



ISSN: 0975-833X

Available online at <http://www.journalcra.com>

International Journal of Current Research

Vol. 16, Issue, 09, pp.30071-30086, September, 2024
DOI: <https://doi.org/10.24941/ijcr.47898.09.2024>

INTERNATIONAL JOURNAL
OF CURRENT RESEARCH

RESEARCH ARTICLE

A GENERAL OVERVIEW OF POULTRY HISTOLOGY

*Şerife Şeyda AYDEMİR

Aksaray University, Health Sciences Institute, Central Campus, Aksaray, Turkey

ARTICLE INFO

Article History:

Received 20th June, 2024

Received in revised form

19th July, 2024

Accepted 19th August, 2024

Published online 30th September, 2024

Key Words

Avian, Poultry, Bird, Histology.

*Corresponding author:

Şerife Şeyda AYDEMİR

ABSTRACT

Poultry are domesticated birds raised by humans for their eggs, meat, or feathers. The domestication of birds occurred several thousand years ago. This likely began as a result of humans collecting eggs from wild birds and raising the hatchlings, but eventually led to the practice of keeping these birds in captivity permanently. Selective breeding for traits such as rapid growth, egg-laying ability, conformation, feather quality, and temperament has occurred over centuries, resulting in modern breeds that often look very different from their wild ancestors. While some birds are still kept in small flocks within extensive systems, most of the poultry available on the market today are raised in intensive commercial operations. This review provides the histological features of poultry and a brief summary of studies conducted on poultry histology.

Copyright©2024, Şerife Şeyda AYDEMİR. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: Şerife Şeyda AYDEMİR. 2024. "A general overview of poultry histology". *International Journal of Current Research*, 16, (09), 30071-30086.

INTRODUCTION

Bird anatomy, or the physiological structure of birds' bodies, shows many unique adaptations that mostly aid in flight. Birds have a lightweight skeletal system and light but strong muscles, and these, along with circulatory and respiratory systems with very high metabolic rates and oxygen supply, allow the bird to fly.

Eye lens (Lens): The lens consists of lens capsule, subcapsular epithelium and lens body. The lens does not contain blood vessels and nerve fibers (Tekelioğlu, 2002). The lens capsule is a slightly thickened basement membrane on the anterior surface. Subcapsular epithelial cells (anterior lens cells) show high mitotic activity. These cells cover only the anterior "hemisphere" of the lens in adults. Subcapsular epithelial cells change shape at the equatorial part of the lens, lengthen and transform into lens fibrils. The lens body consists mainly of lens fibrils. Lens fibrils are very long (up to 12 mm) hexagonal cells. They are located just below the subcapsular epithelial cells. Older lens fibrils lose their nuclei. Lens fibrils are tightly bound together. They contain crystalline proteins in their cytoplasm. These proteins provide the lens with properties such as transparency and light refraction (Junqueira *et al*, 1995).

Poultry lenses are histologically distinguished from mammalian lenses by a circular pad around the center of the lens (Jones *et al*, 2007). This equatorial circular pad formed by modified lens fibers can be very important. There is a space between the center and the circular pad and it is filled with fluid (Kern, 2007; Ross and Pawlina, 2006). The posterior surface of the lens is flat or less curved, while the anterior surface is soft, flexible, transparent and biconvex (Kern, 2007). The primary function of the poultry lens is to send light to the retina, where the image is formed together with the cornea (Jones *et al*, 2007; Samuelson, 2007). The water content of the lens is 65% and the protein content is 35%. Dehydration and sodium-potassium transitions in the lens are carried out by the active sodium-potassium adenosine triphosphate pump in the subcapsular epithelial cells (Jones *et al*, 2007; Wheater *et al*, 1987). Diurnal bird species have a flatter lens surface compared to aquatic and nocturnal species. The lens capsule of poultry contains type IV collagen fibers (Jones *et al*, 2007). Kuloğlu (2016) reported that in the partridge (*Alectoris chukar*), the lens is surrounded by an outer capsule, with subcapsular epithelial cells just below this capsule and lens fibrils under the epithelial cells (Kuloğlu, 2016). Kuloğlu (2022) reported that the lens capsule contains acidic and neutral mucins in histochemical staining of the lens in the partridge.

She reported that the presence of acidic and neutral mucins may be effective in protecting the lens capsule against pathogens (Kuloğlu, 2022).

