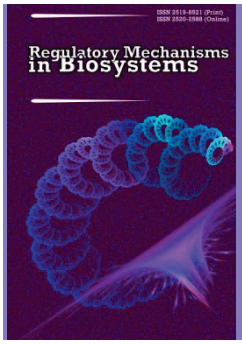

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Peculiarities of histological structure of some organs of serotine bat (*Eptesicus serotinus*)

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Chiroptera is the only group of mammals that is able to fly. They are beneficial for people and ecosystem they live in. In Ukraine, all species of bats are rare or endangered, in particular serotine bat (*Eptesicus serotinus* Schreber, 1774). So as to prevent the extinction of currently existing species of bats, it is crucial to combat their diseases, in particular improve diagnostics, including postmortem diagnostics. At the macroscopic and microscopic levels, morphology of bats has still been studied poorly, especially such of bats that live in Ukraine. Besides, knowledge of the structure of various organs of bats at macroscopic and microscopic levels is necessary for effective pathoanatomic diagnostics of their diseases. We researched the normal histological structure of some organs of *E. serotinus*. For this purpose, we used four corpses of this animal, which had previously died as a result of their disturbance during winter hibernation. We carried out a histological study, for which we sampled organs such as the liver, kidneys, lungs, heart, subcutaneous gland, and spleen. From the samples, we prepared histological sections and stained them with hematoxylin eosin. We described the general patterns of microscopic structure of the said organs of serotine bat. We found that microscopic structure of all the examined organs was similar to that of mammals in general. At the same time, we did observe some peculiarities of the histological structure of the studied organs, especially lungs, compared with such of other mammals, particularly: poor degree of development of the stroma, compact arrangement of parenchyma elements in the parenchyma-structure organs, large variability of sizes of alveolar lumens in the lungs. We assume that those peculiarities had emerged because of bats' adaptation for flight. We believe that it is promising to continue research of microscopic structure of various organs of E. serotinus, as well as other bats living in Ukraine and around the globe.

Keywords: Chiroptera; bats; microscopic changes; liver; lungs; heart; subcutaneous gland; spleen.

Introduction

Chiroptera is an order of mammals living all around the world, except Arctic and Antarctic latitudes (Hutson et al., 2023). They are the only mammals capable of active flight. Bats are an integral component of biotopes where they live (Novaes et al., 2023; Poma-Urey et al., 2023). Furthermore, most bats feed on insects, i.e. live as predators. For human activity, in particular agriculture and forestland economy, bats are beneficial, since the insects they consume are pests of trees, agricultural crops, and also blood-sucking insects that are carriers of diseases of animals and people (Basukriadi et al., 2021; Luciano et al., 2022). As a result of man-caused mass extinction of biotopes where bats live, all the existing species of bats are rare or endangered, included in the International Red Book, as well as red books of countries where certain species live. *Eptesicus serotinus* Schreber, 1774 is also a rare red-book species (Chervona Knyga Ukrainy, 2009). All species of bats living in Ukraine are considered rare or endangered, and therefore included in the Red Book of Ukraine. *Eptesicus serotinus* is a species of mammals of the Chiroptera order, Vespertilionidae family, common in Eurasia, in particular in Ukraine (Tiede et al., 2020; Hutson et al., 2023).

To preserve the existing species and save them from extinction, it is important to monitor diseases of bats, diagnose and combat them (Kirejczyk et al., 2021). For cases involving bat deaths, postmortem diagnostics such as necropsy and histopathological studies are conducted to determine diseases they suffered while alive (Farina et al., 2018). To identify pathological changes in the tissues of bat corpses, it is necessary to know the normal histological structure of their every organ (Mühldorfer et al., 2011). However, there are very few reports of microscopic examinations of bats' internal organs. Most of those studies focused on structure of the digestive organs, because it varies depending on nutrition of bats – insect- or plant-eating (Aylward et al., 2018; Moiseienko & Vlaschenko, 2021). In-detail studies were conducted for anatomical and histological structures of thoracic limbs of bats (Ahmad et al., 2022; Zou et al., 2022). Interest of scientists to structure of the thoracic limb of bats is understandable, since it had transformed into a wing and is an adaptation for flight, and no mammals of other taxonomic orders have such transformations. There are very little data about the structure of organs of parenchymal structure (Cardoso et al., 2023). Moreover, most reports presenting results of researching morphology of certain organs of bats at the microscopic level had dealt with tropical bats (Geronimo et al., 2023). As with *E. serotinus*, there are no literature data with descriptions of microscopic structure of the organs of this animal. Available reports contain studies of biological and ecological aspects of life of *E. serotinus*, but not its morphology (Tiede et al., 2020; Garg et al., 2023).

