MORPHOLOGY OF OCULAR SYSTEM OF DOMESTIC ANIMALS

MORFOLOGIA DO SISTEMA OCULAR DOS ANIMAIS DOMÉSTICOS

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SUMMARY

A literature review on the structures that compose the ocular system of domestic animals is presented in this study. The eyeball is a specialized organ whose primary function is to capture and focus the light onto the photosensitive retina. It comprises three concentrically arranged layers: an outer layer or fibrous tunic, containing the sclera and cornea; a middle coat or vascular layer, comprising the choroid, ciliary body and iris; and the inner coat or nervous layer, which is formed by the retina. In addition, there are the lens and the structures that protect and move the eyeball, such as the orbital fascia, ocular muscles, eyelids, conjunctiva and lacrimal apparatus. Each component can be affected by various diseases, which the veterinarian should be able to intervene in order to preserve this important sense organ.

KEY-WORDS: Eyeball. Veterinary Ophthalmology. Vision.

RESUMO

Este trabalho teve como objetivo realizar uma revisão de literatura sobre as estruturas que compõem o sistema ocular dos animais domésticos. O bulbo ocular é um órgão especializado cuja função primária consiste em captar e focalizar a luz sobre a retina fotossensível. É formado por três túnicas dispostas concentricamente: a camada externa ou túnica fibrosa, que consiste em esclera e córnea; a camada média ou túnica vascular, constituída pela coróide, pelo corpo ciliar e pela íris; e a camada interna ou túnica nervosa, que é formada pela retina. Além desses envoltórios, há o cristalino ou lente e as estruturas que protegem e move o bulbo do olho, que são as fáscias orbitárias, os músculos oculares, as pálpebras, a conjuntiva e o aparelho lacrimal. Cada componente pode ser acometido por afecções diversas, as quais o médico veterinário deve estar apto a intervir, a fim de preservar esse importante órgão do sentido.

PALAVRAS-CHAVE: Bulbo ocular. Oftalmologia veterinária. Visão.

INTRODUCTION

There are many records addressing the origin of veterinary ophthalmology and throughout history, man has been expressing concern regarding vision. At each development stage of science, interpreted with peculiar religious involvement, the study of the vision had great scientific importance (TRAMONTIN, 2010).

The visual system is the sensory organ that the animal should endanger less, and is commonly involved in various clinical diseases (CUNNINGHAM, 2004). Over the past 300 years, new discoveries and published studies allowed better eye examinations while bringing great advances in the field (TRAMONTIN, 2010).

Eye disease is relevant to those who are interested in veterinary ophthalmology since the eye exam is the direct observation of its rough condition, even if the ophthalmoscope is a microscope with low capacity to magnify the structures that make up the visual system (SLATTER, 2005). According to Lovato et al. (2005), the eye exam is important since many ocular disorders can lead to irreversible loss of sight and impaired aesthetics.

A complete ophthalmic examination can help in establishing a fast and accurate diagnosis for many

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ophthalmic and systemic diseases because the eye can be visualized up to the level of the posterior chamber where the orbit is partially exposed (GELATT, 2003). However, Lovato et al. (2005) highlighted the importance of primary health care that may assist the ophthalmologist in identifying diseases in early stages, facilitating early intervention with therapeutic measures for eye recovery.

According to Tramontin (2010), technological advances increasingly provide new techniques and discoveries in medicine, so further development of ophthalmology is expected over the years.

This study presents a literature review on the morphology of the structures that make up the visual system of domestic animals.

LITERATURE REVIEW

This work addresses the structures that make up the ocular system of domestic animals, such as dogs, cats, horses, cattle, goats, sheep and pigs, describing anatomically and histologically the three tunics that compose the eyeball and its attachments. The fibrous tunic, which consists of the cornea and sclera; the vascular tunic, composed of the choroid, ciliary body and iris; and the nervous tunic, which is formed by the retina are described. Additionally, the lens, the orbital fascia, ocular muscles, eyelids, conjunctiva and lacrimal apparatus are also described.

EYE

The eye is an organ whose primary function is to collect and focus light on the photosensitive retina. It lies within a cone-shaped cavity on the face, the orbit, which houses the eyeball and various other soft tissue structures and ocular adnexa, such as muscles and glands, which act on the functional eyeball (FRANDSON et al., 2005). The eye shape is essentially spherical due to the pressure generated by the aqueous humor and lack of elasticity of the cornea and sclera (CUNNINGHAM, 2004).

