UDC 617.764.1-008.8:612.08:599.323.4
DOI https://doi.org/10.33989/2022.8.1.275439

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THE SRUCTURE OF THE HARDERIAN, EXTRAORBITAL AND INFRAORBITAL LACRIMAL GLANDS DUCTS OF THE LABORATORY RATS

The aim of the study was to determine and compare the structure of the excretory ducts of the Harderian gland, extraorbital and infraorbital lacrimal glands of laboratory rats.

Object and methods. Five male laboratory rats were examined by dissecting the lacrimal glands, from which series of thin paraffin sections were obtained for histological examination. Micropreparations were stained with hematoxylin and eosin and examined under a light microscope.

Results. It was found that the tubuloalveolar epithelial components of the extraorbital gland of rats in the middle of the lobe are even denser than in the infraorbital gland, as evidenced by very narrow interstitial fissures. The lacrimal glands of laboratory rats have an individual well-defined connective tissue capsule. Inside the capsule and between the lobes there are slit-like interepithelial interstitial spaces, in which we don`t detect clusters of lipocytes, as occurs in the lacrimal glands of human. In the volume of lobes, both extraorbital and infraorbital glands, the interepithelial interstitial spaces contain vessels of the hemomicrocirculatory tract, mainly capillaries, precapillary arterioles and postcapillary venules. Arterioles and venules are usually visualized outside the lobes in more pronounced interstitial spaces.

Key words: *The Harderian gland; infraorbital and extraorbital lacrimal glands; ductularization; harderization.*

Introduction. The Harderian gland is a gland of the ciliated membrane. It`s a paired exocrine gland in terrestrial animals (except primates, including humans) and secondary aquatic vertebrates. The Harderian glands are associated with the existence of ciliated membranes (third eyelid) in the inner (medial) corner of the eye of animals.

The size of the Harderian gland is larger than the lacrimal gland, but the secretion differs in the content of lipids, a thin layer of which is located on top of the tear film, reduces its evaporation in terrestrial animals and distinguishes it from water washing of the aquatic animals. The color of the secretion of this gland is whitish, has an alkaline reaction, and its duct opens on the inner surface of the lower edge of the third eyelid (Hryn et al., 2017; Katsenko et al., 2019; Каценко и др., 2018).

The Harderian gland was first described in 1694 by the Swiss anatomist Johann Jakob Harder in deer.The Harderian glands are located in the inner corner of the orbit of vertebrates (reptiles, amphibians, birds and mammals), which have a ciliary membrane (other names: the third eyelid). The Harderian glands are most developed in ungulates and rodents. Humans and primates don`t have these glands, or rather they are, but they are in a rudimentary state and don`t perform any function **(Fig. 1).**

The Harderian glands are glands of the external secretion (exocrine glands). The secretion of these glands can get into the eyes, eyelids, and through the nasolacrimal duct into the nasal passages. The Harderian glands produce mainly lipids, which are used to lubricate and moisturize the eyes and blinking membranes. In rats, in addition to lipids, the glands produce melatonin and are a source of porphyrin (Reis Edmyr Rosa dos, Nicola Ester Maria Danielli, & Nicola Jorge Humberto, 2005).

The aim of investigation was to determine and compare the structure of the Harderian gland, extraorbital and infraorbital lacrimal glands excretory ducts of the laboratory rats.

Material and methods. Five adult male laboratory rats were examined by dissecting the lacrimal glands, from which a series of thin 4 μm paraffin sections were obtained for histological examination. Micropreparations were stained with hematoxylin and eosin and examined under a light microscope.

Prior to that, all animals were in the standard conditions of the experimental biological clinic (vivarium) of Poltava State Medical University, according to the rules of keeping experimental animals established by the Directive of the European Parliament and the Council (2010/63 / EU), order of the Ministry of Education and Science, Youth and Sports Of Ukraine dated 01.03.2012 No. 249 "On approval of the procedure for conducting scientific experiments on animals" and "General ethical principles of animal experiments", adopted by the Fifth National Congress of Bioethics (Kyiv, 2013).

