  g.

For the group of lambs aged 6, 7 and 8 months, the mass is falling clearly visible and which reaches  $3.1 \pm 0.79$  g,  $2.8 \pm 0.52$ g



**Fig. 1.** Anatomical structure of the lamb's thymus, aged 5 months

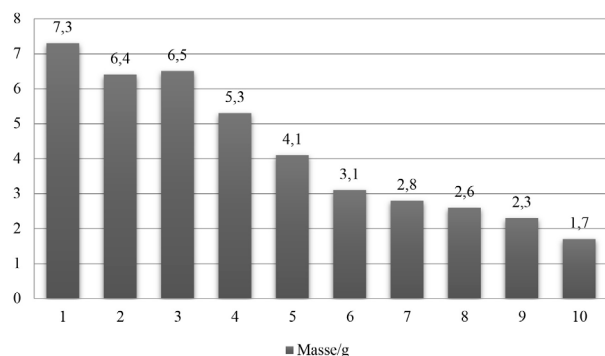
and  $2.6 \pm 0.55$ g, simultaneously. On the other hand, more significant results of the fall in the mass of the thymus of the lambs also noticed in the groups of lambs of the ninth and tenth months of age and presented  $2.3 \pm 0.49$  g and  $1.7 \pm 0.94$  g simultaneously. We deduce that the thymus of this breed acquires the anatomical form of a completely formed organ at the age of sixty days of the period of fetal development. The mass of the thymus is characterized by high dynamism and great individual variability during all periods of pre and postnatal ontogenesis. It reaches its maximum values at the age of eight months of the postnatal development period, and then there is a decrease in absolute and relative mass and, at the age of two, a reduction in the thymus (Fig. 2).

For them the size of the thymus during individual life varies considerably. The relative magnitude of the thymus is greatest in newborn animals; the absolute is at puberty. After that, the thymus gradually atrophies, its tissue is replaced by lipocysts, but the inversion of the thymus is not complete.

Morphometric examination of lambs, aged one and two months, showed a slight decrease in length, from  $4.5 \pm 0.16$  cm to  $4.2 \pm 0.27$  cm, then a slight increase was observed in animals three months old and up to  $4.3 \pm 0.78$  cm. On the other hand, we could see that the length of these organs decreases in the fourth, fifth, sixth and seventh months of age and have the following values:  $3.9 \pm 0.26$  cm,  $3.7 \pm 0.71$  cm,  $3.5 \pm 0.34$  cm and  $3.4 \pm 0.83$  cm simultaneously.

For the results of thymus width of lambs, our research showed a decrease in the value of the first and second month from  $2.3 \pm 0.51$  cm to  $2.1 \pm 0.53$  cm, in contrast, a slight increase in this value that affects the third and fourth month of age and reaches  $1.4 \pm 0.96$  cm  $2.3 \pm 0.87$  cm simultaneously. Looking at the length of the thymus from the eighth month of age, an increase in this value is  $4.5 \pm 0.34$  cm, then this value drops in the ninth and tenth month of age and reaches  $3.8 \pm 0.62$  cm and  $1.4 \pm 0.25$  cm (Fig. 3).

It was also found that a slight decrease in width, also was



**Fig. 2.** Dynamics of thymus mass of lambs in the postnatal period of ontogeny (month, g)

detected at the age of the fifth month and reached  $1.8 \pm 0.39$  cm in width. This value increases in organs by six months and reaches the value of  $2.4 \pm 0.56$  cm.

Concerning the groups of animals aged 7, 8, 9 and 10 months, the value of the width decreases and reaches a minimum threshold of  $0.9 \pm 0.33$  cm in lambs aged ten months; it is  $2.1 \pm 0.38$  cm in the thymuses of seven month old lambs,  $1.8 \pm 0.89$  cm and  $1.2 \pm 0.72$  cm in the thymus of eight and nine month old lambs 'age.