Most of the studies related to the anatomy of Chiroptera focused on macroscopic structure of the skull and teeth (Abdel-Hamid & Alqahtani, 2022), wings (Ahmad et al., 2022), auditory organs (Tarnovsky et al., 2023), heart (Corduneanu et al., 2021; Rahma et al., 2021), digestion organs (Yani & Yuliyantika, 2019), specifically the oral cavity, tongue (Gregorin & Zanatta, 2021), gastrointernal tract (Selim & El Nahas, 2015; Strobel et al., 2015); and respiratory pathways (Smith et al., 2021; Håkansson et al., 2022). At the microscopic level, normal microstructure was stu-

died for digestive organs (Paksuz, 2014; Silva et al., 2020), sexual apparatus (Danmaigoro et al., 2014; Jubilato et al., 2019; Abiaezute et al., 2020; Oguejiofor et al., 2020; Sohn et al., 2020), mostly of males, and also the skin (De Souza Suguiura et al., 2023). Some studies focused on structure of the lungs (Ojuolape et al., 2016), kidneys, and spleen. The mentioned studies were mostly comparative-morphological.

There are reports in the sphere of physiology, biochemistry (Peng et al., 2019; Ramos et al., 2020), and microbiology (Corduneanu et al., 2021; Luna et al., 2023) of bats. Many sources focused on diseases of bats and their diagnostics, in particular histopathological. Changes were examined during dermatitides (Boone et al., 2021; De Souza Suguiura et al., 2023), diseases of parasitic etiology (Adhikari et al., 2020; Fernandes et al., 2022; Gugnani & Denning, 2023), viral infections (Irving et al., 2021; Kohl et al., 2021; Jones et al., 2023), including paramixovirus (Haas & Lee, 2023), rabies (Folly et al., 2021), and infections of other etiology (Fritze et al., 2019; Colunga-Salas et al., 2021). Mentions of *E. serotinus* are found only in general reviews of pathologies. Therefore, we believe that studies, the results of which are presented in this paper, are relevant and can be informative for researchers in the spheres of zoology and veterinary medicine who are studying Chiroptera.

Materials and methods

The study was performed in 2022–2023 at the Department of Anatomy, Histology, and Pathomorphology of Animals named after V. H. Kasianenko of the National University of Life and Environmental Sciences of Ukraine (Kyiv). The material was sampled from the corpses of the examined animal and further treated according to the ethic norms of the international and Ukrainian legislations. The material for the study comprised of corpses of three males and females of *E. serotinus*, which were already deceased when delivered to the Chiroptera Rehabilitation Center (Kyiv); according to the preliminary data, the animals had died as a result of interrupted winter hibernation. To identify the cause of death of the animals, we performed pathoanatomic necropsy of the corpses using the method of complete evisceration. For the histological study, we sampled the liver, spleen, kidneys, lungs, myocardium, and subcutaneous gland (if those organs were observed to have no visible macroscopic changes).

The material obtained was fixated in 10% buffered solution of formalin according to Lillie (1969), and then the samples were engulfed in paraffin. We prepared 5 μm paraffin sections, and stained them with ready-to-use hematoxylin and eosin solutions, manufactured by Leica. The resulted preparations were examined and photographed under a MC 100 LED light microscope, equipped with a Canon EOS 550D.

Results

The liver was red-brown, located completely in the right upper quadrant. In it, we could distinguish the right, left, and the middle lobes, divided by not deep inter-lobar septa. The middle lobe was adjacent to the diaphragm, with which it was connected by a ligament, and the right was connected to the duodenum, and the left lobe was connected to the stomach. On the caudal surface, there was located the porta hepatis, the entering and exiting place of the blood vessels. The bladder was small, located to the right; from each lobe, a bile duct branched off. Together, they formed a general bile duct entering the duodenum.

Microscopically, the liver parenchyma was represented by hepatic lobules of hexagonal shape. The center of the lobule contained a central vein with a quite large lumen and thin walls (Fig. 1). From the central vein, radially, towards the boundary of the lobule, there were located hepatic laminae, formed by rows of hepatocyte cells. On the histosections, hepatocytes were rectangular or polygonal, with rounded corners (Fig. 1, 2). Nuclei of hepatocytes were rounded, distinctively basophilic, with clearly visualized nucleoli and chromatin. We often observed two-nucleus hepatocytes, approximately 15% of the general number (Fig. 1). Cytoplasm of hepatocytes was non-homogenous, eosinophilic, but with a clear tendency towards basophilic color, with more or less intensively stained regions, which was obviously associated with presence of inclusions of various compounds (lipids, glycogen, etc.). Inside the hepatic laminae on the preparations, we saw grains of bilirubin pigment – oval or irregular-shaped, dark-brown, with yellowish tint. Between the hepatic laminae, there were vessels located radially from the central vein – sinusoid capillaries (Fig. 1). The lumens of the vessel contained blood. The spaces of Disse were expressed poorly.

