ODDÍL 8. LÉKAŘSKÉ VĚDY

§8.1 LUNG ORGANOMETRY OF DOMESTIC MAMMALS IN COMPARATIVE ASPECT (**Goralsky L.P.**, Zhytomyr Ivan Franko State University, **Glukhova N.M.,** Polissia national university, **Sokulskiy I M.,** Polissia national university, **Kolesnik N.L.,** Polissia national university, **Dunaievska O.F.,** Polissia National University, **Pavliuchenko O.V.,** Zhytomyr Ivan Franko State University)

Introduction. In the course of life, animals and humans continuously interact with the environment, receiving from it both substances necessary for life and being exposed to the negative effects of a combination of physical, chemical, and biological factors [1, 2].

Respiration is one of the most important physiological functions of a living organism [3, 4]. Respiration is a complex multifactorial and multistage function of the body, which includes the following physical processes: biomechanics of external respiration (lung ventilation), convection and diffusion of gases, chemical processes of association and dissociation of complex and simple compounds, transport of gases by blood and internal (tissue) respiration [5].

The body's cells constantly need oxygen and use it in the biological oxidation of organic substances to produce energy. Normal functioning, namely, the life of the body, is possible only if the energy that is continuously consumed is replenished. The body replenishes its energy expenditures with the energy released during the oxidation of nutrients. The task of the gas transport system is to provide the body with an amount of oxygen that is adequate for its energy needs [6].

External respiration is the very first stage of the respiratory process and is a rhythmic process provided by the respiratory system and consists of two main processes: pulmonary ventilation (the process of gas exchange between the atmosphere and the lungs) and pulmonary respiration (the process of gas exchange between the lungs and blood) [7]. As a result, blood arterialization in the lung tissue is achieved and the acid-base state of the blood is maintained by freeing the body from excess carbon dioxide. In humans and animals, external respiration is provided by the trachea, bronchi, bronchioles, and alveoli. Gas exchange between the lungs and the environment is carried out by inhalation and exhalation. Thus, external respiration is a stage of the respiratory process that performs gas exchange between the environment and the body [6].

Effective gas exchange is possible only when the functions of various organs are integrated and coordinated. This complex, multifunctional process consists of external (pulmonary) respiration, transport of gases by blood, and gas exchange in tissues (tissue or internal respiration). External respiration in particular consists of three stages: a ventilation the exchange of air between the environment and the alveoli; diffusion of gases through the alveolar-capillary membrane; and blood perfusion in the pulmonary capillaries.

Respiration is a set of physiological processes that ensure the intake of oxygen into the body, its use by tissues for redox reactions, and the excretion of carbon dioxide from the body [8]. All processes of oxygen delivery to tissues and carbon dioxide excretion from the body are provided by the general functional respiratory system, which includes the following naturally interrelated and interacting elements [9, 10].

The respiratory system of humans and mammals should be considered an open system of the body, which provides it with a number of complex morphofunctional and adaptive reactions to the air environment [11, 12, 13].

Such a functional property of the respiratory system determines its categorization into several morphofunctional divisions: The airway (conductor) division is a tracheobronchial tree that conducts airflow through the bronchial system. The respiratory department is a part of the respiratory system where gas exchange takes place [14, 15].

The lungs are smooth, compact, parenchymal tissue located in the pleural cavity within the chest [16, 17]. In mammals, the lungs are usually formed by lung lobes, which is due to the need for their stretching in different directions [18]. The lungs do not have their own muscles and therefore cannot contract or stretch on their own. They change their volume passively, following changes in the volume of the thoracic cavity.

In most domestic animals, each lung is divided into three lobes by the cranial and caudal interlobular gaps: cranial, middle, and caudal (diaphragmatic). The right lung has an additional lobe on the mediastinal surface. In ruminants, in addition, the right cranial lobe is divided into two lobes by a notch.

The lungs are based on a bronchial tree formed by the branching of two main bronchi. Each of the main bronchi is divided into lobar bronchi, which go to the lobes of the lungs. In the lung lobes, these bronchi are divided into segmental bronchi, which give rise to their segments. Segmental division of the lungs has important clinical significance. This is due to the fact that in the case of pathological processes in the lungs, pathological foci are concentrated in the segmental direction [16].

The results of Shchipakin`s M.V. (2016) research showed that the lungs of the dachshund breed dogs consist of seven lobes. The right lung includes the cranial, middle, caudal, and accessory lobes. The left lung consists of the cranial, middle, and caudal lobes. The cranial lobe of the right lung contains four segmental bronchi. The cranial lobe of the left lung includes three segmental bronchi. The middle lobes of both lungs have two segmental bronchi. The additional lobe of the lungs includes two segmental bronchi. The caudal lobes of both lungs have four segmental bronchi. All segmental bronchi are branches of the main bronchi and divide the lung lobes into the corresponding segments [19].