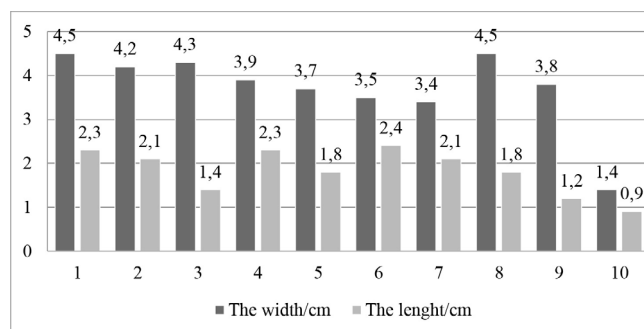
Examination with an optical microscope showed us that the cortex forms the peripheral part of the thymus lobes, filling the lumens of the reticular epithelial skeleton densely. In the sub capsular area of the cortical substance there are large lymphoid cells and they penetrate to the bottom of the organ. The thymus is divided into segments (structural units of the thymus) by connective tissue septa (trabeculae) extending from the capsule. In the lobules, the cortical and cerebral regions are easily distinguished.

The cortical area is somehow delimited by a cell barrier, which differentiates from the cortical substance. It is made up of pericapillary endothelial cells, also the basement membrane also found in the cortical area in the thymus of the second month, sometimes extra-medullary foci appear in the cortex. In newborn animals, at the level of the cortical region, a distinction is made between the subcapsular zone of the deep bark and the cortico-medullary zone, it has been observed that the trabeculae share only the cortical region, the medullary zone is common to all lobules. Through the door, called the cortico-medullary joint, the arteries and nerves enter the thymus, the veins and lymphatic vessels exit. Capillaries branch off from the inter-lobular arteries, which are more numerous in the cortical region. The capillary lymphatic network is also denser in the cortical zone (Fig. 4).

It has been noted that the thymus is divided into segments (structural units of the thymus) by septa of the connective tissue (trabeculae) extending from the capsule. In the lobules, the cortical and medullary regions, which are easily distinguished on the blades of lambs of the first aged, in the cortical zone, there is a distinction between the sub capsular zone of the deep cortex and the cortico-medullary zone. On the one hand, it has been noted that the trabeculae share only the cortical area, while the medullary area is common to all lobules. The network of lymphatic capillaries is denser in the cortical area.

We could not elucidate in the thymus, a peripheral germinal center, in the medullary zone, there are Hassall corpuscles and in the cortical region, nourishing cells in mitosis are detected too. It has been noted that Hassall corpuscles are also found in the medullary zone. The number of these bodies increases with the age of the lambs.

At the level of histological sections of the thymus of older lambs, it was also possible to detect each lobe is enveloped in a fibrous capsule. From the inner side of this capsule, there are conjunctive



**Fig. 3.** Dynamics of the morphometry (length, width) of the thymus of lambs in the postnatal period of ontogeny (month, cm)