The eye develops from the neural tube ectoderm (neuroectoderm), mesoderm and surface ectoderm. The neuroectoderm gives rise to the retina and optic nerve while the mesoderm forms the remaining structures, except the lens, lacrimal glands and the epithelium of the conjunctival sac and eyelids, which are derived from the surface ectoderm (DYCE et al., 1997).

According to Dyce et al. (1997), the main irrigation of the eye is performed by the external ophthalmic artery, a branch derived from the maxillary artery, ventral to the orbit, to irrigate structures rostral to the face. The arteries that originate from the ophthalmic artery can be divided into the following three groups: those that irrigate the eyeball, those that irrigate the eye muscles and those that leave the orbit to irrigate adjacent structures.

The eye consists of three tunics concentrically arranged: the outer layer (fibrous tunic), the middle layer (vascular tunic) and the inner layer (tunica nervosa) (JUNQUEIRA & CARNEIRO, 2004).

The fibrous tunic consists of sclera and cornea, which are in the limbus, and is composed of very dense collagen tissue that, resisting the internal pressure, gives firmness and shape to the eye (DYCE et al. 1997).

The middle layer (vascular tunic) consists of the choroid, the ciliary body and the iris (JUNQUEIRA & CARNEIRO, 2004). It is also known as uvea and is situated deeply to the sclera, where is fixed (DYCE et al. 1997).

The inner layer (tunic nervosa) or retina is the innermost layer and communicates with the brain by the optic nerve. In addition to these wrappers, the eye has the lens, a transparent, biconvex structure which is held in position through a circular ligament, the ciliary zonule, which is inserted over a thickened middle layer that covers partially the iris (JUNQUEIRA & CARNEIRO, 2004).

The visual system captures and focuses the light on the photoreceptors, transducers that convert light into electrical impulses sending it through the visual cortex, where the sensation of vision occurs. Homeostatic and anatomical mechanisms, which refine and protect the system, vary among species, depending on their functional needs (SLATTER, 2005).

The electrical information generated by exposure of photoreceptors to light undergoes initial neural processing within the retina. Lastly, this information leaves the eye through the optic nerve, in whose fibers are the axons of retinal ganglion cells. Most axons of the optic nerve make synapse in the thalamus, and from there the visual information goes to the primary visual cortex in the occipital lobe of the brain for conscious perception (FRANDSON et al., 2005).

The structures that protect and move the eyeball include orbital fascia, ocular muscles, the eyelids, conjunctiva, and the lacrimal apparatus; most of these structures are contained within the orbit (DYCE et al., 1997).

ORBIT

Orbit is the bone structure of the skull that contains the eye or ocular structures and their surrounding soft tissue (BROOKS, 2005). Domestic animals display two orbital patterns, incomplete, like in dogs and cats and complete, like in horses, cattle, goats and pigs (Figure 1). The orbit separates the eye from the cranial cavity while foramina and fissures on the walls determine the pathways of blood vessels and nerves from the brain to the eye (GELATT, 2003).

The orbit consists of frontal, lacrimal, sphenoid, zygomatic, palatine and maxilla bone. Three bone processes, the zygomatic process of the frontal bone, the frontal process of the zygomatic bone and the zygomatic process of the temporal bone, play a role in the formation of the lateral bone wall of the orbit (GETTY, 1986).

The location of the orbits inside the skull determines the degree of binocular vision. Animals with laterally placed orbits, like horses, have a reduced binocular vision and depth perception in relation to