The results of the study show that the lobular bronchi of the right and left sable lungs are not equally developed. Thus, the smallest cross-sectional area and diameter, respectively, are the bronchi of the middle and accessory lobes. The bronchi of the cranial lobes have an opposite direction to the course of the main bronchi. The bronchi of the caudal lobes are more developed relative to other bronchi because they are more actively involved in the respiratory process [20].

In foxes and arctic foxes, after bifurcation of the trachea, left and right main bronchi are formed, from which lobular bronchi in turn extend, and thus form a bronchial tree. The results of morphometry showed that the coefficients of asymmetry of the cross-sectional area and diameters of the main bronchi in the arctic fox were 1 in both cases, while these indicators in the fox were 1.1. The ratio of the diameter and cross-sectional area of the bronchus of the right cranial lobe to the bronchus of the same name on the left side in the arctic fox is 0.9 and 0.9, and in the fox, these indicators are 1.2 and 1.4 [21].

The degree of morphofunctional complexity of the lung organization in animals is not the same: it is simpler in lower terrestrial vertebrates and becomes more complex as the overall organization of animals increases [22].

The structural and functional unit of the lungs is the acini, which is formed by a set of alveoli. The conductive and transitional zones ensure the transfer of oxygen to the alveoli and carbon dioxide from them as a result of air movement during inhalation and exhalation. In the respiratory zone, the movement of gases is carried out by diffusion. According to the international histological nomenclature, the set of branches of the terminal bronchioles is called the primary lung lobe or acini. The terminal bronchiole is divided into respiratory bronchioles of the 1st, 2nd, and 3rd order, into which the alveoli open. In the epithelium of the respiratory bronchioles, the number of ciliated cells progressively decreases and the number of cuboidal epithelial cells increases. Respiratory bronchioles of the 3rd order branch into alveolar passages and end in alveolar sacs, which are separated by interalveolar septa with a developed capillary network with an average of 20 alveoli [23].

According to a scientific article (Prokushenkova O.G., 2013), the morphometric parameters of the lungs of newborn piglets change asynchronously. In piglets, there is a natural tendency for the weight of the right lung to predominate, which is explained by the particularities of their structure and topography. The caudal lobe has the largest relative area in both lungs, and the cranial and additional lobes have the smallest. The absolute lung weight increases asynchronously with the age of animals, and the relative weight has a tendency to decrease, due to the intensive growth of animal body weight [23]. From the results of research and publications of Prokushenkova O.G. (2009), it was found that the lung weight of puppies dogs in the newborn period changes asynchronously. There is a natural tendency to the prevalence of the right lung weight, which is explained by the peculiarities of their structure and topography. The coefficient of lung asymmetry in day-old puppies is maximal and amounts to 1.60, while with age it gradually decreases, reaching 1.36 in 20-day-old animals. This is due to the formation of gas exchange and the intensive growth and development of the respiratory system, which is inherent in all animals in the neonatal period [24].

The studies of Obidnyi Y. O. (2008) indicate that the respiratory organs of neonatal animals have significant incompleteness of structures, which is especially manifested by the presence of areas of atelectasis, which in turn contribute to the development of bronchopneumonia. The alveoli of the lungs of newborn animals are straightened during the first breath, but not all of them are filled with air, especially in the peripheral areas of the lobes of the organ [25].

In the process of vertebrate evolution, there is a change in the structure of the capillary flow of the respiratory lung, which is accompanied by a decrease in the lumen of capillaries [26; 27, 28]. These changes are due to the intensification of pulmonary respiration, an increase in the length of the capillary vascular networks of the respiratory lung, and a decrease in the size of the blood cells – red blood cells [29]. In the course of vertebrate evolution, from fish to mammals, there has been a sharp decrease in the amount of smooth muscle in the lungs both at the interface between the semiconducting and respiratory compartments and in the respiratory compartment itself. This was probably compensated for in vertebrates by the development of airways, as well as the development of elastic elements in the respiratory tract and alveoli [30, 31].

The structure of the vertebrate lungs became more complex as they specialized as air respiratory organs by increasing the respiratory surface area through the formation of lung cavities of increasing orders, the formation of respiratory bronchioles of the first to fourth order, reducing the size of respiratory septa, air capillaries and alveoli, and thinning the partitions between respiratory cells and alveoli [32, 33].