Removal of the Harderian gland for further study begins with a paired incision on both sides with a length of about 4 mm, starting from the corners of the eye outwards and inwards. Tweezers expand the study field and remove the eyeball. Anatomical tweezers are used to remove the circular muscles of the eye that are attached to the eyeball and the optic nerve. The fascia, which lines the entire cavity of the orbit, is removed and the gland is visualized. Around the gland is the circular muscle, due to the fascia of which the Harderian gland is tightly fixed. The glandular tissue is carefully dissected with a scalpel or surgical scissors and removed by a single complex formed by the Harderian gland and infraorbital lacrimal glands. The Harderian gland is located in the lower pole relative to the orbit and is separated from the infraorbital gland by a thin isthmus (Шерстюк та ін., 2017; Svintsytska, & Hryn, 2016).

Results and discussion. We found that the tubuloalveolar epithelial components of the extraorbital gland of rats inside the lobe are even denser than in the infraorbital gland, as evidenced by very narrow interstitial lumens. The lacrimal glands of laboratory rats have an individual distinct connective tissue capsule. Inside and between the lobes in their interstitial spaces, we found no accumulation of lipocytes as occurs in the human lacrimal glands. In the volume of the lobes of the Harderian gland, extraorbital and infraorbital glands, the interpithelial interstitial spaces contain vessels of the hemomicrocirculatory tract, mainly capillaries, precapillary arterioles and postcapillary venules. Arterioles and venules are usually visualized outside the lobes in more pronounced interstitial spaces (Reis Edmyr Rosa dos, Nicola Ester Maria Danielli, & Nicola Jorge Humberto, 2005; Каценко та ін., 2020; Шерстюк та ін., 2020).

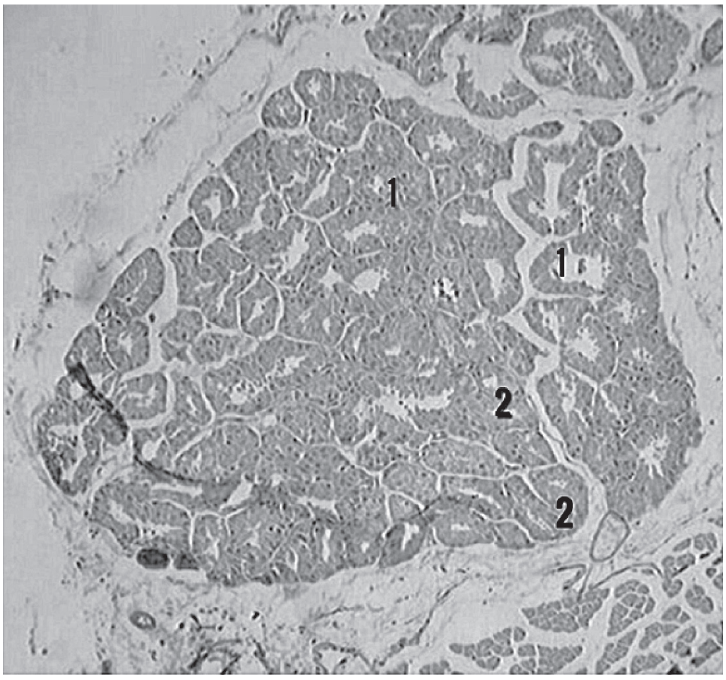

Fig. 1. ***The Harderian gland. Thin paraffin section, staining with hematoxylin and eosin, x 40. 1 – lacrimal ducts; 2 – terminal divisions of the lacrimal ducts.***

Another interesting fact is that with age, the parenchyma and stroma of the lacrimal glands of rats undergo changes that involve the transformation of the parenchyma, in particular its acinuses, which are visually similar to the acinus of the Harderian glands. This transformation of the structure of the lacrimal glands is called in the scientific literature "harderization". It should be noted that this transformation of the structure is practically not described by researchers.

In addition, with age, rats change the shape of the epithelial excretory ducts, the disappearance of their terminal extensions and giving them the shape of tubes. These morphological transformations of the shape of the excretory ducts are morphologically called "ductularization". At the same time in the stroma of the lacrimal glands of rats with the processes of aging there are phenomena similar to the phenomena occurring in the glands of the elderly, namely: lymphocytic infiltration and fibrosis, which cause aging of the lacrimal apparatus of the human eye "dry eye" (Шерстюк, Свінцицька, & Пілюгін, 2009a; Шерстюк, Свинцицкая, & Пилюгин, 2009b; Шерстюк та ін., 2016a).