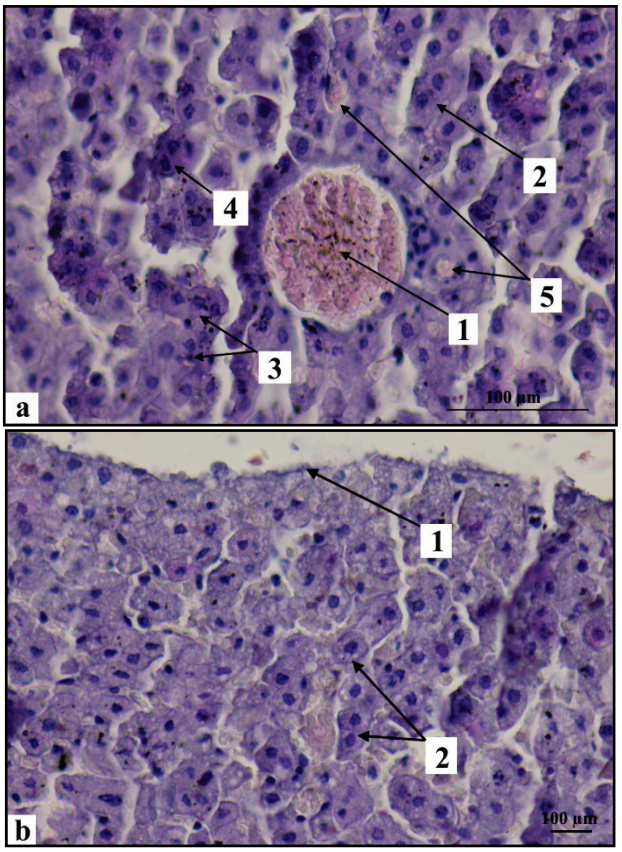

Fig. 1. Liver of *E. serotinus*: *a* – central vein (*1*), hepatic lamina (*2*), hepatocytes (*3*), two-nucleus hepatocyte (*4*), sinusoid capillaries (*5*); *b* – capsule (*1*), hepatocytes (*2*); hematoxylin and eosin

The liver stroma was represented by very poorly developed inter-lobular fibrous connective tissue in the form of thin layers. In its thickness, there were located hepatic triads, its components being inter-lobular artery, vein, and bile duct. The liver was externally covered by a thin connective-tissue capsule (Fig. 2), observed to have two layers: mesothelial layer and subserous region, represented by a thin layer of swollen fibrous connective tissue.

The pancreas was located along the duodenum in the mesentery and was a mesentery type of structure of this organ. It was light-pink, and the excretory ducts fell into the cranial part of the duodenum. The gland had a distinctive lobular structure; the lobules were barely visible without special equipment.

Microscopically, the pancreas had exocrine and endocrine parts. The exocrine part was represented by acinuses (Fig. 3, 4), formed by secretory cells – pancreatocytes. Nuclei of the cells were closer to the basal region, rounded or oval. There were clearly seen bundles of chromatin. In the apical part of cytoplasm of the pancreatocytes, there were found multiple eosinophile granules (zymogen granules). Cytoplasm in the basal region was rather stained basophilically. The pancreatoytes were located in the thin basal membrane; each acinus was surrounded by thin layer of swollen fibrous tissue. Between the acinuses, there were small accumulations of endocrinous cells – the islets of Langerhans (Fig. 4), found in small amount. Cells of the islets were rounded, the nuclei were oval-stretched, and cytoplasm was eosinophilic, with basophilous inclusions.

Stroma of the gland was represented by thin layers of swollen fibrous connective tissue, located between the acinuses; thicker layers were seen between the lobules (Fig. 5). On the outside, the pancreas was covered by a capsule (Fig. 3), formed of swollen fibrous connective tissue. The stroma contained blood vessels. The network of arterial vessels, arteries of meat-elastic type, was well-developed (Fig. 5).