Birds, having separated from reptilian ancestors in the course of evolution, adapted to flight, as a result of which they acquired a unique respiratory apparatus, the ability to conquer a large living space, and enhanced metabolism, which fundamentally distinguishes them from other vertebrates [34]. Increased interest in bird biology and the study of their species variability has allowed the accumulation of extensive factual material that is successfully used in various fields of practice, as well as the development of many theoretical problems of evolutionary nature and functional morphology of vertebrates [35, 36].

Due to the high level of metabolism, birds have characteristic anatomical and physiological features of the respiratory system that provide intensive gas exchange at rest and during flight [37, 38]. These features can be divided into two main parts: on the one hand, these are low-extensibility lungs with a system of air sacs, and on the other hand, the thorax with respiratory muscles [39, 40].

Therefore, the respiratory system of birds, which was formed in connection with the development of an active flight function, led to characteristic transformations in the structure of the lungs and air sacs [41, 42, 43], but also in the formation of the bronchial system, forming a single morphofunctional system, in which each component is in close correlation with each other, being a harmonious combination of structural and functional data of the organism, adequate to its environment and providing the body with optimal vital activity [44, 45]. Such a structure of the anatomical and physiological structure of the respiratory system ensures maximum oxygen saturation of the blood at rest and during flight [46, 47]. The lungs and bronchial system of birds form a single morphofunctional complex that provides intensive gas exchange [48, 49].

In poultry, the lungs are paired, elastic, parenchymal organs, not divided into lobes, light pink in color, located symmetrically in the dorsal part of the thorax, and pressed into the intercostal spaces. The lungs are quadrangular in chicken, triangular in duck and goose, and topographically extend from the second to the sixth rib in chicken, and from the first to the ninth rib in duck and goose [50].

The functional relationship of these morphofunctional parts, which is expressed by the physical relation of pressure and volume, provides the mechanics of respiration. The two components of the respiratory system: the respiratory locomotor apparatus and the lungs evolve as a whole, with the ectosomatic, more active respiratory motor system being the leading one in this correlation system.

The lungs and air sacs, which are an important part of the respiratory system of birds, due to their complex anatomical structure, are often subject to inflammatory processes with a long course during intensive production, which often requires therapeutic intervention [51, 52]. The study of the respiratory system of birds is important for the practical use of inhalation and tube anesthesia during surgical procedures [53, 54].

In the middle of the avian lungs, ecto and endobronchi, located closer to the lateral and medial surfaces of the lungs, extend from each mesobronchus along its entire length. In the chicken, endobronchi extend from the medial surface of the mesobronchus in the dorsal and ventral directions, and ectobronchi extend from its lateral surface in the cauda-dorsal and cauda-ventral directions. The ecto- and endobronchi, in particular, branch into a large number of small lung tubes called bronchioles (parabronchi). Externally, the ecto- and endobronchi run parallel to each other, connected by transverse bronchial tubes, forming a grid-like pattern.

In the chicken, the bronchi extend caudodorsally at an obtuse angle, forming a grid-like structure. In the duck and goose, the dorso- and ventrobronchi of the ecto- and endobronchi extend in the craniodorsal direction at an acute angle, forming a fan-shaped structure. The authors suggest that different functional loads on the respiratory apparatus of the studied bird species in different habitats are one of the important formative factors that affect the lungs and bronchial system as a complex biomechanical structure [50].

An important and new area of scientific research in modern morphology is the study of adaptive morphofunctional changes in the organism of living beings to the conditions of the external and internal environment [55, 56, 57]. In addition, knowledge of the morphological features and functional state of organs and systems in the normal state will make it possible to accurately correct the vital processes of the body in case of pathology associated with the respiratory system [58, 59, 60].

Morphological and functional features of the respiratory system organization in domestic animals are not fully understood. This issue is of great theoretical and practical interest. Despite preventive measures in animal farming, there has been a recent trend of increasing respiratory diseases, including lung pathology [61]. Damage to the respiratory system is a frequent phenomenon in modern conditions [62]. Functional features of the lung structure and increased blood and gas transport determine the high degree of intensity of organ damage under the influence of various exogenous and endogenous factors [63, 64]. Surgical treatment, correct interpretation of research results, and prevention of these diseases are impossible without knowledge of the comparative morphology and topography of the respective organs in the normal state. Consequently, the application of our morphological marker criteria for assessing the morphofunctional state of the lungs in clinically healthy animals will not only be of cognitive importance but will also be the basis, as indicators of the norm, for the prevention and diagnosis of diseases of various genesis. The research results will also be important for the comparative anatomy of animal constitution studies in animal husbandry and will contribute to the successful development of the livestock industry, an increase of animal productive qualities, etc.

Based on the mentioned above, the purpose of this study was to find out the macroscopic comparative structure of the lungs and to conduct a comparative organometric assessment of morphological structures in domestic mature animals belonging to the class Mammalia. On the basis of morphometric studies, to propose criteria for a normal organ to be used in morphological studies.