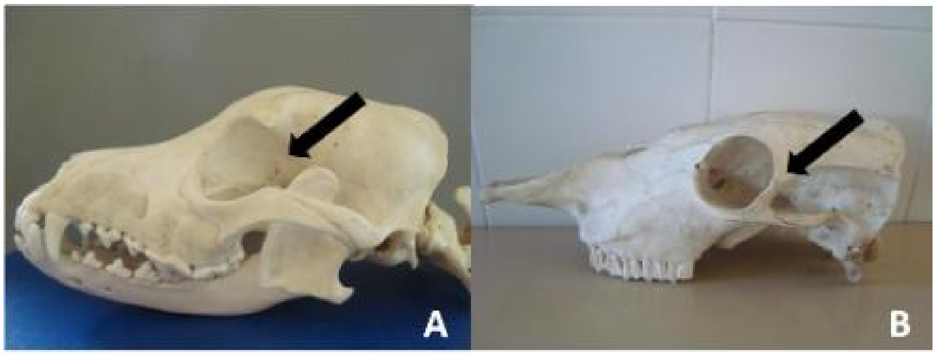

Figure 1 - Dog skull (A) showing the incomplete orbit (arrow) and cattle skull (B), which illustrates the orbit (arrow).

Source: SA, 2012. Laboratory of Experimental Ophthalmology - UFRPE.

animals with eyes more frontally placed, like cats and dogs (BROOKS, 2005).

Unlike the human orbits, which are conical, four-sided pyramidal cavities, the ventral portion of the orbit of the domestic species is limited by soft tissues, notably the pterygoid muscles (FRANDSON et al., 2005). According to Brooks (2005), the orbit area behind the ocular bulb is called retrobulbar. The periorbital area indicates the area around the orbit, including the eyelids, soft tissue and skull.

SCLERA

The sclera is the major part of the fibrous tunic of the eye (SLATTER, 2005). It is white, sometimes gray or blue, and meets the cornea in a transitional region called limbus (FRANDSON et al., 2005). It is tough and elastic since its main function is to protect the intraocular contents (VIETH, et al., 1995; URBAN et al., 2002).

The axons of the optic nerve pierce the sclera at the posterior pole of the eye, the cribriform area. The sclera is the insertion site of the extraocular muscles of the eye (FRANDSON et al., 2005) while innervation occurs due to long and short posterior ciliary nerves, trigeminal branches (URBANO et al., 2002).

According Dyce et al. (1997), the sclera is perforated by several small ciliary arteries and larger vorticose veins. It is covered by a thin membrane, sheath bulb, separating it from the retrobulbar fat, providing a cavity where the bulb can move.

The sclera layers are episclera, stroma and lamina fusca. The episclera is composed of dense vascular connective tissue that originates from the surface scleral stroma and episcleral blade that covers it. The scleral stroma consists of collagen fibers arranged in an uneven checkerboard pattern parallel to the surface of the globe. The lamina fusca innermost layer is in close contact with the uvea and presents pigmented cells (URBAN et al. 2002).

LIMBUS

The limbus is the transition zone between the cornea and sclera. The homogeneous and transparent corneal collagen becomes opaque and fibrous (JUNQUEIRA & CARNEIRO, 2004). The limbus, cornea, sclera, conjunctiva and the episcleral blade are overlapped and adhered in the region where they meet (VIETH et al., 1995). In this highly vascularized zone, there are blood vessels that play an important role in inflammatory processes of the cornea (JUNQUEIRA & CARNEIRO, 2004).

According to Brooks (2005), limbal stem cells are stimulated to form the corneal epithelium during the corneal ulceration. Inflammatory cells and blood vessels penetrate the cornea through the limbus.

CORNEA

The cornea is the transparent front layer of the fibrous tunic and the most powerful refractory layer of the eye. Transparency and regular curvature are essential to focus light on the retina (FRANDSON et al., 2005). Because it is avascular; it receives nutrients through the vessels of the limbus and the fluid from the anterior chamber (JUNQUEIRA & CARNEIRO, 2004).

Despite careful distribution of the fibers, corneal transparency is not only a structural phenomenon but also depends on the physiological and continuous pumping of interstitial fluids, a process located in the posterior epithelium (DYCE et al., 1997). According to Turner (2010), the corneal endothelium has pumps to remove excess fluid, which leaves the cornea relatively dehydrated and also helps to maintain transparency. If this pump fails, dense corneal edema may occur, leading to bluish-gray coloration of the cornea and increasing thickness.

A cross-section of the cornea shows five distinct regions: the tear film; the corneal epithelium, which is non-keratinized stratified squamous and its basement membrane; the corneal stroma, which is composed of fibrocytes, keratocytes, collagen and ground substance;

the Descemet's membrane, which is the endothelial basement membrane; and, the corneal endothelium, which has the thickness of a cell, and is located subsequent to the Descemet’s membrane (SLATTER, 2005).