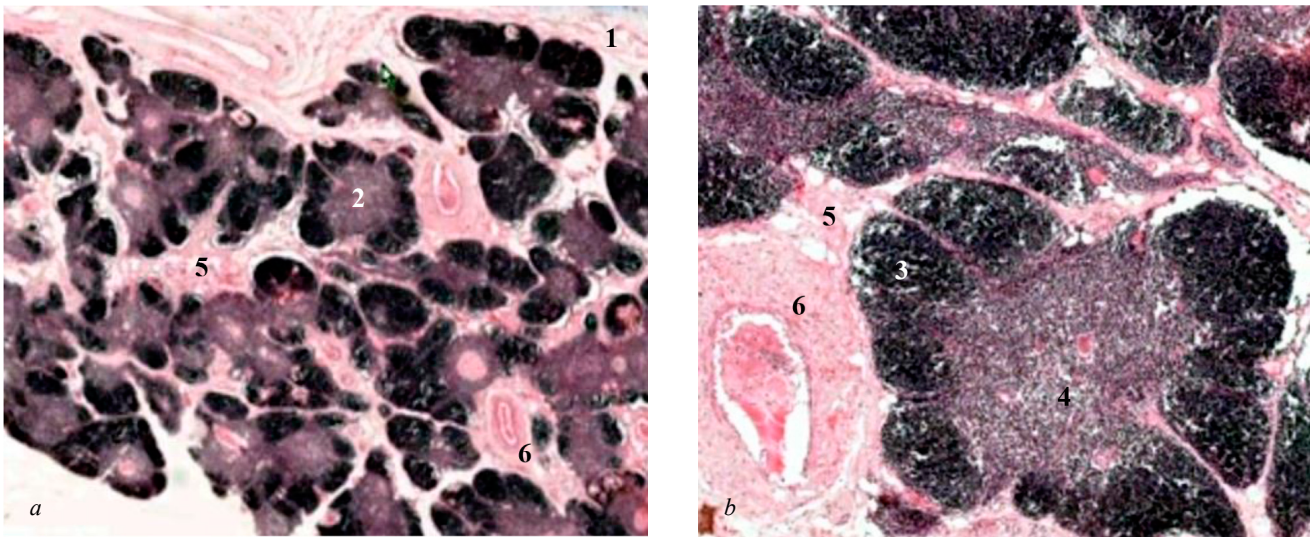


Fig. 4. Histological section of the thymus lamb 05 months old. Hematoxylin and eosin staining. a –  $\times 40$ ; b –  $\times 100$ . 1 – capsule, 2 – lobules of the thymus, 3 – cortical zone, 4 – medullary zone, 5 – inter lobular connective tissue, 6 – blood vessels.

septas which sink more or less deeply into the parenchyma and divide it into numerous lobules. The septae and the perivascular spaces and the single invasive cells. These elements separate the thymus into pseudo lobules. The epithelial space of the thymus and the perivascular spaces are always separated by a layer of closed and flat epithelial cells, with a basal lamina which contributes to the blood-thymic barrier.

Also it was noted that in the thymus, the partitions separate from the interior of the body, dividing the gland into lobules. In each lobule, there is a cortex and a medulla. The body is based on epithelial tissue, composed of epithelial cells. The location of Hassall corpuscles differs by their shape and size, their tinctorial signs, their density and their inclusions. Image also showed us also several lobules in a fragment of lobe. Each lobule includes a dark peripheral zone, the cortex, and a clear central region which is the medulla in which there are small zones colored in red, the Hassall corpuscles. The interlobular connective septas only isolate the cortical region, so that the medullary zone of a lobule extends into the medulla of its neighbors (Fig. 5).

In the parenchyma, a dense network of reticular fibers was found. In each lobule, which differs in size, the cortex and medullary zone, also differ in location and can reach an almost equal sum for the two tissue components. The base of the lobule is a loose network of sponge-like star-shaped epithelial cells. The corpuscles are infiltrated by T lymphocytes with an optically dense round nucleus and a narrow basophilic cytoplasm.

Microscopic examination also showed that in the medulla there are layered epithelial bodies formed of reticular epithelial cells with concentric layers, the cytoplasm of which contains large vacuoles and bundles of fibrils. It was also noted that the medulla substance has a lighter color due to the predominance of the reticular epithelial base. The characteristic formations of the medullary zone are in concentric star-shaped epithelial clusters. In the cortical layer of Hassall corpuscle are missing. In addition, in the medullary area there are large epithelial cells (Fig. 5).

Microscopic observation tells us that the inter-lobular connective tissue limits the vessels and fills the spaces between the individual lobes of the thymus. Each lobule includes a peripheral cortex. The