Outline of the main material.

The presented scientific work is a fragment of the comprehensive research of the Department of Normal and Pathological Morphology, Hygiene and Forensics of Polissya National University on the topic: "Development, Morphology, and Histochemistry of Animal Organs in Normal and Pathological Conditions" (state registration number is 0113V000900).

Experimental animals were selected in the phase of morphological and functional maturity according to the principle of analogs, breed, and age. In the work, 30 individuals of 6 species of animals belonging to the class Mammalia – Mammals were used: Orictolagus cuniculus L., 1758 – European rabbit; Sanis familiaris L., 1759 – domestic dog; Sus scrofa, forma domestica L., 1758 – domestic pig; Ovis aries L., 1758 – domestic ram (sheep); Bos Taurus L., 1758 – domestic bull; Equus ferus caballus L., 1758 – domestic horse.

Fresh lungs were subjected to anatomical dissection from the surrounding tissues of the studied animals (female: male ratio was 2:1) and their shape, color, and consistency were determined.

During the study, the general rules of good laboratory practice GLP (1981), the provisions of the "General Ethical Principles for Animal Experiments" adopted by the First National Congress on Bioethics (Kyiv, 2001), and the rules for the treatment of experimental animals in accordance with EU Council Directive 2010/63/EU on the implementation of regulations, laws, administrative provisions of the Member States on the protection of animals used for scientific purposes were followed [65, 66]. The entire experimental part of the study was conducted in accordance with the requirements of the international principles of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986) [67], the Rules for the Conduct of Work with Experimental Animals approved by the Order of the Ministry of Health of Ukraine No. 281 of November 1, 2000 "On Measures to Further Improve Organizational Forms of Work with Experimental Animals" and the relevant Law of Ukraine "On the Protection of Animals from Cruelty" (No. 3 of November 1, 2000) [68, 69].

For macroscopic studies and organometric analysis, lungs were taken from clinically healthy animals (n=5).

After necropsy, the shape of the lungs, their location in the thoracic cavity, and their absolute and relative weight, length, width, and thickness of the lobes of the organ were determined.

The absolute and relative weight of the organ, and the lung development index, which allows for assessing the shape of the organ, were determined.

The absolute weight of the lungs and their lobes was determined by weighing. Relative lung mass (RM) was calculated by the formula:

$$RM = \frac{AM}{MotA} 100\ \%,$$

where AM is the absolute mass (AM) of the lungs;

MotA is the mass of the animal.

The linear parameters of the organ (length, width, and thickness) were determined by direct measurement.

The coefficient of asymmetry (CA) of the lungs was determined according to the following formula:

$$CA = \frac{AMRL}{AMLL},$$

where: AMRL - an absolute mass of the right lung.

AMLL - an absolute mass of the left lung.

The lung development index (LDI) was determined by dividing the total length by the width using the following formula:

$$LDI = \frac{OL}{OW} \times 100,$$

where: OL - length of the organ.

OW - organ width.

The lung development index allowed us to determine the shape (types) of the lungs (dilated-shortened, intermediate, moderately elongated, elongated): in the case of an LDI value of 85-100%, the shape is defined as dilated-shortened; with an LDI of 101-120%, the shape is defined as intermediate, with an LDI of 121-130% moderately elongated, with an IRI of 131-140% elongated.

The names of the morphological structures of the lungs are given in accordance with the International Veterinary Anatomical Nomenclature [70].

Digital data were processed by variational and statistical methods on a personal computer using the Microsoft Excel program. The average arithmetic mean (M) and the statistical error of the average arithmetic mean (m), the probability of the difference between the arithmetic means of two variation series by the probability criterion (p), and Student's tables were determined. The difference between the two values was considered significant at $p \leq 0.05$, 0.01, 0.001 [71].

There is no doubt that the study of the morphophysiological state of the animal body is and always remains the most important issue of the morphological direction in biological, veterinary, and medical research, among others. In this regard, morphological studies of agricultural domestic mammals are carried out on a large scale, as they are necessary as normal indicators for the diagnosis of diseases of various genesis, to assess the impact of housing conditions, animal feeding, productivity improvement, etc.

A comprehensive study of the respiratory system, including the lungs, which perform extremely vital functions in the human and animal body, the main one being gas exchange, is of great importance.

Based on the objectives of our morphological studies, the following stages were performed: lung dissection, description of their shape, structure, and topography; determination of absolute and relative lung weight; determination of absolute and relative lung indices.

The lungs of domestic mammals, according to the symmetry of their bodies, are divided into left and right lungs and have a partial structure.

An important criterion for the development of a particular organ, which directly indicates its morphological and functional maturity, is absolute weight.