The corneal surface is very sensitive, as it is densely innervated with sensory nerve fibers close to the anterior epithelium. These innervations emerge from the long ciliary nerves, which are branches of the ophthalmic nerve. Their axons form the afferent branch of the corneal reflex, which closes the lids when the cornea is touched (DYCE et al., 1997).

CHOROID

The choroid is an intermediate layer located between the sclera and retina (VIETH et al., 1995), which is at the rear of the vascular tunic. It is highly vascularized and has multiple layers. The deepest layer is the *tapetum,* which is a reflective surface designed to pop up the light entering in the retina, thus increasing the dim light vision (FRANDSON et al., 2005).

The loose connective tissue between choroidal vessels is rich in cells, collagen and elastic fibers. Cells containing melanin pigment, which confer dark color to this layer, are frequently observed (JUNQUEIRA & CARNEIRO, 2004). The vessels network in the choroid is irrigated by the posterior ciliary arteries and drained by vorticose veins (DYCE et al., 1997) while the choroid is responsible for feeding the external part of the retina (VIETH et al., 1995).

In the dorsal part of the eye, the choroid forms a slightly reflective area of varied coloration, known as *tapetum lucidum*. The *tapetum* cells contain crystalline rods arranged so that light falling on them is divided into its components, resulting in characteristic iridescence (DYCE et al., 1997).

CILIARY BODY

The ciliary body is a circumferential thickening of the vascular tunic that gives rise to many fine suspensory ligaments that support the lens. It is involved with the accommodation of the lens and is responsible for the production of aqueous humor in the anterior segment of the eye bulb (FRANDSON et al., 2005).

According to Gelatt (2003), the ciliary body is macroscopically divided into: pleated anterior part, iris crown and posterior flat part. The outer most anterior part of the ciliary body forms the ciliary slit. It is shaped like a ring with ridges radiating towards the lens, in the center, and before the ring continues with the iris (DYCE et al., 1997).

The adult ciliary body is constituted by two layers of epithelium. The non-pigmented inner layer is closest to the vitreous while the outer layer is pigmented. The pigmented layer is continuous to the retinal pigment epithelium (SLATTER, 2005).

The ciliary body coating consists of a bicellular epithelial layer whose basic component is the connective tissue within which lies the ciliary muscle. This muscle is constituted by three smooth muscle fiber bundles which insert in the sclera on one side and in different regions of the ciliary body, on the other side. One of these bundles has the function of distending the choroid while the other, when contracted, relaxes the tension of the lens (JUNQUEIRA & CARNEIRO, 2004).

IRIS

The iris is the most anterior portion of the vascular tunic (VIETH et al., 1995), it consists of a pigmented ring that sits between the cornea and the lens, whose primary function is to control the light entering the eye through the pupil (FERRAREZI, 2010). According to Brooks (2005), pupil size changes as the intensity of the ambient light varies, constricted and dilated in bright and low light, respectively, thus controlling the amount of light entering the eye.

The pupillary edge has a smooth sphincter muscle responsible for the contraction of the pupil, and a myoepithelial structure, radially arranged, which helps to dilate the pupil. The iris motor innervation is autonomous, with adrenergic and cholinergic fibers innervating both the sphincter and the dilator muscle of the pupil, although the first is assigned the predominance of a parasympathetic innervation and the second, to the maintenance of the tonicity, a sympathetic innervation (BICAS, 1997).

According to Dyce et al. (1997), the iris is a flat ring of tissue attached, at its periphery, to the sclera by the pectineal ligament and ciliary body. The iris divides the space between the cornea and the lens in the anterior and posterior chambers, respectively, which communicate through the pupil. Both are filled by the aqueous humor. The place where the anterior surface of the iris meets the fibrous tunic is the iridocorneal angle, where the aqueous humor produced by the ciliary body is reabsorbed in the venous circulation (FRANDSON et al., 2005).

The anterior surface of the iris is lined with simple squamous epithelium, the continuation of the corneal endothelium. A slightly vascularized connective tissue follows with few fibers, large quantities of pigment cells and fibroblasts, followed by a layer rich in blood vessels embedded in loose connective tissue. The posterior surface is covered by the same epithelial layer overlying the ciliary body, and in this region the layer is richer in melanin (JUNQUEIRA & CARNEIRO, 2004).