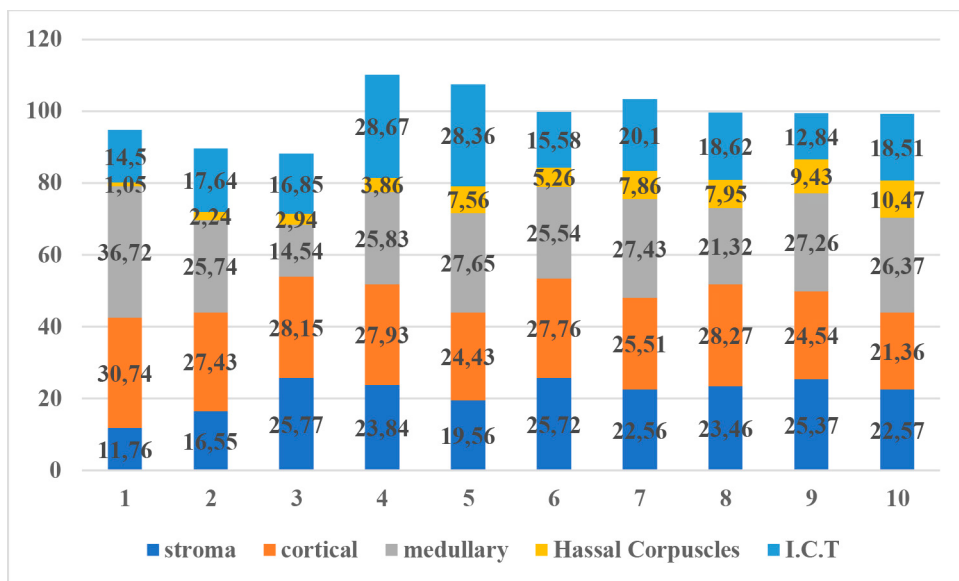
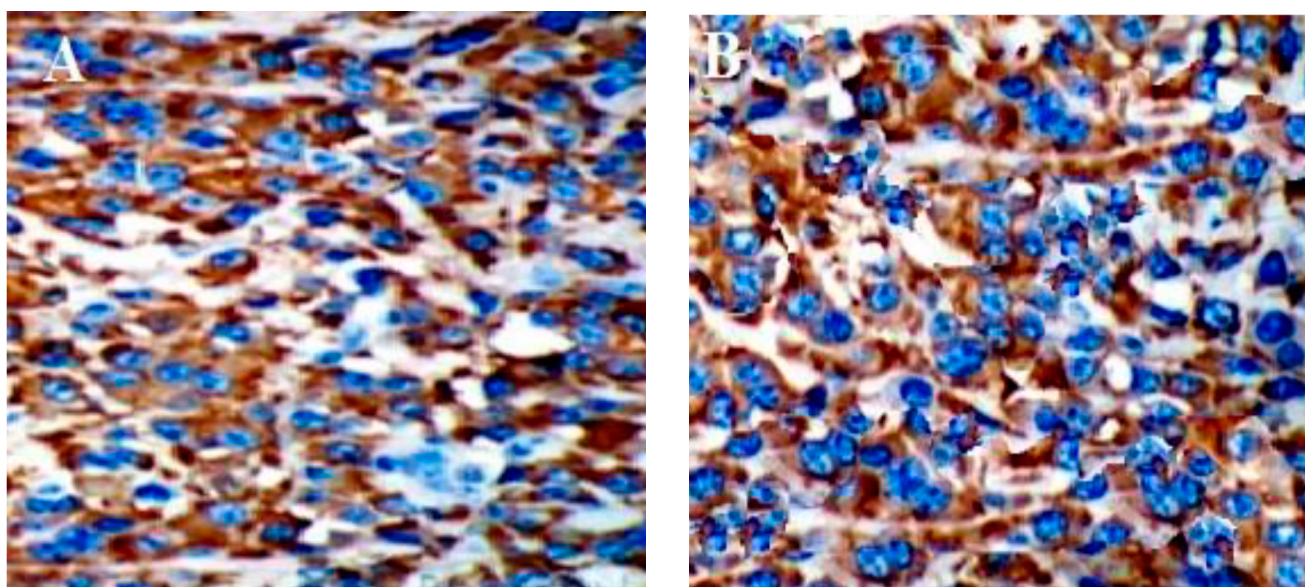


Fig. 5. Relative area dynamics of thymus tissue composition of lambs in the postnatal period of ontogeny



**Fig. 6.** Lymphocytes detected in the thymus of the lamb of the (A) fifth and (B) tenth month. Immunohistochemical reaction with anti-CD57 +

lower density is the vessels and the number of reticular epithelial cells, we also find specific Hassall corpuscle, also the organ differentiates into medullary and cortical parts, they are infiltrated by cell spans and the epithelial structure typical of the face becomes difficult to distinguish. The epithelial cells are spread apart and remain connected to each other only by intercellular bridges, taking the form of a loose network. In the stroma of the medullary area, particular structures appear, forming Hassall corpuscle.

The cortex is inversely rich in reticular tissue, there are more epithelial reticular cells. They form a support network by interconnecting the ends of their cytoplasmic protuberances. In addition, in the parenchyma, we found the blood vessel and a Hassall corpuscle, made up of concentric layers of reticular cells, these reticular cells exhibit hyaline and keratin degeneration.

At the peripheral zone, the network is completed by a continuous foundation of flattened reticular tissue separated from the connective tissue of the capsule, septae and perivascular spaces by a basement membrane. The cortical meshes contain the Hassall corpuscle.