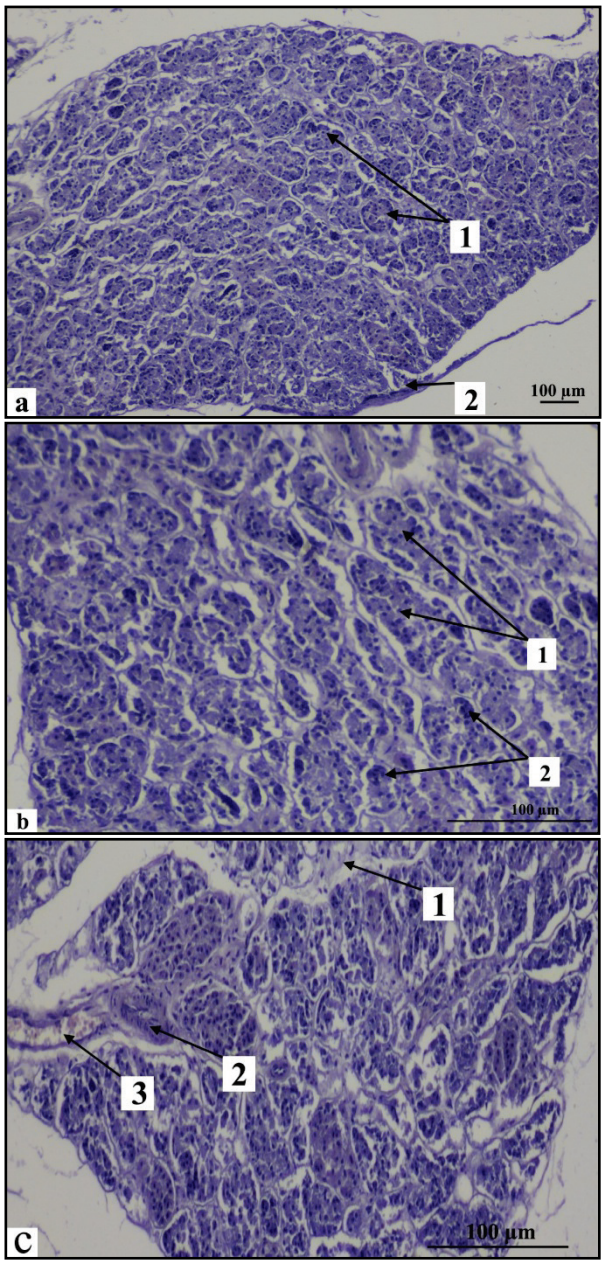

Fig. 2. Pancreas of *E. serotinus*: *a* – capsule (*1*), acinuses (*2*); *b* – acinuses (*1*), islets of Langerhans (*2*); *c* – interlobular connective tissue (*1*), artery in longitudinal (*2*) and transversal (*3*) sections; hematoxylin and eosin

The kidneys were located at the level of the first-second lumbar vertebrae, looked like paired bean-shaped organs, the lateral margin was swollen, the median was somewhat concave, and there was the renal hilum of brown color. The kidneys were smooth, with distinct cortex and medulla layers and a small pelvis on the sections.On the outside, the kidney was covered by a capsule, the around-kidney fat was developed poorly.

Microscopically, we observed nephron elements – the renal corpuscles and kidney tubules – straight and tortuous (Fig. 6). The renal corpuscles were composed of the glomerulus and capsule of the renal corpuscle (Fig. 7). The glomerulus was a cluster of capillaries, formed by a ramification of the afferent arteriole. The glomerulus capillaries were lined with endotheliocytes that had large basophilically stained oval or polygonal nuclei; and erythrocytes were visualized in the capillary lumens (Fig. 7). Between the vessels, there were mesangial cells, rounded, their nuclei stained poorly. On the margin of the glomerulus, there were located podocytes – flat cells of the visceral layer of the capsule, with elongated dash-like basophilic nucleus (Fig. 7). The parietal layer of the capsule was represented by single-layer plastic epithelium, cells of which had elongated basophilic nuclei. Epithelium was located on a quite well-developed basal membrane. Between the internal and external layers of the capsule, there was a quite large space.

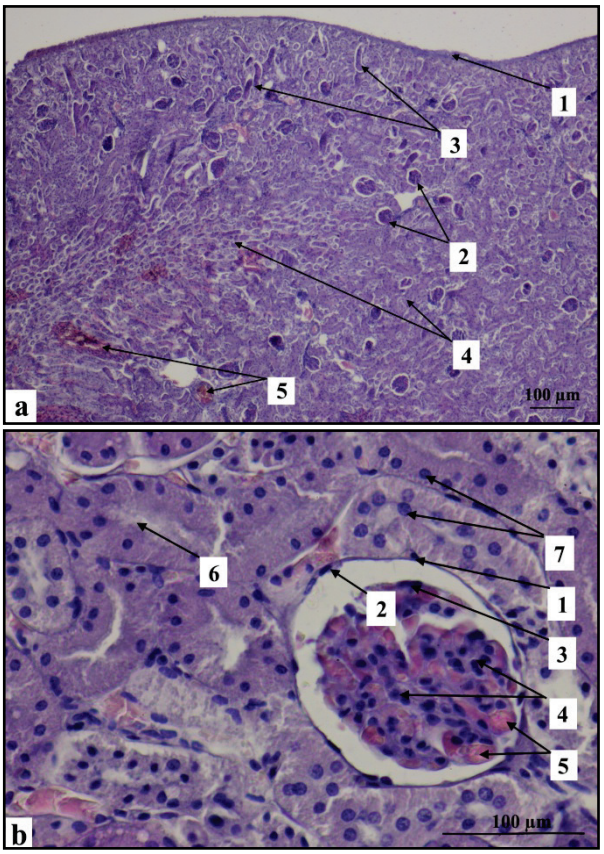

Fig. 3. Kidneys of *E. serotinus*: *a* – capsule (*1*), renal corpuscles (*2*), straight tubules (*3*), tortuous tubules (*4*), vessels (*5*); *b* – capsule of renal corpuscle (*1*), epitheliocyte of the capsule (*2*), podocyte (*3*), endotheliocytes (*4*), erythrocytes (*5*), lumens of the tubules (*6*), epitheliocytes of the tubules (*7*); hematoxylin and eosin