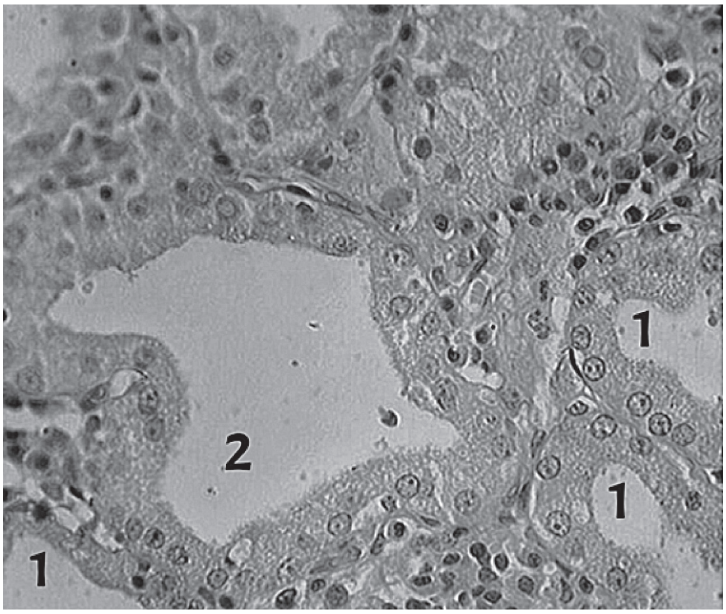

Fig. 2. ***Infraorbital lacrimal gland of the laboratory rat. Thin paraffin section, staining with hematoxylin and eosin, x 400. 1 – terminal divisions; 2 – excretory duct.***

In our previous works, we compared and summarized the data obtained by studying the three-dimensional organization of the glandular epithelium of functionally homogeneous human lacrimal glands (palpebral and orbital lobes). This is what requires us to maintain the same methodological principle when studying the lacrimal glands of laboratory rats (the Harderian gland, extraorbital and infraorbital glands). In our research, we proceeded from the fact that the lacrimal gland of rats, like humans, is a polymeric organ that has its own specifics of syntopic relationships in three-dimensional space. Therefore, at the beginning of the study, we needed to identify the level of structural organization of the lacrimal gland tissues of laboratory rats, which would correspond to the concept of structural and functional unit. To do this, it was necessary to study both the organization of the excretory duct system and the structure of the bloodstream of a particular part of the gland and it as a whole **(Fig.2)** (Пилюгин и др., 2008; Driss Zoukhri et al., 2008).

Myoepithelial cells are well visualized on our drugs. They surround the secretory departments and excretory ducts of the glands. The cells are able to shrink and provid secretion from the final department **(Fig. 3)**.

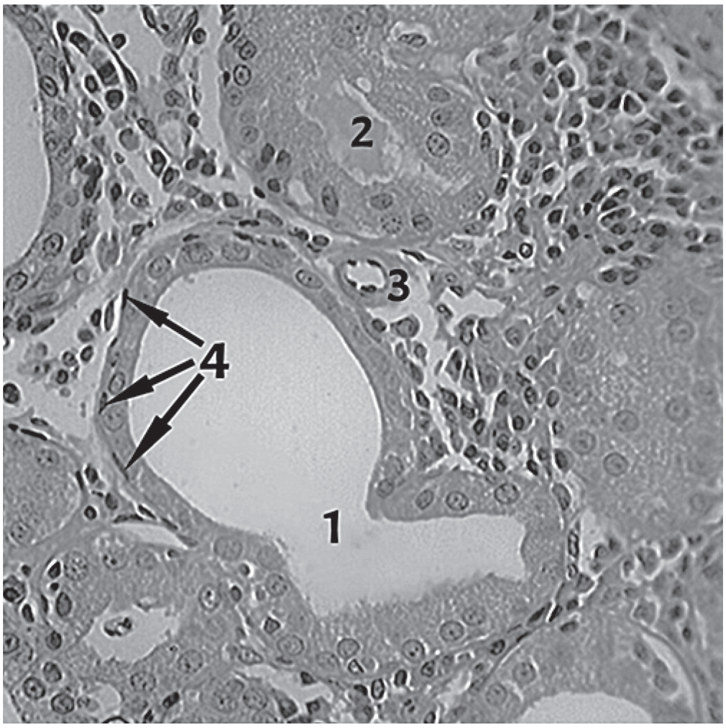

Fig. 3. ***Infraorbital gland of the laboratory rat. Thin paraffin section, staining with hematoxylin and eosin, x 400. 1 – place of ducts fusion; 2 – terminal division; 3 – blood vessel (precapillary arteriole;. 4 – nuclei of myoepithelial cells.***