The medullary meshes shelter a population of polymorphic tissue, also including Hassall corpuscle, other observations held by the visualization of epithelial tissue of the thymic framework, are recognized thanks to the layer of voluminous and clear reticulum

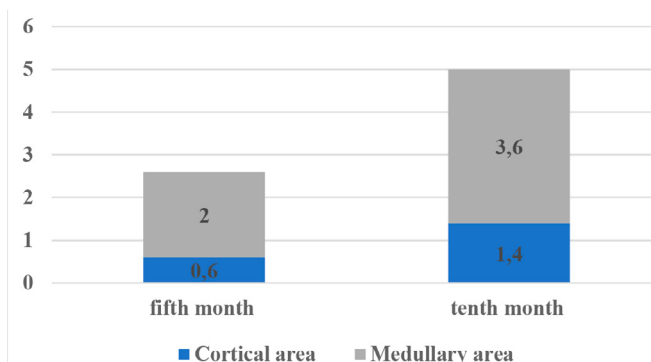
which contrasts. We also note that the epithelial component is more important in the medullary cord, than in the cortex, so it has been observed that Hassall corpuscle formation results from the accumulation of flattened epithelial tissue of secret type.

After analyzing the studies of statistical data of the different compartments of the thymus, we could see that the stroma, which is composed of capsule and trabecula, has a percentage of  $25.77 \pm 1.42\%$ , which is a maximum value in thymus cells of one-month-old lambs and the minimum sum was found to be  $11.76 \pm 1.07\%$ , in two-month-old lambs this sum is at most  $25.72 \pm 1.96\%$  and at minimum of  $22.56 \pm 1.66\%$ , which led us to conclude that the stroma component is variable for all age groups. Regarding the cortical area, the large areas are visualized is  $30.74 \pm 1.51\%$ , while it is minimal, is  $27.43 \pm 1.74\%$ , in the thymus of animals aged two months, we found that these values change to  $28.27 \pm 1.55\%$ , which is a maximum value, while it is minimum of  $21.36 \pm 1.53\%$

When examining the medullary zone, the values obtained are maximum in the thymus of one-month-old lambs, which reached the sum of  $36.72 \pm 1.11\%$ , this sum can reach a value of  $14.83 \pm 1, 58\%$  which is a minimum rate. For two-month-old animals, the maximum sum was found to be  $21.32 \pm 1.71\%$ , while the minimum value is  $27.26 \pm 1.39\%$ . For Hassall's corpuscles of thymus from the first month old lambs, it was found that their quantities are  $1.05 \pm 2.98\%$ , which has the minimum value, while the maximum sum is  $3.86 \pm 2,71\%$ , in the thymuses of two-month-old animals, it was observed that the quantity of Hassall corpuscles reached its maximum and  $10.47 \pm 0,98\%$ , while the minimum was  $5.86 \pm 0, 92\%$ , these values increase in value in the thymus of one month old animals in the second month of thymus of lambs.

The interlobular connective tissues (ILC) of the thymus, according to their positions, whether it is the ILC of the cortical zone or the ILC of the medullary zone, were visualized and calculated as follows, a maximum sum of  $28.67 \pm 1.79\%$ , found in thymus of 04 month old lambs, this value is a minimum of  $14.5 \pm 1.75\%$  also found in thymus of one month old lambs. Concerning the thymuses of lambs aged 2 months, a sum of  $20.1 \pm 1.34\%$  and  $12.84 \pm 1.49\%$  for the thymuses of lambs of the ninth month of age.

In summary, the surface of the gland is covered with a capsule of connective tissue, from which leave trabeculae which divide the



**Fig. 7.** Graph of the number of lymphocytes located in the functional areas of the thymus of lambs / unit



parenchyma of the organ into lobes. At the time of physiological maturity, the ratio of structures changes in the direction of an increase in the stroma and a decrease in the parenchyma component.

The immunohistochemically method, which detects T lymphocytes, allowed us to identify them in histological sections, due to the unevenly brown coloration of the cytoplasm on the background of the lymphocytes of the thymus segments of blue color. These cells are located in all the morpho-functional areas of the thymus, in the cortical and medullary area of the thymus lobes, as well as at the border of the cortex of the lobules, the morphometry of these cells is not the same (Fig. 6).

At high magnification, you could see the shape of the lymphocytes, they are round and not very polygonal. In the thymus of animals of the fifth month, lymphocytes are found mainly in the cortical zone, their number is  $0.60 \pm 0.05$  cells in the field of view, while in the medullary zone it is  $2.00 \pm 0.20$  cells in the field of view. Analysis of allows us to identify a tendency to increase the number of lymphocytes.