AQUEOUS HUMOR

The aqueous humor is a transparent liquid found in the anterior and posterior chambers of the eye. The production and absorption rates are high enough to replenish the total volume of the chambers, several times a day (CUNNINGHAM, 2004). In healthy animals, the production rate is proportional to the drainage rate while keeping a constant pressure (DYCE et al., 1997).

The secretion of aqueous humor is performed by the ciliary process of the ciliary body. The material flows from the posterior to the anterior chamber through the pupil and is absorbed by the venous system in the angle between the cornea and the iris (CUNNINGHAM, 2004). The aqueous humor is drained into the venous system by the canal of Schlemm, the irregular edge canal in the corneal stroma. This is possible due to the presence of a system of labyrinth spaces, the Fontana spaces, which extend from the cornea endothelium to the canal of Schlemm (JUNQUEIRA & CARNEIRO, 2004).

VITREOUS

The vitreous humor is an acellular gel that fills the vitreous chamber, the space between the lens and the optic disc (FRANDSON et al., 2005), and consists primarily of water, hyaluronic acid and collagen fibrils. Transparent, it keeps the debris from embryonic vitreous, hyaloid artery, and squamous cells of the anterior uvea and retina (BICAS, 1997).

Unlike the aqueous humor, the vitreous humor is not continuously replenished, having a constant volume (DYCE et al. 1997). It forms one of the refractive media of the eye and provides the necessary pressure to properly position the retina against the pigmented epithelium (Gelatt, 2003).

According to Dyce et al. (1997), the lens in the embryo is nourished by the hyaloid artery, a branch of the central retinal artery which passes through the vitreous body. The artery usually degenerates after birth and the lens is then nourished by diffusion.

RETINA

The retina is the most complex structure of the eye; it converts light energy into chemical energy to generate the electrical signal that is carried to the brain. It is the most metabolically active tissue in the body (per unit weight), as indicated by oxygen consumption, and choroidal circulation supplies the entire peripheral retina and the retinal layers in the vicinity of the optic disc (BROOKS, 2005).

According to Brooks (2005), the retina is classically described as a structure of ten layers, which are from outer (sclera) to inner (vitreous): retinal pigment epithelium (not pigmented in the tapetal region); rod and cone photoreceptors; external limiting membrane; outer nuclear layer (contains rods and cones cell bodies); outer plexiform layer (synapse layer between photoreceptor axons and dendrites of bipolar and horizontal cells); inner nuclear layer (contains the cell bodies of bipolar, horizontal, ganglion and Müller cells); inner plexiform layer (synapse layer between the inner nuclear layer and ganglion cells); ganglion cell layer (a single layer of cells whose axons form the optic nerve); nervous fiber layer (contains the axons of ganglion cells); and, the internal limiting membrane (separates the retina from the vitreous).

The inner or nervous layer of the eye contains photosensitive receptor cells and is known as the retina. It is an extension of the brain, which remains connected through the optic nerve. The retina begins where the optic nerve penetrates the choroid, shaped as a concave cup, covers the choroid and ends at the pupillary edge. Only the posterior two thirds of the retina can be affected by the light entering the pupil (DYCE et al., 1997).

Retinal blood vessels are visible through an ophthalmoscope on the surface of the retina. They form a network of arteries and veins that enter the retina through the optic disk and supply increased retinal nutrition while the remainder is supplied by choroidal vessels (CUNNINGHAM, 2004).

OPTICAL DISC

The axons of the ganglion cells of the retina leave the eye via the so-called optical disk to form the optic nerve, which is usually round, but may also be elliptical (BICAS, 1997). There are no photoreceptors in the optical disk, which makes this region completely blind (RAMOS, 2006).

Arterioles and venules emerge from the optic disc, spreading in several specific patterns for each species to nourish and drain the retina. The arterioles are branches of central retinal artery (DYCE et al. 1997).

OPTIC NERVE

The innervation of the eye and its accessory structures originate in six or more cranial nerves. The majority of them enter the orbital cone, but some reach directly the accessory structures (DYCE et al., 1997).

