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Morphological Features of Vertebrates' Lung Adaptation to Environment

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ABSTRACT

This article discusses morphological changes in the lung structure during environmental adaptation. Adaptive reactions of amphibians, reptiles, and some mammals living in the steppe and mountain regions were studied at the ultrastructural level. The obtained materials revealed the features of the pulmonary epithelium of vertebrate animals living in different biotopes. The airborne barrier of representatives of the species of reptiles, amphibians, and mammals had a different structure depending on the habitat of the terrestrial vertebrate. An increased, intense, and also very small secretion of surfactant was observed **-** *a mixture of surfactants lining the pulmonary alveoli. Aeromatological membranes had different thicknesses in the studied animals. In populations of the mountainous region of vertebrates, a thinning of the airborne membrane system, an increase in the airway area, and a decrease in the number of mucous cells were observed. In vertebrate populations living in the steppe zones, increased secretion of surfactant, mucosal hyperplasia, and fluid loss in the superficial airways was revealed. The thickness of the airborne membrane system was significant. Increased secretion of mucosal cells and increased secretion of "mixed" type cells were detected using a scanning microscope.*

Keywords: *adaptation, amphibians, mammals, microscope, surfactant, pneumocytes.*

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I. Introduction

Determining the mechanisms of adaptation of living organisms - humans and animals to the environment is one of the most important problems of biology. This problem can be considered in two ways: firstly, the occurrence of adaptive changes in the body under the influence of environmental factors can be considered as an acquired property of the body during ontogenesis. Secondly, we can say that this is a property of adaptation to the environment, which is attached to the body at the genetic and phenotypic level, formed during evolution [1-2].

The main focus here is on the ability to identify and distinguish between similar adaptation mechanisms (identical environmental conditions) that develop during ontogenesis and develop during phylogenesis. This article presents the results of studying at the cellular level similar mechanisms of adaptation of the respiratory part of the lungs of terrestrial vertebrate populations that differ in their environment. To achieve this goal, an electron microscopic study of the respiratory tract of terrestrial vertebrates, such as amphibians, reptiles, and mammals in mountain and steppe habitats, was carried out [3-4].

Such studies are very important for the concept of adaptive processes of the body, the influence of the environment on the ultrathin structure of the lungs, thereby being one of the foundations for the development of theoretical biology (evolutionary theory, ecology, comparative morphology and physiology) and medicine [5].

II. Materials and methods

At a comparative morphological level, the lungs of amphibians, reptiles, and mammals living in different biotopes were studied. Animals were kept in the steppe and mountainous regions of the Almaty region (Balkhash, Raimbek regions, Tau-Turgen valley at an altitude of 2800 m above sea level) [6].

For histological examination of the lungs, smaller particles were placed in the latch. As a fixative, a 10% neutral formalin was used. Sections 3-5 μm thick were stained with hematoxylin-eosin and Van Gieson methods after dewaxing. [7].

To study sections of the lungs using electron microscopy, they were fixed for 2.5 hours in 2.5% glutaraldehyde (pH 7.4-7.6) and 2 hours in a 1% solution of osmium acid. Then it was treated with ethanol and acetone and poured into epon (812). Morphometric studies were performed on an electrogram, statistical processing was performed according to the student method (G.F. Lakin, 1990). Small sections were treated with uranyl acetate and lead citrate (Reynolds method). Thin sections were examined and photographed using an EVM-100L electron microscope [8-9].

For scanning electron microscopy, lung particles (5 × 3 × 3 mm) were treated with alcohol and acetone, dehydrated and then dried. After the particles were catalyzed by gold, they were studied in raster mode by a Super - probe 733 electronic microanalyzer. The samples were enlarged to 800-4000x and photographed [10].

III. Results and Discussion

In caudate amphibians under steppe conditions (Smooth newt (Lissotriton vulgaris)), adaptive reactions are associated with increased secretion of surfactant, hyperplasia of mucous cells with ultrastructural features of type II pneumocytes, “mixed” type cells, and fluid loss in the surface airways. Many microfibers are observed on the apical side of "mixed" type cells. The thickness of the aeromatic membrane system was significant. Increased secretion of mucosal cells and increased secretion of "mixed" type cells were detected using scanning microscopic data [11].

In caudate amphibians living in mountainous areas (Central Asian salamander (Ranodon sibiricus)), a decrease in the number of mucous cells, a decrease in the secretion of surfactant, a thinning of the airborne membrane system, and an increase in the area of the respiratory tract was observed. Scanning microscopy results showed an increase in the area of the respiratory surface [12].

Figure 1. Central Asian salamander (Ranodon sibiricus). X 1600

Adaptation reactions were detected in tailless amphibians living in different biotopes. Adaptive properties in steppe populations were determined by the intensive synthesis of surfactant and mucus. There was also an accumulation of capillaries, which prevents the reduction of endogenous fluid from the respiratory surface. The results of a scanning microscope showed many long small eyelashes on the apical surface of type I and type II pneumocytes. It can be assumed that fibrous structures help retain surfactant [13].

In the population of tailless amphibians living in mountainous regions, in the cytoplasm of type II pneumocytes, there was a small number of osmiophilic bodies. The airborne membrane system is thin. Scanning microscopy revealed a small amount of surfactant, a sharp decrease in the number of small eyelashes, and the area of the respiratory surface [14].

A sudden increase in the surfactant of the phospholipid complex was found in one and in different species of reptiles (snake, lizard) living in the steppe zone. An increase in the number of mixed cells was observed in snakes (the steppe viper (Virera ursinii) and the halys viper (Gloydius halys)). In turn, this helps retain moisture from the airways of the lungs. The basement membrane of the airborne membrane system has been expanded [15].

Reduced surfactant levels were found in reptiles living in mountain habitats.