According to morphometric studies, cattle and horses had the largest body weight of the studied animals, and it was in them that the absolute weight of the lungs was the largest, respectively 3102.4±98.62 g in cattle and 3318.1±364.4 g in horses. Pigs had a significantly lower absolute lung weight (896.8±50.66 g), followed by sheep (471.02±46.34 g), dogs (201.3±18.4 g), the lowest absolute lung weight was in rabbits (18.05±1.32 g) which had shown in Table 1.

Table 1.

Absolute and relative lung weights of domestic mammals, M ± m, n = 5

Animal type	Indicators	
	Absolute mass (g)	Relative mass (%)
Rabbits	18.05±1.32	0.62±0.013
Dogs	201.3±18.4***	1.21±0.14***
Pigs	896.8±50.66***	0.65±0.018
Sheep	471.02±46.34	0.72±0.038
Cattle	3102.4±98.62***	0.59±0.024
Horses	3318.1±364.4	0.60±0.052

*Note: * p≤0.05; ** p≤0.01; *** p≤0.001 compared to the previous study group.*

According to the results of our studies, the relative weight of the lungs in domestic mammals is different. According to our data, the highest relative lung weight is in dogs – 1.21±0.14 % (Table 1). We attribute this feature to the fact that in this species of animals, breathing is frequent and intense, and the residual air is used quite quickly. On average, in 1 minute, depending on the age and size of the animal, a dog makes 14-30 respiratory movements at rest, and during movement and under other circumstances, the respiratory rate can increase 2-2.5 times [72]. In most of the other domestic animals investigated by us, the relative weight of the lungs was similar: in cattle – 0.59±0.024%, in horses – 0.60±0.052%, in rabbits – 0.62±0.013%, in pigs – 0.65±0.018%, in sheep – 0.72±0.038% (Table 1).

According to the results of our morphometric data, there is a pronounced asymmetry between the absolute weight of the right lung to the absolute weight of the left lung in domestic mammals, the development index of which is equal to: in rabbits – 1:1.30, in dogs – 1:1.33, in sheep – 1:1.37, in pigs – 1:1.34, in cattle – 1:1.37, in horses – 1:1.2. Their development index (length to width ratio) is ambiguous: in rabbits, the lung development index is 90±1.89%; in cattle and sheep, the development index is 117±2.21% and 114±2.08%, respectively; in horses, this development index is 127±2.74%; in pigs and dogs, this figure is 136±3.01 and 137±2.84%, respectively.

Analyzing the results of such studies in detail, taking into account the macroscopic structure of the lungs, their asymmetry coefficient (the ratio of the absolute mass of the right lung to the left), we suggested a morphological scale for determining the lung development index (marker features), according to which we classified the lungs of domestic mammals in terms of their structure and shape into 4 types: Type 1 – dilated-shortened type (LDI = 85-100%; Type 2 – intermediate type (LDI = 101-120%);

Type 3 – moderately elongated type (LDI = 121-130%); Type 4 – elongated type (LDI = 131-140%). According to our proposed scale for assessing lung markers in clinically healthy animals, their development index is different: in rabbits, the lung development index is 90±1.89%, so their lungs are of the expanded-shortened type; in cattle and sheep, this index is 117±2.21% and 114±2.08%, respectively, so their lungs are defined as expanded-elongated type; horses have an LDI equal to 127±2.74%, so their lungs are of moderately elongated type; in pigs and dogs, the LDI is 136±3.01% and 137±2.84%, respectively, so their lungs are of elongated type.

In modern morphology of nowadays, morphometric (quantitative morphology) research methods allow for establishing the interrelationships and interdependence of quantitative changes in individual structures of the animal body, quantitative and relative characteristics of certain morphological components (individual lobes, individual areas, etc.) at different stages of individual and phylogenetic development and unequal functional states of a particular animal body system, depending on their species characteristics [73].