Thus, the number of lymphocytes in the cortical zone of the lobules of the thymus of lambs of the tenth month of age, in the field of view increases to  $1.40 \pm 0.09$ , more than 2 times. At the limits of the medullary zone of the lobules of the thymus, the number reaches  $3.60 \pm 0.50$ , the number of lymphocytes in the field of view increases proportionally. Thymic bodies are well defined here, also thymocytes in this area have medium and small lymphocyte morphology, have a high degree of distinct differentiation (Fig. 7).

## Discussion

The results show that the thymus of lambs has two lobes and is located just above the heart, below the trachea. Lobulation is well pronounced in newborns; from 6 to 8 months, it is gradually lost. It is relatively large at birth, for older lambs it begins to shrink and becomes very small, includes the thoracic and cervical lobes connected by an isthmus. The cervical lobe has unpaired and paired parts. Similar results have been provided by researchers for other animals such as birds, the thymus is also located in the neck, it is located parallel to the vagus nerve and the jugular vein (Kareem, 2017). On either side of the neck there are 7-8 separate lobules extending from the third cervical vertebra to the upper thoracic segment. Each lobule is enclosed in a thin capsule of fibrous connective tissue and is surrounded by fatty tissue. From the capsule, the septum invades the parenchyma of the thymus and partially divides it into lobes. The bud or bean-shaped part of the thymus reaches a maximum value of 6-12 mm in diameter at the age of 3-4 months, then undergoes involution, these data correspond to the results of the researchers (Kanasiya et al., 2017).

Other researchers find that the thymus of calves and lambs have two paired cervical parts (right and left), an unpaired (intermediate) and unpaired cervical thoracic. The pairs of cervical parts of the larynx of the thyroid cartilage are placed along the trachea and, before entering the thoracic cavity, merge into an unpaired (intermediate) cervical part connected by an isthmus to the unpaired thoracic square shape with a part located on the left in the anterior mediastinum. It was also noted that researchers have discovered that in newborn piglets, such as calves, the thymus is made up of two paired particles and one unpaired particle. Thoracic thymus contained in the left pericardial mediastinum according to (Priem et al., 2001; Lieshchova & Gavrilin, 2020).

In foals, the thymus is thick, rounded in shape and located in the chest cavity below the trachea, reaching the nucleus and protruding slightly from the first rib according to (Weller et al., 2012; König et al., 2020). Authors note that in puppies, the thymus is small and contained in the chest cavity, reaching 6 ribs. The neck is negligible. It is several millimeters long and is contained neutral in the trachea just before the entrance to the chest cavity at the base of the heart.

The thoracic part of the thymus, occupying 2/3 of the ventral part of the pericardial mediastinum. It touches the cranial surface of the sternum and consists of a right particle, located from the skull to the pericardium, and a more elongated left particle, which reaches the ridges, the medial, most of the thymus closes the lobes of the lungs according to (Gasparri et al., 2016). The authors' research results Gasparri et al. (2016) show that the thymus of the African rhino is similar to a vascular tree adorned with small glandular lobules. Many marsupials have multiple thymus paired cervical thymus (formed from the third gill pouch) and mammary thymus (formed from the fourth and fifth pouch). The structure and function of the thymus in marsupial and placental animals appear to be similar.

According to our research, the morphological features of the thymus in lambs related to the age of the thymus were well defined, mass and linear features prevail at all times over the same indicators of the gland in sheep, as has been described. by other authors (Kareem, 2017). Lobulation of the gland depends on the age of the lambs and the degree of organ involution.

The cervical section is the largest; the pinkish color gives the impression of an unpaired middle lobe. The pairs of cervical lobes which leave it reach the submandibular salivary glands and are differentiated by their color, studies on thymus color have been found in the research of (Abdulkarimi et al., 2011), which mention that the staining depends on the age of the animal.

Our results were similar to the work of (Chaurasia et al., 2019), who mentioned that the cortex forms the peripheral part of the thymus lobes, densely filling the lumens of the reticular epithelial skeleton. In the subcapsular area of the cortical substance there are large lymphoid cells and they penetrate to the bottom of the organ, so it is divided into segments (structural units of the thymus) by connective tissue septa (trabeculae) extending from the capsule. In the lobules, the cortical and cerebral regions are easily distinguished according to (Pearse, 2006). The cortical area is somehow delimited by a cellular barrier, which is differentiated from the cortical substance. It consists of peri-capillary endothelial cells, also the basement membrane found also in the cortical zone of the thymus of the 02-month age group, sometimes extra-medullary foci appear in the cortex, similar studies carried out on goats by the author (Taniuchi., 2015).