The renal tubules on the histopreparations were seen in the transversal, length-wise, and diagonal sections (Fig. 6). The lumens in the tubules were of insignificant sizes. The walls of the tubule were membranes covered by a single-layer cuboidal epithelium. Nuclei of epitheliocytes were stained basophilically, rounded, rarely somewhat oval (Fig. 7). Cytoplasm was slightly non-homogenous, especially in the apical part, poorly eosinophic. Between the renal corpuscles and the tubules, there were observed thin layers of swollen fibrous connective tissue (intermediate connective tissue).

The renal capsule consisted of a thin layer of dense fibrous connective tissue (Fig. 6). In some places, mesotheliocytes were visualized on its the external side. The vessels of the kidneys, arterial and venous, were located between the corpuscles and the tubules in the layer of intermediate connective tissue (Fig. 6).

The spleen was located along the large curve of the stomach, sat in the large omentum. It was elongated, narrow, of somewhat sickle-like shape. Its proximal and distal margins were rounded. The splenic hilum was on its medial surface.

Microscopically, the parenchyma of the spleen was composed of lymphoid nodes, or the white pulp, located closer to its surface, and the red pulp (Fig. 8). Lymphoid nodes (Fig. 8, 9) on the histopreparations were slightly elongated-oval and rarer rounded. There was an artery in their center, with narrow periarterial zone around (Fig. 8). Around it, there was a light center, which contained a small number of lymphoid cells, surrounded by the mantle zone, which was a dense accumulation of lymphoid cells, including T- and B-lymphocytes, plasmocytes, and macrophages (Fig. 8). The marginal zone was on the boundary of the lymphoid node and the red pulp, surrounded by blood capillaries. The red pulp consisted of blood cells, in which we saw presence of large amount of erythrocytes, and also lymphoid cells, macrophages, and single megakaryocytes. Cells

of the red pulp formed pulp cords, located along the venous sinuses (Fig. 8, 9). The capsule covered the spleen on the outside and was formed by dense fibrous connective tissue (Fig. 9). From the capsule into the parenchyma thickness of the spleen, trabeculae branched off, also formed of dense fibrous connective tissue (Fig. 8).

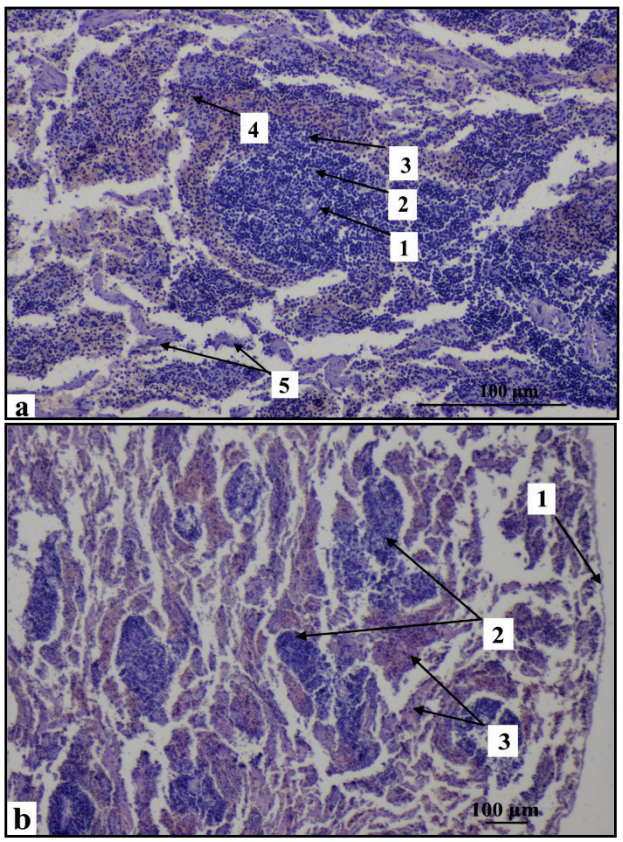

Fig. 4. Spleen of *E. serotinus*: *a* – periarterial zone of the lymphoid node (*1*), mantle zone of lymphoid node (*2*), marginal zone of lymphoid node (*3*), red pulp (*4*), trabeculae (*5*); *b* – capsule (*1*), lymphoid nodes (*2*), red pulp (*3*); hematoxylin and eosin

The heart was ellipsoid, located in the area of ribs 3-6. It comprised four chambers: right and left atrium and right and left ventricles. The atrium was well-developed; the muscles were somewhat thicker in the left atrium. In the left ventricle, the myocardium was well-developed, the thickness ratio of the left-ventricle wall to the right-ventricle wall was about 2:1. The ventricles' cavities had cranial, caudal, and medial walls (the latter was a membrane between the ventricles). There were a tricuspid valve between the right atrium and the ventricle and bicuspid valve between the left atrium and the ventricle. They had their characteristic structural elements – papillary muscles, tendinous cords, trabeculae, etc.