Conjunctiva: The conjunctiva, which develops from the ectoderm together with the eyelids in seven weeks, is a thin and transparent mucous membrane. It covers the posterior surface of the eyelids and the anterior surface of the sclera. It continues with the eyelid skin at the mucocutaneous junction at the lid margin and with the corneal epithelium at the limbus (Özer, 2010). The conjunctiva is a thin, transparent membrane that covers the part of the eye up to the cornea and the inner surface of the eyelids. This membrane prevents the eyelids from damaging the eyeball during movement and keeps the inner part of the eye separate from the external environment. It also acts as a physical barrier, preventing dust, foreign bodies, and microorganisms from reaching the deeper parts of the eye and causing inflammation (Akgöz, 2006). The conjunctiva not only contributes to the secretion of the tear film but also plays a role in immunological defense reactions and has the ability to resorb (Kocamiş, 2005). The conjunctiva consists of two layers: epithelium and stroma (lamina propria). Goblet cells that secrete abundant mucin are present in the epithelium (Özer, 2010). The structures called microvilli and micropil on the surface of the epithelium are covered with glycocalyx and a hydrophilic mucin layer (Kocamiş, 2005). Mucins are high molecular weight glycoproteins that constitute the major component of the mucus layer and are formed by the addition of predominantly oligosaccharides and limited amounts of N-glycans to a central peptide core (Carlstedt, 1985) and are produced by many epithelial tissues in vertebrates (Carlstedt *et al.* 1985; Öztapak, 2005). Mucin secreted from goblet cells that intercalate between the microvilli in the corneal epithelium provides surface smoothness and, due to its high water-holding capacity, ensures that tears remain in the cornea (Kocamiş, 2005; Reece, 2009). Goblet cells also contain high levels of lysozyme to digest bacterial cell walls. Lysozyme is found in most animal tissues and secretions. However, it is found in much higher concentrations in leukocytes, nasal secretions and tears (Reece, 2009).

Light microscopically, the conjunctiva consists of nonlymphoid and lymphoid regions (Aştı *et al.*, 2000). Nonlymphoid conjunctiva consists of 2-5 layers of stratified squamous epithelium containing goblet cells (Aştı *et al.*, 2000; O'Sullivan *et al.*, 2004). Kuloğlu (2018) reported that numerous goblet cells and stratified squamous epithelium were observed in the nonlymphoid conjunctiva of the chukar partridge (*Alectoris chukar*). The conjunctiva is divided into four sections: palpebral conjunctiva, fornix, bulbar conjunctiva and plica semilunaris. The palpebral conjunctiva consists of marginal, tarsal and orbital sections and covers the inner surface of the eyelids. The marginal conjunctiva has a multilayered but nonkeratinized epithelium similar to the skin. The tarsal conjunctiva is very tightly connected to the tarsi under it. The epithelial cells here are cylindrical. Vascularization is quite dense in the tarsal conjunctiva. It continues under the orbital conjunctiva. There are papillary formations on its surface (Özer, 2010). Kuloğlu (2018) reported that papillary formations were observed on the surface of the partridge orbital conjunctiva. In a study conducted on guinea pigs (Gasser *et al.*, 2011), it was reported that PAS positive reaction was observed in conjunctival goblet cells without any regional distinction. Kuloğlu (2018) stated that no reaction was observed in the marginal region surface

epithelium with the PAS staining method, and that tarsal and orbital region goblet cells showed reactions at different intensities. In studies conducted on rats (Sprague-Dawley) (Huang *et al.*, 1988) and humans (Shatos *et al.*, 2003), it was noted that conjunctival goblet cells contain both neutral and acidic mucins in similar proportions. Kuloğlu (2018) stated that the goblet cells in the tarsal and orbital regions of the chukar partridge (*Alectoris chukar*) also contain both neutral and acidic mucins. Furthermore, it was indicated that a small number of goblet cells in the chukar partridge contain only neutral or carboxylated mucins (Kuloğlu, 2018). Kuloğlu (2018) reported that in the PAS/AB pH 2.5 application, unlike the AB (pH 2.5) application, PAS positive dominance was observed in the mucins present in the majority of the goblet cells in the tarsal and orbital regions of the chukar partridge (*Alectoris chukar*).