The optic nerve is a cranial nerve formed from the optical disc; the two optic nerves have more axons than all the dorsal roots of the spinal cord together (CUNNINGHAM, 2004). Composed primarily of axons of retinal ganglion cells, the optic nerve connects the retina to the visual and non-visual centers in the brain (BROOKS, 2005).

The optic nerve begins as a single layer of cells with a central lumen. The nerve fibers, which originate from the ganglion cells in the inner neuroblastic layer, grow toward the optic stalk, forming the nerve fiber layer of the retina and finally the optic nerve (SLATTER, 2005).

According to Dyce et al. (1997), the optic nerve enters the orbit through the optical foramen towards the photoreceptor cells of the retina. It is very loose in order to enable eye movements, and coated by meninges, acquired during its development as the stem of the optic cup (Figure 2).

LENS

The lens is a transparent, biconvex, proteinaceous disk suspended between the posterior chamber and the vitreous. It is surrounded by an elastic capsule which serves as the attachment site by the suspensory ligaments at the lens equator (FRANDSON et al., 2005).

The lens is composed of three parts, the lens fibers, long thin prismatic elements; the lens capsule, an acellular coating that is homogeneous, hyaline and thicker in the anterior lens epithelium; and, the subcapsular epithelium, a single layer of cuboidal epithelial cells present only at the anterior portion of the lens (JUNQUEIRA & CARNEIRO, 2004).

The lens, unlike its adjacent liquid is a solid structure, but elastic enough to change its shape. It is biconvex and has anterior and posterior pole, equator and a central axis which coincides with the optical axis of the eye (DYCE et al., 1997). The lens depends on the aqueous humor for its nutrition and excretion, as the fiber and lens epithelial cells depend, almost exclusively, on the glucose metabolism which is contained in it for energy production (SHIMAMURA, 2008).

According to Junqueira & Carneiro (2004), the lens is held in position by a system of radially oriented fibers, called the ciliary zonule. The zonular fibers insert on one side into the lens capsule and on the other, into the ciliary body. The lens capsule is elastic and under permanent tension and would assume a more spherical shape without the opposition exerted on the periphery (DYCE et al., 1997).

The sight of objects at small and large distances is related to the shape of the lens. To view objects more than six meters away, the suspensory ligaments exert traction on the equatorial region of the lens, due to a relaxation of the ciliary muscles of the ciliary body, causing anteroposterior flattening of the lens which reduces the refraction of rays. For objects closer to the eye, the lens assumes a more spherical shape due to decreasing traction on the suspensory ligaments caused by contraction of the ciliary muscles of the ciliary body (CUNNINGHAM, 2004).

EYELIDS

According to Frandson et al. (2005), the eyelids are formed by two moving folds of skin, one upper and one lower, and the gap between them is the palpebral fissure. They offer mechanical protection and have specialized structures to protect the eyeball as cilia and mucus-producing glands (LUCCI et al., 2006; NARIKAWA et al., 2007).

The eyelids emerge from the orbital bone edges and, like curtains, are intermittently directed over the exposed portion of the eye and remain closed during sleep, when sight is not required (DYCE et al., 1997).

The cilia are present on the outer surface of the upper eyelid edge in dogs, horses, cattle, pigs and sheep. Few cilia are present in the lower eyelid of horses, cattle and sheep while cats have no cilia (SLATTER, 2005).

The eyelid movement is caused by its own muscles while the muscle responsible for eyelid closure is innervated by the facial nerve (VIETH et al., 1995). The closure of the palpebral fissure physically protects the cornea from trauma and is also involved in the production, distribution and drainage of the corneal tear film. In addition, the eyelids help remove foreign bodies and oxygenate the cornea (SLATTER, 2005).

According to Rito (2009), the surface ectoderm gives rise to eyelid structures like skin, cilia and conjunctival epithelium. The mesenchyme of the neural crest gives rise to deeper structures such as dermis and tarsus. The upper eyelid develops from the frontonasal process and the lower eyelid from the maxillary process.

Getty (1986) states that the innervation of the upper lid is made by the infratrochlear nerve that distributes in the skin of the medial portion of the upper eyelid and the adjacent area, runs dorsorostral and then, ventral to the oblique dorsal muscle (Figure 3).