Microscopically, the wall of the heart was made of three layers – endocardium (Fig. 10), composed of the endothelial layer (endotheliocytes, located on the basal membrane) and subendothelial layer (thin layer of swollen fibrous connective tissue), which was adjacent to the myocardium; myocardium (Fig. 10) – the heart muscle, comprised of fibers formed by cardiomyocytes, between which the inter-muscular connective tissue was located (Fig. 11); serous, external membrane was formed by two layers: visceral (epicardium) and parietal (pericardium), with a cavity between them. Epicardium (Fig. 10) was formed by one-layer flat epithelium (mesothelium), under which the subepicardial layer was located, formed of swollen fibrous connective tissue, which contained a large amount of fatty cells and blood vessels.

The muscular fibers of myocardium on the histopreparations occurred in the lengthwise, transverse (Fig. 11), and diagonal cuts. Due to the small size of the bats' hearts, the entire heart is taken for histopreparations instead of just pieces of its wall. The muscular fibers were formed by cardiomyocytes, which were elongated, of somewhat spindle-like shape on the lengthwise samples. On the transversal sections, cardiomyocytes were rectangular or irregular-polygonal, with rounded corners. The cellular membrane of cardiomyocytes was thin. On the lengthwise sections, the nuclei were elongated, dash-like in shape, basophilic, located in the cell's center. On the lengthwise samples, some cardiomyocytes were observed to have two nuclei, located one behind another, along the longitudinal axis of the cell. On the transverse samples, cardiomyocyte nuclei were rounded (Fig. 11). Cytoplasm of cardiomyocytes was dark-red, somewhat grainy on the transverse sections; transverse alignment on the longitudinal sections was manifested indistinctly. Cardiomyocytes, located one near another, grew together, forming muscular fibers. Between the muscular fibers, there were very thin layers of fibrous connective tissue. Those layers were thicker between the bundles of muscular tissues. In the layers of intermuscular connective tissue, there were blood vessels that supported the cardiac muscle.

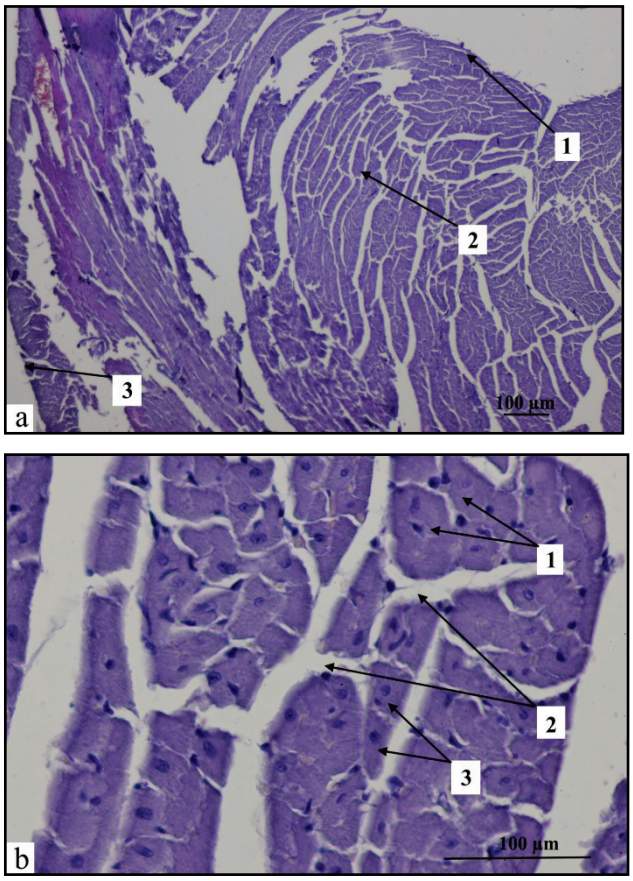

Fig. 5. Heart of *E. serotinus*: *a* – endocardium (*1*), myocardium (*2*), epicardium (*3*); *b* – cardiomyocytes in the transversal section (*1*), nuclei of cardiomyocytes (*2*), intermuscular connective tissue (*3*); hematoxylin and eosin

The lungs were in the thoracic cavity, occupying most of it. The right and left lungs were of approximately the same size. The lung tissue was pink-reddish, of elastic consistency. On the outside, the lungs were covered by a smooth shiny pleura, their shape was conical. In each lung, there may be designated the frontal (apical), middle (central), and posterior (diaphragmatic) lobes. While the lobar structure in the right lung was distinct, the division into lobules in the left one was quite conventional, and the septa between the lobules were insignificant. The trachea ramified at the bifurcation point into the left and right primary bronchi, which entered the pulmonary hilum of a respective lung, and in its thickness they ramified further.