According to the analysis of scientific results from the literature [74] and our own research [75], the right lung in domestic mammals is larger than the left, which is manifested by signs of asymmetry, depending on the species. In most domestic mammals, the left lung has three lobes (cranial, middle, caudal), and the right lung has four lobes (cranial, middle, caudal, and accessory). The peculiarity of the horses' lungs is that the division of the lungs into lobes is poorly defined (the middle and caudal lobes have merged into one and form the caudal lobe), and at their sharp edge, there is an inclined interlobular gap that divides each lung into cranial (smaller) and caudal (larger) lobes. The right lung has an additional lobe. As a result of this evolutionary restructuring of the lungs, their shape and size in general, and of the lobes in particular, have changed, and as a rule, the absolute and relative mass of individual lobes to the total absolute mass of the lungs. This is not accidental, as the variety of lung shapes, according to their lobular structure, observed in mammals, follows certain patterns, their adaptive changes in the course of evolution. Therefore, depending on the species, in the process of evolutionary development, the shape of the lungs in general, and the lobules in particular, their absolute and relative masses change. Thus, according to the results of our studies, the highest value of the absolute weight in domestic experimental animals is in the caudal lobes of the right lung: rabbits (5.63±0.41 g), dogs (47.96±6.38 g), sheep (164.08±16.17 g), pigs (267.07±29.48 g), cattle (903.78±72.18), horses (1423.8±102.71 g). In the left lung, such indicators are slightly lower than in the right and are respectively 5.56±0.32 g, 44.26±6.02 g, 129.10±10.02 g, 247.88±28.04 g, 756.98±67.93 g, and 1308.66±98.75 g. We attribute such high values of the results of the absolute weight of the caudal lobes of the lungs in domestic mammals to the morphotopography of the lungs, their functional load in general and the lung lobes in particular, during pulmonary (external) respiration, which occurs due to the activity of the external respiratory apparatus [72].

Smaller morphometric values are common for the cranial lobes of the lungs. For the right lobe, these values are 1.71±0.06 g in rabbits, 27.29±3.21 g in dogs, 56.12±6.04 g in sheep, 82.17±8.96 g in pigs, 318.31±38.16 g in cattle, and 214.02±24.04 g in horses. The absolute weight of the left lobe in rabbits is 0.79±0.03 g, in dogs is 22.09±3.01 g, in sheep is 39.58±4.08 g, in pigs is 62.59±8.02 g, in cattle is 259.98±29.02 g, and in horses is 197.43±19.24 g (Table 2).

At the same time, the absolute weight of the middle lobes of the right and left lungs in the experimental mammals, except for dogs and sheep, in which the absolute weight of such lobes is greater than that of the cranial lobes and has an intermediate value between the absolute weight of the cranial and caudal lobes. Thus, the absolute weight of the middle lobes in the right lung of rabbits is 1.98±0.07 g, of dogs – 23.65±2.96 g, of sheep, is 35.06±3.26 g, of pigs is 102.72±11.04 g, of cattle is 402.69±40.02 g. In the left lung, this figure is 1.49±0.05 g in rabbits, 19.91±2.84 g in dogs, 30.36±2.31 g in sheep, 72.73±9.21 g in pigs, and 292.25±31.38 g in cattle. The lowest absolute weight in the composition of the lung lobes was observed for the additional lobe, which was 0.89±0.04 g in rabbits, 16.14±2.08 g in dogs, 17.72±1.72 in sheep, 61.63±7.48 g in pigs, 168.41±27.33 g in cattle, and 174.2±16.02 g in horses (Table 2).

When analyzing the total absolute mass of the lungs and their anatomical components, in all experimental animals, the absolute mass of the right lung is greater than that of the left lung (Table 2), so there is a pronounced asymmetry between the absolute mass of the right lung to the absolute mass of the left lung in domestic mammals, the ratio of which is equal to: in rabbits – 1:1.30, in dogs – 1:1.33, in sheep – 1:1.37, in pigs – 1:1.34, in cattle – 1:1.37, in horses – 1:1.2 (Table 2).

Table 2.

Specific features of the absolute mass of lung particles of domestic mammals (g), M ± m, n = 5

Parts of the lungs		Animal species					
		Rabbits	Dogs	Pigs	Sheep	Cattle	Horses
Cranial	left	0.79±0.03	22.09±3.01 **	62.59±8.02***	39.58±4.08 ***	259.98±29.02 ***	197.43±19.24
	rights	1.71±0.06	27.29±3.21 ***	82.17±8.96***	56.12±6.04	318.31±38.16 ***	214.02±24.04
Middle	left	1.49±0.05	19.91±2.84 ***	72.73±9.21 ***	30.36±2.31	292.25±31.38 ***	–
	rights	1.98±0.07	23.65±2.96 ***	102.72±11.04 ***	35.06±3.26	402.69±40.02 ***	–
Caudal	left	5.56±0.32	44.26±6.02 ***	247.88±28.04 ***	129.10±10.02	756.98±67.93 ***	1308.66± 98.75 ***

	rights	5.63±0.41	47.96±6.38 ***	267.07±29.48 ***	164.08±16.17	903.78±72.18 ***	1423.8±102.71 ***
Additio-nal	left	–	–	–	–	–	–
	rights	0.89±0.04	16.14±2.08 ***	61.63±7.48***	17.72±1.72	168.41±27.33 ***	174.2±16.02
Total:	left	7.84±0.73	86.26±8.01 ***	383.2±28.75 ***	199.04±19.82	1309.21±43.38 ***	1506.1±60.48*
	rights	10.21±0.91	115.04±10.14 ***	513.6±49.88 ***	272.98±26.91	1793.19±54.87 ***	1812.0± 62.92
AM of both lungs		18.05±1.02	201.3±18.4 ***	896.8±50.66 ***	472.02±46.34	3102.4±98.62 ***	3318.1±364.4
CA of the lungs		1:1.30	1:1.33	1:1.34	1:1.37	1:1.36	1:1.2