In newborn animals, at the level of the cortical region, a distinction is made between the subcapsular zone of the deep bark and the cortico-medullary zone, it was observed that the trabeculae only share the cortical region, the medullary area is common to all lobules. Through the gate, called the cortico-medullary joint, arteries and nerves enter the thymus, veins and lymphatics exit. The capillaries start from the interlobular arteries, which are more numerous in the cortical region. The capillary lymphatic network is also denser in the cortical area, which has been described by researchers (Goldstein et al., 2016; Salkova et al., 2017).

According to researchers (Lio et al., 2011) demonstrate that thymus formation in ontogeny occurs before other organs of the lymphoid system and endocrine glands. In humans, a basic organ in the form of paired epithelial cords is detected by the 4th week of intrauterine development. In the early stages of development, paired strands of multi-layered epithelium are surrounded by mesenchymal cells, which are thought to migrate from the neural crest. From these cells a capsule, interlobular septa and reticular tissue of the thymus develop. At the initial stage of development, the epithelial region of the thymus in the cervical part presents a lumen of the thymopharyngeal duct, which subsequently usually becomes obstructed.

According to research by (Sivan et al., 2013), who also demonstrated that the stromal elements of mesodermal origin are capillaries, septa and perivascular spaces and single invasive cells.

It was also noted that in the thymus the septa separate from the inside of the body, dividing the gland into lobules. In each lobule there is a cortex and a medulla. The body is based on epithelial

tissue, made up of epithelial cells, research has been done on the rabbit by the authors (Khaleel et al., 2018), who found the same results.

The localization of Hassall's corpuscles differs in shape and size, density and inclusions, each lobule includes a dark peripheral area, the cortex, and a clear central region which is the spinal cord in which there are small colored areas in red, Hassall's corpuscles. The interlobular connective septas isolate only the cortical region, so that the medullary zone of one lobule extends into the neighboring medullary zone, results similar to the research of (Chaurasia et al., 2018), On the thymus of goats.

In the parenchyma, a dense network of reticular fibers was found. In each lobule, which is different in size, the cortex and spinal cord also differ in their location and can amount to almost equal sum for the two tissue components. The base of the lobule is a loose network of sponge-shaped star-shaped epithelial cells as cited by the authors (Kalhor et Moran., 2019).

Immunohistochemistry detected T lymphocytes, identify cells, located in all morpho-functional areas of the thymus, in the cortical and medullary area of the thymus lobes, as well as at the edge of the lobule cortex, the morphometry of these cells is not the same, results made pat (Kannan et al., 2016), on chicken thymus, they found the same results as ours.

The shape of the lymphocytes was round and not very polygonal. In the thymus of first month old lambs, lymphocytes are mainly found in the cortical zone, data found in research from (Ceylan & Alabay, 2017), report almost similar results in pigs. Thus, the number of lymphocytes in the cortical area of the thymus lobules of lambs of the second month of age. At the limits of the medullary zone of the lobules of the thymus, the number of lymphocytes in the field of view increases proportionally, recherches found by (Mikušová et al., 2017), thymic bodies are also defined herein, also the thymocytes of this zone have a morphology of medium and small lymphocytes, have a high degree of differentiation, according to (Palumbo, 2008), in the medullary zone of the thymus, thymocytes undergo antigen-dependent maturation. This area is formed by a dense network of epithelial reticulocytes and its cells are small.

### Conclusion

The study of the morphological characteristics of the thymus of lambs revealed a decrease in the indexes of the parameters according to the age of the animal. As well for the length as for the width, concerning the mass, it took a descent of the indexes. The histological structure of the thymus of lambs appears very lobulated, surrounded by a capsule of loose connective tissue from which short septa emerge containing the blood vessels, penetrating deeply. The thymic parenchyma is divided into two distinct areas, a dense outer layer, the cortex, and an inner, faintly colored area, the medulla. Statistically, the percentage of the tissue composition of the different areas of the thymus varies according to the age of the animal, a clearly visible regression of the indexes was noticed, the T lymphocytes grouped in all the areas of the thymus with predominance of the cortical area, this The latter is rich in Hassall corpuscles, the numbers of which were very high in the thymus of tenth month lambs. Our research was carried out for future studies in medical disciplines with the aim of improving the fields of research in immunology and infectious pathology.

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