Microscopically, the lung tissue was found to have its main components, characteristic for the mammal lungs: alveoli, bronchi, broncholi, and inter-alveolar connective tissue. Alveoli on the histopreparations were rounded, oval, or irregular-shaped (Fig. 12), and significantly varied in sizes (sometimes 4–5 times). A distinctive feature was that the small alveoli seemed "surrounding" the large alveoli (Fig. 12). The alveolar wall was covered by flat cells of aerogenic epithelium (alveolocytes).

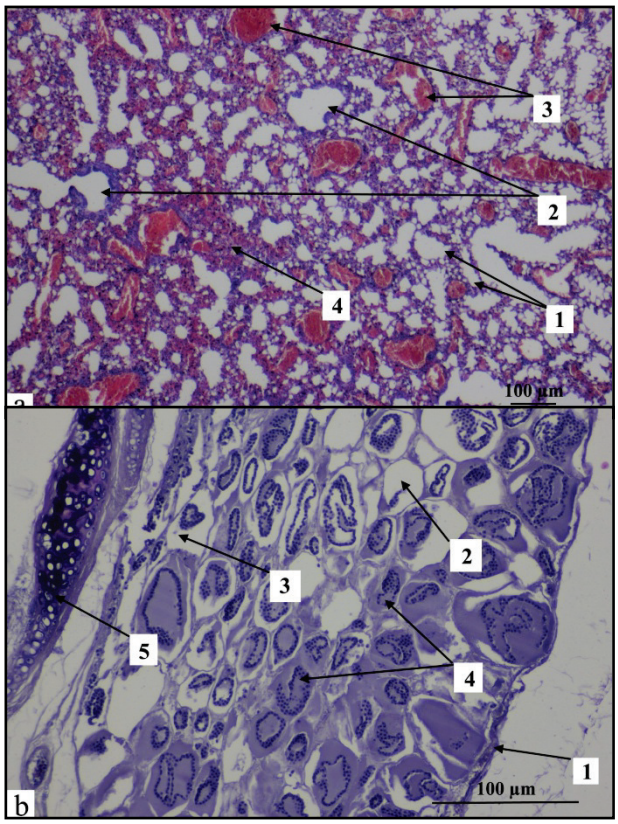

Fig. 6. Lungs of *E. serotinus*: *a* – alveoli (*1*), middle bronchi (*2*), blood vessels (*3*), inter-alveolar connective tissue (*4*); *b* – epithelial layer (*1*), lamina propria (*2*), submucous layer (*3*), bronchial glands (*4*), hyaline cartilage (*5*); hematoxylin and eosin

The bronchi varied in diameter. Their wall was composed of the mucous membrane, formed of the epithelial layer, represented by columnar epithelium, lamina propria, and submucous membrane (Fig. 13); the middle and large bronchi had a fibrous-cartilage layer of the wall. The mucous membrane of the bronchi contained a large number of bronchial glands, the terminal sections of which on the histopreparations were rounded or oval (Fig. 13) and formed by mucus-synthesizing cells. The mucus on the histopreparations was grayish. The terminal sections were in the lamina propria, and sometimes also at the level of submucosa of the mucous membrane. The fibrous-cartilage membrane comprised of elements of hyaline cartilage, which on the histopreparations were ellipsoid, surrounded by layers of fibrous connective tissue (Fig. 13). Cartilage tissue was dark-blue and porous (lacunas of the hyaline cartilage). The bronchioles were small, with thin walls formed by flat epitheliocytes; they were connected with groups of alveoli, forming lung acinuses. The interalveolar connective tissue was represented by thin layers of pink collagen fibers, sometimes diffusely infiltrated by an insignificant amount of lymphoid cells (Fig. 12). It contained a large amount of blood vessels, which were notably blood-filled (Fig. 12).

Discussion

In general, the microscopic structure of the examined internal organs of *E. serotinus* corresponded to the microscopic structure of those organs in mammals in general. In each of the studied organs, there were found all the main components characteristic for mammals.