CALT (Conjunctiva Associated Lymphoid Tissue): Potential pathogens and harmful substances constantly threaten the conjunctiva of the eye. Effective defense mechanisms are required to protect the structural and functional integrity of such delicate tissues. The most important component of these mechanisms is mucosa-associated lymphoid tissue (MALT), which is found in almost all mucosal regions of the body. Mucosa-associated lymphoid tissues (MALT) are structures that are localized in different tissues and in which specific response and/or tolerance against the antigens in the mucosa occur, and they differ from lymphocyte infiltrations with some characteristic features such as "high endothelial venules" (HEV) (Kelsall, 2004). Aggregated and solitary lymph follicles in MALT have germinal center, dome, corona and interfollicular regions. The close association of these follicles with the epithelium is important for an actively working MALT (Liebler-Tenorio & Pabst, 2006).

Recent studies have shown that MALT consists of specialized local stimulating regions (Organized-mucosa associated lymphoid tissues, O-MALT) and diffuse effector regions (Diffuse-mucosa associated lymphoid tissues, D-MALT) (Hannant, 2002; Knop & Knop, 2003; Liebler-Tenorio & Pabst, 2006; Russell *et al.*, 2000). It is reported that O-MALT is typically localized to critical antigen entry sites such as the digestive and respiratory systems. Following the uptake and presentation of antigens, memory cells formed as a result of the local immune response in O-MALT go to D-MALT in other mucous membranes through the blood and settle (Elson, 1997; Gebert *et al.*, 1996; Knop & Knop, 2003; Liebler-Tenorio & Pabst, 2006). Cell traffic between different mucous membranes depends on the specific migration of these cells between tissues, which is thanks to special vessels (HEVs) with high endothelial cells located in the interfollicular areas and at the bottom of the follicles (Cain & Phillips, 2008; Franklin & Remus, 1984; Knop & Knop, 2005). In this way, a common mucosal immune reaction is formed (Elson, 1997).

Some researchers (Astley & Chodosh, 2005; Bayraktaroglu & Aştı, 2009; Fix & Arp 1989; Fix & Arp, 1991) have reported that conjunctiva-associated lymphoid tissue is similar in terms of location, epithelial and vascular properties to intestinal and bronchial-associated lymphoid tissues, where MALT is considered organized. CALT is lymphoid tissues located at different densities in different parts of the conjunctiva according to animal species. It is stated that factors such as healthy eye, age and individual differences may be effective in the number and distribution of conjunctival lymph follicles

(Guiliano *et al.*, 2002). CALT consists of solitary and aggregated lymph follicles and FAE (Follicle-associated epithelium) that cover these follicles, does not contain goblet cells and also contains specialized membranous epithelial cells (M cells, M cells) for the uptake of antigens (Aşti *et al.*, 2000a; 2000b; Liebler-Tenorio & Pabst, 2006; Kuloğlu, 2019). CALT plays an important role both in responding to diseases that may occur in the eye and in the recognition of some diseases (such as corneal transplant rejection, ocular allergy, dry eye disease) (Knop & Knop, 2005). CALT, which plays an important role in the ocular immune system, must have some characteristic features in order to be considered as a part of MALT. Accordingly, solitary and/or aggregated lymph follicles should form the lymphoid tissue, and these follicles should contain the dome, germinal center, corona and interfollicular areas, and also FAE, including M cells, should cover the follicles (Bayraktaroğlu & Aşti, 2009, Liebler-Tenorio & Pabst, 2006). Kuloğlu (2022), it was determined that conjunctival lymph follicles in chukar partridge (*Alectoris chukar*) were separated from lymphocyte infiltrations with the complete formation of cellular organization and typically had MALT characteristics.

The location of conjunctival lymph follicles differs between species. They are reported to be located in the palpebral conjunctiva in cattle, sheep and pigs (Chodosh *et al.*, 1998), in palpebra nictitans in dogs (Guiliano *et al.*, 2002) and mice (Sakimoto *et al.*, 2002), in areas close to the lacrimal punctum in the nasal angle of the lower conjunctiva in rabbits (Franklin & Remus, 1984; Knop & Knop, 2005), in the nasal angle in turkeys (Fix & Arp, 1989). The appearance of lymph follicles at the macroscopic level may also differ between species. For example, in humans, lymph follicles are disc-shaped, whereas in rabbits, monkeys and other species, they are round (Knop & Knop, 2000). CALT follicles were observed to be clustered around the nasal region in chukar partridge (*Alectoris chukar*). Considering the standing position, the increase in the number of lymph follicles towards the nasal angle can be associated with the accumulation of tears here (Kuloğlu, 2022).