*Note: * p≤0.05; ** p≤0.01; *** p≤0.001 in relation to the previous research group.*

Therefore, analyzing the results of lung morphometry in domestic mammals in general and their lobes in particular – their absolute and relative values, we found that each lung lobe (cranial, middle, caudal, supplementary) is characterized by certain indicators of its absolute mass, depending on the morphotopography of the lungs, the functional load in general and the lung lobes in particular and, accordingly, the species characteristics of the experimental animals. For instance, the absolute weight of lung lobes in experimental animals varies depending on their species, body weight, and size. Accordingly, the lowest absolute weight of all lung lobes was found in rabbits (the smallest animals), slightly higher in dogs, then sheep, and pigs, and the highest in cattle and horses, the largest animals in terms of live body weight.

The relative weight of the anatomical parts of the lungs (cranial, middle, caudal, and additional lobes) in experimental domestic mammals, relative to the average absolute lung weight, is directly proportional to the body weight of the animals and the absolute weight of the organ and varies depending on the absolute lobar weight and absolute lung weight, which is also consistent with the results of other scientists [76, 77]. According to our morphometric studies, the caudal lobes of the right and left lungs account for the largest percentage of the total lung weight, the size of which depends on the absolute lobular mass, respectively. In the right lung of rabbits, this figure is 31.19±1.38%, in dogs – 23.83±1.82%, in pigs – 29.79±1.37%, in sheep – 34.76±3.04%, in cattle – 29.13±2.54%, in horses – 42.91±4.06%. In the left lung, the relative weight of the caudal lobes in accordance with the total absolute weight of the lungs is 30.8±1.54% in rabbits; 21.98±1.82% in dogs; 27.64±1.66% in pigs; 27.35±2.36% in sheep; 24.4±1.92% in cattle; and 39.44±3.57% in horses (Fig. 1). At the same time, we associate the highest percentage of caudal lobes of the horses' lungs (Fig. 1) with the absence of middle lobes in the lungs due to their merging into the component of caudal lobes.

The cranial lobes have a smaller relative mass in the morphoarchitectonics of the lungs of experimental animals. However, in the right lung, the relative mass of cranial lobes (in rabbits – 9.47±0.89%, dogs – 13.56±0.92%, sheep – 11.89±1.07%, pigs – 11.89±1.07%, cattle – 10.26±0.97%, horses – 6, 45±0.62%) is greater than that in the left lung, which is 4.38±0.31%, 10.97±0.96%, 6.98±0.67%, 8.4±1.04%, 8.38±0.64%, and 5.95±0.51%, respectively (Fig. 1), which coincides with the results of other scientists.

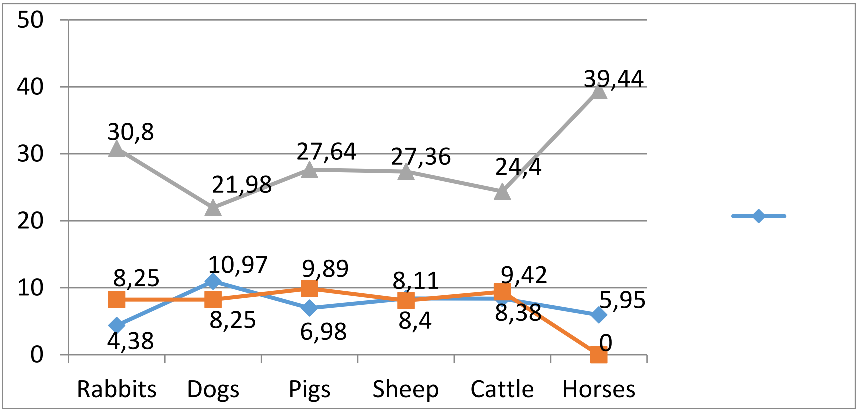

Fig. 1. *Species-specific features of the relative mass of left lung lobes in domestic mammals (%)*