In the hepatic lobules, there were observed clearly distinct hepatic laminae, between which sinusoid capillaries were located. It has to be noted that interlobular blood vessels, both sinusoid capillaries and the central vein, were blood-filled, while the spaces of Disse, between the sinusoid capillaries and hepatic laminae, were significantly smaller visually than in other species of animals. In our opinion, this indicates a smaller space occupied by hepatic lobules, and therefore either smaller sizes of the liver, or, which is more likely, more compact location of hepatic lobules in the organ thickness (Mohamed et al., 2017). The latter assumption was evidenced by the poorly developed interlobular connective tissue. Perhaps, those specifics caused smaller relative mass of the liver in relation to the mass of animal body, and this may be one of adaptations for flight.

Similar pattern was seen in the pancreas – highly developed blood vessels, poorly developed stroma, and exceptionally thin capsule (Cardoso et al., 2023). Moreover, very small, compared with other animals, were the islets of Langerhans. Thus, it would be practical to assume a more compact location of parenchymal elements of the gland inside the organ.

The structure of elements of the kidney parenchyma – nephrons – was no different from such in other mammals, including other bats (Studier et al., 1983). Absolutely typical structure was observed in the renal corpuscles and renal tubules, except very narrow lumens of the tubules. This could be related to the mechanism of excreting a portion of urine prior to take off in order to decrease the body mass. The capsule and the intermediate connective tissue of the kidneys were developed poorly.

The spleen was observed to have a similar structural tendency. Highly developed elements of the white pulp were the lymphoid nodes. Their condition indicated high immune activity: lymphoid elements were clearly divided into zones and basophilic color was highly intensive – those are signs that a large amount of lymphoid cells is present (Hanadhita et al., 2019). This was evidenced by the elements of the organ's stroma – capsule and connective-tissue trabeculae, thin and poorly developed. In general, the structure of the spleen did not have significant deviations from such in other mammals.

The microscopic structure of the heart's wall was also no different from that in other mammals. There were no substantial differences in the structures of myocardium, endocardium, and epicardium. Furthermore, there was not observed the pattern characteristic of other internal organs of *E. serotinus* – more compact location of the functional elements and thin connective-tissue layers that had been developed to a lower extent. The intermuscular connective tissue was highly developed, at the level of other mammals. In our opinion, thick layers of swollen fibrous connective tissue, in addition to performing a support function, also serve as "dampers" during contractions and relaxations of the cardiac fibers, which – because of their elasticity – create a necessary space for movement. Thus, the principle of compact location does not work for the myocardium.

The lungs of *E. serotinus* had the highest number of distinctive microstructural peculiarities that distinguish them from lungs of other mammals. Such peculiarities of the structure of the lung tissue were alveoli of various sizes and a high level of blood filling of the vessels. The blood filling of the vessels can be explained by high degree of intensity of blood circulation in this organ, since flight requires fast and complete gas exchange between inhaled air and blood. Also, we should take into account a large number of respiratory moves per minute in bats, which are predatory. Regarding the sizes of alveoli, such type of their structure does not occur in mammals other than Chiroptera. Alveoli are of approximately the same size in pathologically unaltered lungs in all mammals, including humans (Paksuz, 2014). Therefore, it can be inferred that such a peculiarity of the structure of lungs is directly associated with adaptation of bats for flight. We saw that small alveoli seemed to surround large alveoli. Accordingly, bats have a different structure of lung acini compared with other mammals, though some authors have not reported this peculiarity (Maina et al., 1991). The authors assume that such a location and sizes of alveoli are intended to provide intense and stable respiration of the bats during flight, and also provide airiness of the lungs and decrease in the mass during flight. Therefore, it is possible that those alveoli perform the function similar to the functions of air sacs in birds. We should note that only through clinical spirometric studies on live animals can this assumption be finally confirmed or disproved.

As with the bronchi, their structural peculiarities fully corresponded to those described for various mammals.

The given elucidations of the anatomical data regarding shape, location, and type of macroscopic structure of the studied organs were not an objective of our research and are presented only because such data regarding the anatomy of *E. serotinus* are absent in the literature.

Thus, we described the microscopic structure of the liver, kidneys, pancreas, spleen, heart, and lungs of *E. serotinus*. We identified the general correspondence of their structure to the morphological patterns of those

organs in mammals at the microscopic level, as well as their other structural peculiarities, characteristic for Chiroptera, and particularly *E. serotinus*.

Conclusion

We described the peculiarities of the microscopic structure of the liver, kidneys, pancreas, spleen, heart, and the lungs of *E. serotinus*. We found that the general patterns of the histological structure of those organs corresponded to such of other mammals. At the same time, we determined distinctive peculiarities of their structure, namely compact arrangement of elements of the parenchyma and low level of the stroma development in the organs of parenchymal structure, and also distinctive location and great variability of sizes of lumens of alveoli in the lungs. We believe that the mentioned peculiarities can be signs of adaptation of this animal for flight and are intended for decreasing absolute sizes of the internal organs, thus reducing mass during flight.

The authors declare that they have no potential conflict of interest concerning the authorship or publication of this article.

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