From the studied glands of laboratory rats, it is possible to allocate some aggre-

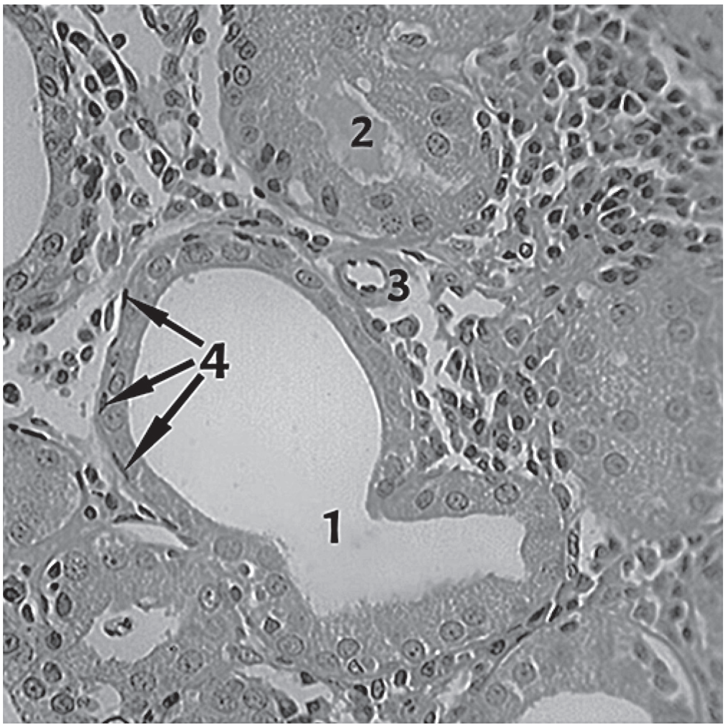

Fig. 3. ***Infraorbital gland of the laboratory rat. Thin paraffin section, staining with hematoxylin and eosin, x 400. 1 – place of ducts fusion; 2 – terminal division; 3 – blood vessel (precapillary arteriole;. 4 – nuclei of myoepithelial cells.***

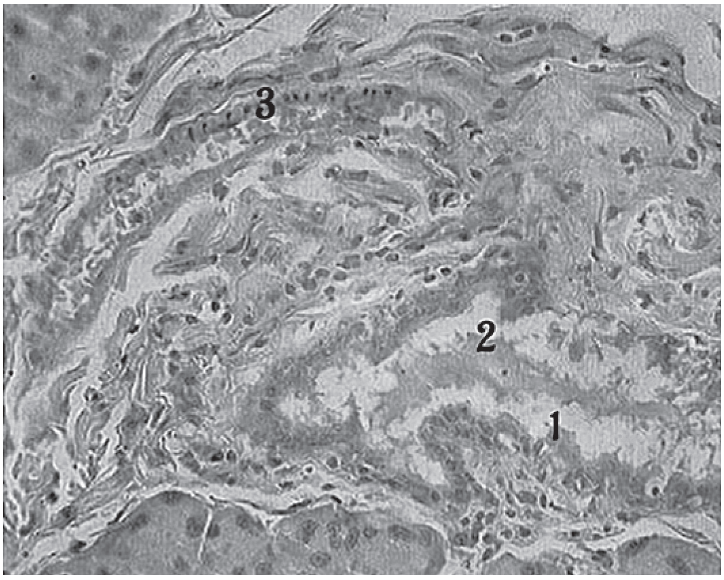

Fig. 4. ***Extraorbital gland of the laboratory rat. Thin paraffin section, staining with hematoxylin and eosin, x 400. 1 – intralobe lacrimal duct; 2 – secret in the lumen of the duct; 3 – blood vessel (arteriole).***

gates within one lobe, lacrimal excretory ducts at them of the smallest diameter. They end with the terminal extensions.