The relative mass of the middle lobes of the lungs is different in the experimental animals but is smaller in comparison with the morphometric parameters of the caudal lobes. However, their organometric data are a bit higher than the relative mass of the cranial lobes, except in dogs, in which the relative mass of the middle lobes is slightly higher than that of the cranial lobes (Fig. 2). Specifically, the relative mass of the middle lobes of the right lung in rabbits is 10.97±0.98%, in dogs – 11.75±1.14%, in pigs – 11.45±1.04%, in sheep – 7.42±0.88 and in cattle – 12.98±1.32%, in the left lung such indicators are lower than in the right lung and are respectively 8.25±0.81%, 9.89±0.64%, 8.11±0.72%, 6.43±0.62% and 9.42±0.88% (Fig. 2). And additional fractions have the lowest relative weight in the morphostructure of the lungs, according to the results of our studies: in rabbits – 4.93±0.36%, in dogs – 8.02±0.48%, in pigs – 6.87±0.64%, in sheep – 3.75±0.12%, in cattle – 5.42±0.56% and in horses – 5.25±0.68% (Fig. 2).

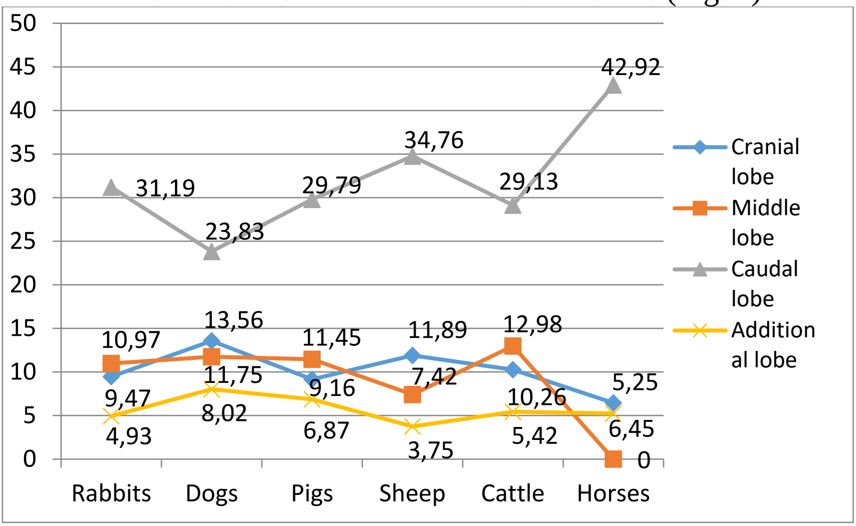

Fig. 2. *Species peculiarities of the relative mass of right lung lobes in domestic mammals (%)*

To summarize, the absolute and relative weight of the lungs in domestic animals and their morphological structures is different and depends on the species characteristics of the animals, their body weight and the absolute weight of the organ.

Conclusions.

The lungs, according to the symmetries of the animal body, are divided into left and right lobes and have a typical lobar structure: the left lung in all experimental animals (except horses) has three lobes – cranial, middle, and caudal; the right lung has four lobes – cranial, middle, caudal, and additional. In horses, the interlobular heart notch divides the right and left lungs into only two lobes – the cranial (much smaller) and caudal (larger), and the right lung has an additional lobe on the medial side. The left lung is much smaller than the right.

The absolute weight of the lungs in domestic mammals (the smallest in the rabbit – 18.05±1.32 g, the largest in the horse – 3318.1±364.4 g) is synchronously subject to well-known and recognized facts of organ development, depending on the phylogenetic level of animal development (the higher the species of animals in systematic terms (their size, live weight, etc.), the greater the organometric parameters of the organ).

The relative weight of the lungs in the mammals we study changes asynchronously, depending on the body weight of the animals and the absolute weight of the lungs (the percentage of the organ's weight that falls on the body weight of the animals). Thus, the highest relative weight is in dogs – 1.21 ± 0.14%, the lowest in cattle – 0.59 ± 0.024%. An intermediate value of the relative lung weight is characteristic of horses (0.60±0.052%), followed by rabbits (0.62±0.013%), pigs (0.65±0.018%), and sheep (0.72±0.038%).

In domestic mammals, taking into account the species characteristics of animals, depending on their respiratory type, their lungs are different in shape and size and are determined by their development index: In rabbits (LDI = 90±1.89%), the lungs are of the dilated-shortened type; in cattle (LDI = 117±2.21%) and sheep (LDI = 114±2.08%), the lungs are of the dilated-elongated type; in horses (LDI = 127±2.74%), the lungs are of the moderately elongated type; in pigs (LDI = 136±3.01%) and dogs (LDI = 137±2.84), the lungs are of the elongated type.

In domestic mammals, a significant asymmetry is observed (the ratio of the absolute weight of the left lung to the right), the ratio of which is: in rabbits – 1:1.30, in dogs – 1:1.33, in sheep – 1:1.37, in pigs – 1:1.34, in cattle – 1:1.37, in horses – 1:1.2.

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