The histological constitution of the eyelids, from outside to inside, starts with the skin formed by keratinized stratified squamous epithelium and dermis of the connective tissue. This dense connective tissue forms the palpebral plate where the eyelid sebaceous glands are found while the mucosa consists of a stratified prismatic epithelium (JUNQUEIRA & CARNEIRO, 2004).

THIRD EYELID

Gelatt (2003) reported that the nictitating membrane or third eyelid is a thin layer of tissue in the medial canthus of domestic animals. It is a mobile protection structure, located between the cornea and lower lid, in the nasal portion of the lower conjunctival sac. The muscles controlling the third eyelid are vestigial in domestic animals while the membrane moves passively on the eye when it is retracted by the eye retractor muscle (SLATTER, 2005).

The third eyelid gland is located on the inner surface of the third eyelid. The lacrimal gland is flat and tubuloalveolar and located on alveolar part of the eyeball (SLATTER, 2005).

CONJUNCTIVA

The conjunctiva is a mobile anatomical structure, semi-transparent and likely to be moist and shiny. It lines the inner surface of the eyelids, internal and external of the third eyelid and the anterior portion of the globe adjacent to the limbus. The space covered by the conjunctiva is called the conjunctival sac (SANTOS, 2011). Rito (2009) stated that it is abundantly supplied by blood and it is the only lymphatic drainage system of the eye.

The conjunctival epithelium has cubic stratification and its lamina propria consists of loose connective tissue (JUNQUEIRA & CARNEIRO, 2004).

EXTRAOCULAR MUSCLES

According to Getty (1986), the eye has several muscles external to the orbit, highlighting among them: the orbicularis oculi, the sphincter of the eyelids; the medial levator of the eye angle that runs from the nasofrontal fascia, rostromedially to join the orbicularis oculi muscle towards the medial corner and lifts the medial portion of the upper eyelid; the lateral retractor muscle of the eye angle, which arises from the temporal fascia caudal to the lateral corner of the eye and runs rostrally as a narrow band that dips into the orbicularis oculi muscle; and, the malar muscle, which

Figure 2 - Optic nerve of a dog eye (arrow).
Source: SA, 2012. Laboratory of Experimental Ophthalmology - UFRPE.

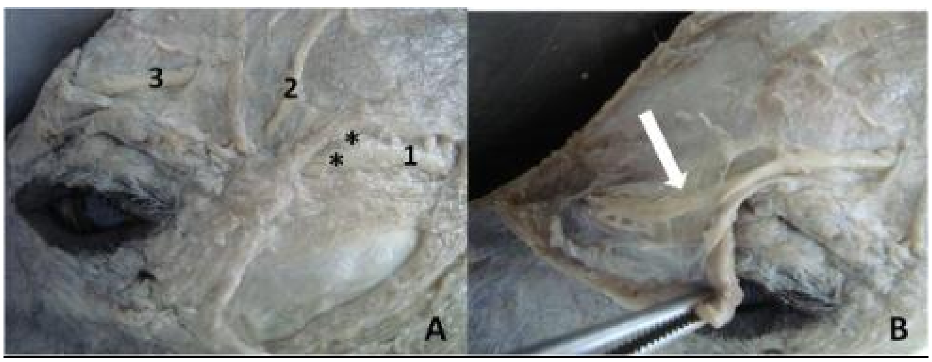

Figure 3 - A: zygomatic branch (1), palpebral branches of the zygomatic branch (*), lacrimal nerve (2) and nerve infratrochlear (3) of a dog. B: infratrochlear nerve (arrow) of a dog.
Source: SA, 2012. Laboratory of Experimental Ophthalmology - UFRPE.

Figure 4 - The internal muscles of the eye orbits of a dog, periorbital tissue (1), dorsal rectus muscle (2), lateral rectus muscle (3) and ventral rectus muscle (4).
Source: SA, 2012. Laboratory of Experimental Ophthalmology - UFRPE.