The cavities of the terminal divisions of both the extraorbital and infraorbital lacrimal glands of laboratory rats are connected to the cavity of only one excretory tube of the smallest caliber. These smallest ducts, merging, form ducts of larger diameter, which are localized within the volume occupied by the lobe. The fusion forms the duct of the lobe of the gland. Such ducts are able to integrate a different number of tubuloalveolar aggregates, which resemble a typical adenomer (sublobule unit) of the human lacrimal glands (Maryinak et al., 2021; Шерстюк та ін., 2016).

Analysis of a series of thin successive paraffin sections and decomposition analysis of photoreconstructions allows us to conclude that the individual lacrimal glands of laboratory rats (extra- and infraorbital) consist of numerous lobes that have almost the same principle of organization as the lobes of human lacrimal glands. Each lobe has several axial excretory intralobe ducts. Their branches are surrounded by secretory epithelial components in the form of terminal divisions and the corresponding smallest terminal lacrimal ducts.

The longest and largest ducts of the rat lacrimal glands are located outside the adenomers. As a result of this structure, in some histological sections we see only relatively large lumens of ducts and their walls, and in others – ducts of small diameter, up to their final bag-like expansions, which form clusters (adenomers of lobes) **(Fig. 4).**

To the elementary level of organization of the structure of the lacrimal glands, we have attributed the set of final extensions and their corresponding ducts, which is united by one duct, which first performs a collector function in the secretion current. Such a duct in rats is the intralobular duct. In the lobule there are several centrally located tubuloalveolar elementary units, namely, intralobular ducts (Каценко, 2021; Bannier-Hélaouët et al., 2021).

Conclusions. 1. The epithelial tubular structures of the lacrimal gland of a laboratory rat form a complex-branched system of excretory ducts, in which there are no typical plug-in ducts, which would be the connecting component between the end section and the excretory duct system.

2. The absence of insertion ducts leads to a change in the appearance on histological preparations of tubuloacinar aggregates of the lacrimal glands of rats in favor of tubuloalveolar assemblages.

3. Among the excretory ducts of the lacrimal glands of the laboratory rat can be distinguished: intra-lobular, lobular and common excretory ducts, through which the secretion is secreted. The common ducts of the extra- and infraorbital lacrimal glands, as a rule, combine to form their common duct.

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БУДОВА ПРОТОК ГАРДЕРОВОЇ, ЕКСТРАОРБІТАЛЬНОЇ ТА ІНФРАОРБІТАЛЬНОЇ СЛЬОЗОВИХ ЗАЛОЗ ЛАБОРАТОРНИХ ЩУРІВ

Мета дослідження. З’ясувати та порівняти будову екскреторних проток Гардерової, екстра- та інфраорбітальної сльозових залоз лабораторного щура.

Об’єкт і методи. Було досліджено 5 лабораторних щурів самців шляхом препарування сльозових залоз, з яких для гістологічного дослідження отримали серії тонких парафінових зрізів. Мікропрепарати фарбували гематоксиліном та еозином та досліджували під світловим мікроскопом.

Результати. Встановлено, що трубчасто-альвеолярні епітеліальні компоненти екстраорбітальної залози щурів всередині часточки розташовані навіть щільніше, ніж в інфраорбітальній залозі, про що свідчать дуже вузькі інтерстиціальні щілини. Сльозові залози лабораторних щурів мають індивідуальну чітко окреслену сполучнотканинну капсулу. Всередині капсули і між часточками є щілиноподібні міжепітеліальні інтерстиціальні простори, в яких ми не виявляємо скупчення ліпоцитів, як це відбувається в сльозових залозах людини.

В об'ємі часток, як екстраорбітальної та інфраорбітальної залози, міжепітеліальні інтерстиціальні простори містять судини гемомікроциркуляторного русла, переважно капіляри, прекапілярні артеріоли та посткапілярні венули. Артеріоли і венули зазвичай візуалізуються за межами часток у більш виражених інтерстиціальних просторах.

Ключові слова: *Гардерова залоза; інфраорбітальна і екстраорбітальна сльозові залози; дуктуляризація; гардеризація.*

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Отримано 09.06.2022