The following phenomena were identified:

- thinning of the airborne membrane, fusion of the basement membranes of the epithelium and endothelium, an increase in the volume of the respiratory region [16].

Figure 2 – The the steppe viper (Virera ursinii)

A network of folded capillaries in the respiratory department. X300

Reptiles living in mountain and steppe regions had the following features in the respiratory part of the lungs: vesicles formed in the epithelial and endothelial aerogematic membrane systems. This indicates a high level of gas exchange.

Although the morphofunctional differentiation of amphibians and reptiles is simple, ultrastructural results show that adaptation to direct and indirect environmental factors were observed in reptiles [17].

Ultrastructural adaptive changes were also found in the respiratory compartments of lung rodents living in the steppe and mountain regions. The main feature of the respiratory part of the lungs in rodents living in mountain biotopes was the thinning of the aerogematic membrane system. The area of the respiratory tract increases. This ensures a smooth gas exchange process. The surfactant-alveolar complex is not changed. In the histological section of the lungs of the large gerbil in the respiratory sections, large acini with a thin membrane system are visible [18].

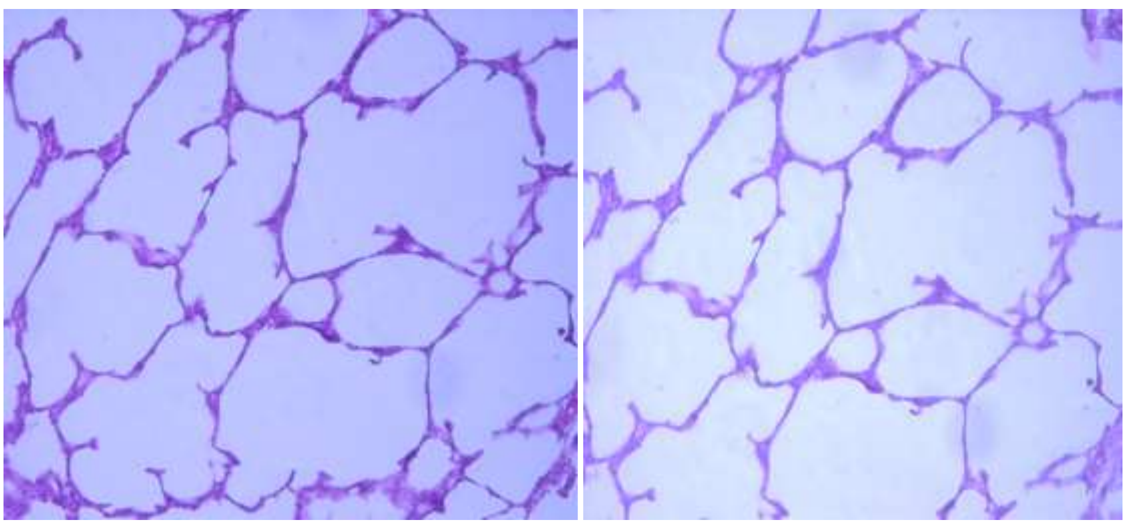

Figure 3 – The Great gerbil (Rhombomys opimus) x200

Thus, morphofunctional studies have shown the features of interspecific and interspecific adaptation of vertebrates to various ecological environments. The adaptation mechanism consists in the synthesis of the ultrastructure of the pulmonary capillaries (increase and decrease of the working area) under different regimes of mucous components and surface-active complex [19].

Table 1 – The thickness of the aerogematic membrane of vertebrates. (nm)

Species of Vertebrates	
The smooth newt (*Lissotriton vulgaris*) 1312.4±15.3	The Central Asian salamander (*Ranodon sibiricus*) 748.4±12.2 P<0.001
The steppe viper (*Virera ursinii*) 758.7±14.1	The halys viper (*Gloydius halys*) 476.3±7.8 P<0.001
The common vole (*Microtus arvalis*) 755±13.0	The great gerbil *(Rhombomys opimus)* 225.1±4.2 P<0.001

IV. Conclusion

The study of the adaptation reactions of a representative of caudate amphibians living in the steppe regions, at the ultrastructural level, the presence of mucous cells and hyperplasia of “mixed” cells were observed. A large number of small vesicles were found on the upper surface of the cell. The intensity of secretion by mucous and mixed cells was confirmed using a scanning electron microscope.

The adaptive mechanisms of amphibians living in the steppe zones had the following feature - the folds of blood papillaries increased, which helped the representative of amphibians, in this study, tailed amphibians to reduce the loss of endogenous liquid substances from the respiratory part of the lungs.

In the ultrastructure of light amphibians living in mountainous areas, a decrease in the number of pneumocytes was determined, in the cytoplasm of which there was a small number of osmophilic bodies. The airborne membrane system was thinner compared to populations living in the steppe zones.

In reptiles living in the steppe zones, there was a lack of moisture loss on the respiratory surface of the lungs; a very strong synthesis of surfactant; increased secretion of mucous components by mixed cells; decrease in the surface of the respiratory surface of the lungs. In reptiles living in the highlands, a decrease in the synthesis of surfactant, narrowing of blood capillaries, an increase in the respiratory surface of the lungs, and fusion of the basement membranes of the epithelium and endothelium were found [20].

Adaptation changes were also found in the respiratory parts of the lungs of mammals living in different ecological regions.

In mammalian highlands, thinning of the airborne membrane was noted, the respiratory region of the lung increased, this helps to ensure a smooth gas exchange process. Opposite changes were observed in mammalian steppe zones.

This article shows the adaptation processes of terrestrial vertebrates to their environment in the form of morphological and ultrastructural changes in the respiratory parts of the lungs. Also in this article, morphometric data on the thickness of the airborne membrane of animals are compiled, which directly depends on their environment.

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