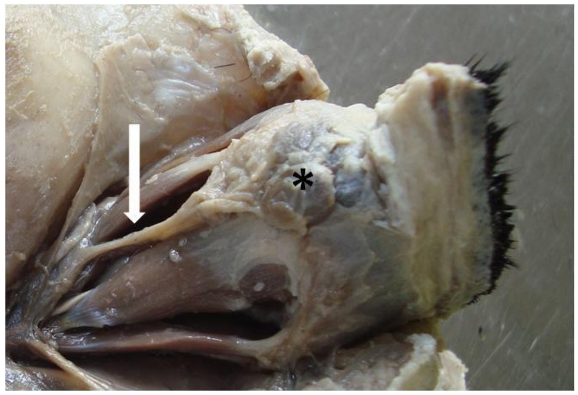

Figure 5 - Lacrimal gland (*) and the lacrimal nerve (arrow) of a dog.
Source: SA, 2012. Laboratory of Experimental Ophthalmology - UFRPE.

consists of vertical fibers that open the lower eyelid and acts to depress it.

The muscles that move the eye are located behind the eyeball. All, except one, originate near the optic foramen, at the apex of the orbital cone (DYCE et al., 1997).

The extraocular muscles are formed by seven striated muscles that give movement to the eyeball, the bulb retractor muscle; oblique dorsal and ventral muscles; and, the rectus dorsal, ventral, medial and lateral muscles (Figure 4) (FRANDSON et al., 2005).

According to Dyce et al. (1997), all four recti muscles are inserted anterior to the equator, by means of wide but very thin tendons. The oblique muscles attach to the eyeball near the equator and, due to contraction, tend to rotate the eyeball around the visual axis. The retractor bulb emerges from the vicinity of the optic foramen, and is inserted in the eyeball posterior to the equator.

LACRIMAL APPARATUS

The lacrimal glands consist of serous cells that contain in the apex, secretory granules that stain weakly while the secretory portion is surrounded by myoepithelial cells. These glands produce a saline secretion with the same sodium chloride concentration of the blood, which is poor in protein and contains lysozyme, an enzyme that digests the capsule of certain bacteria (JUNQUEIRA & CARNEIRO, 2004).

The apparatus comprises a series of serous and seromucous lacrimal glands and systems of ducts that drain their secretion from the conjunctival sac (FRANDSON et al., 2005).

The lacrimal gland is flat, located between the eyeball and the dorsolateral wall of the orbit (DYCE et al., 1997). According to Cunningham (2004), it produces tears in response to parasympathetic nerve stimulation.

The lacrimal nerve arises from the ophthalmic nerve and runs rostrodorsal along the dorsal rectus muscle to finish in the lacrimal gland. It emerges from the orbit ligament and joins the zygomatic and frontal nerve in the formation of the auricular plexus; however, in some cases it may arise from the maxillary nerve (Figure 5) (GETTY, 1986).

The tear is drained through the lacrimal points and canalicuri and the nasolacrimal duct, which consist of mucosal stratified epithelium containing some mucous glands and hair cells that contribute to tear drainage (ROSA, 2011).

The tear film is a trilaminate bed essential for maintaining the integrity of the ocular surface (FONSECA, 2011). It is an essential layer of protection, whose disappearance leads to serious changes in the conjunctiva (SLATTER, 2005). According to Rite (2009), it is secreted by the lacrimal, tarsal and third eyelid glands, as well as the conjunctival goblet cells.

Dyce et al. (1997) described the three layers of the tear film. The outer lipid layer originates from the secretion of the tarsal glands and helps spread tears, slowing the dissolution of the film. The middle aqueous layer derived from the lacrimal glands, dampens and nourishes the cornea. Last, the innermost mucus layer produced by the goblet cells of the conjunctiva keeps the tear film very close to the cornea.

VISUAL FIELD

The eyes of domestic mammals protrude more from the face compared to primates, including man. The eye position on the head is related to the environment, habits and feeding methods. In general, predators have eyes at the front while preys have eyes placed laterally for greater peripheral or side vision (DYCE et al., 1997).

The portion of the environment from which the light enters the eyes and stimulates the retina is the visual field (FRANDSON et al., 2005). According to Slatter (2005), in prey animals, the eyes are positioned with divergent visual axes and the total visual field approaches 360°. The binocular field, the area where the light from a single object falls on both retinas, is relatively small, around 65°.

Predators on the other hand, have visual axis closer to parallel, more frontal eyes, larger binocular field, 85°, and, subsequently, a wider blind zone. The wide binocular field offers greater accuracy in depth perception and increased coordination with body movements (SLATTER, 2005).

CONCLUSION

The ocular system of domestic animals is composed by anatomical components which contribute to the visual function.

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