In studies, CALT has been described in human (Knop & Knop, 2000; Wotherspoon *et al.*, 1994), rabbit (Franklin & Remus, 1984; Knop & Knop, 2005), guinea pig (Latkovic, 1989), mouse (Sakimoto *et al.*, 2002), chicken (Fix & Arp, 1991), turkey (Fix & Arp, 1989), sheep (Chodosh *et al.*, 1998; Liebler-Tenorio & Pabst, 2006), goat (Aşti *et al.*, 2000a; 2000b), cattle (Bayraktaroğlu & Aşti, 2009), camel (Sandıkçı *et al.*, 2005), pig (Chodosh *et al.*, 1998), monkey (Ruskell, 1995), baboon (Astley *et al.*, 2003). CALT in the rabbit consists of solitary and/or aggregated lymph follicles. It is reported that these follicles are covered by a single layer of squamous epithelium that does not contain goblet cells (Franklin & Remus, 1984; Knop & Knop, 2005). Kuloğlu (2022), it was determined that CALT in chukar partridge (*Alectoris chukar*) was similar to the above-mentioned features. Studies have shown that the conjunctiva consists of non-lymphoid and lymphoid regions in light microscopic examination. While the nonlymphoid conjunctiva consists of 2-5 rows of stratified squamous epithelium containing goblet cells (O'Sullivan *et al.*, 2004), the lymphoid region is reported to consist of solitary or aggregated lymph follicles and specialized FAE without goblet cells that cover these follicles (Aşti *et al.*, 2000b; Knop & Knop, 2003). In CALT, as in MALT lymph follicles, there are germinal center, corona, interfollicular regions and subepithelial dome region (Chodosh

& Kennedy, 2002). The findings obtained Kuloğlu (2022), are similar to CALTs identified in other species.

The transfer of the resulting immune response to MALT structures in other mucous membranes is due to HEVs (High Endothelial Venule) located in interfollicular areas and playing a role in the specific migration of lymphocytes between tissues (Cain & Phillips, 2008; Franklin & Remus, 1984; Knop & Knop, 2003). Kuloğlu (2022), HEVs (High Endothelial Venule) were found in the interfollicular areas of CALT in chukar partridge (*Alectoris chukar*) and at the bottom of the follicles.

Pecten Oculi: The anatomy of pecten oculi is specific to the bird's eye and is highly pigmented and vascular. Located at the end of the optic nerve, it connects the retina to the vitreous tissues (Dayan and Özyayın, 2013; Aydemir and Kuloğlu). In all vertebrates, the outer retina which includes the retinal epithelium (RPE) and photoreceptors (rods and cones) is supplied by the large fenestrated capillaries of the choriocapillaris. In most vertebrates a second vascular system nourishes the inner retina which includes all layers vitreadto the photoreceptors. This other vascular supply which is termed a supplemental nutritive device (SND) (Walls1942) or supplementary retinal circulation (Rodieck 1973) can take several forms, but in avian species it is represented as the pecten oculi. The pecten oculi in the avian is an interesting structure that defies functional analyses, despite the fact that it has been studied for over 300 years (Brach 1977). In avian, pecten oculi has a very vascular and pigmented structure (Kiama *et al* 1994, Gultiken *et al* 2012). It is located at the head of the optic nerve and extends from the retina towards the vitreous part (Braekevelt 1988, Orhan *et al* 2011). The size of the pecten oculi depends on the visual needs of the bird. Thus while birds active in the daytime have a large and highly complex pecten oculi with many folds; birds active at night have a relatively small and simple pecten oculi (Meyer 1977). Histological features of the pecten oculi in all birds are very similar. It is composed of a thinly pleated plexus consisting of very large capillary vessels assembled by a sparse matrix of pigmented stromal cells. In most birds, the pecten apex is held together by a densely pigmented, fibrous 'bridge' of tissue which has a reduced vascularization with respect to the pecten pleats. The pecten oculi is attached basally to the optic nerve head and distally to the vitreous body by fine strands of vitreous tissue which interdigitates with processes of the bridge cells (Brach 1977). In the avian, retina is thicker than mammals and retinal blood vessels are absent (Pettigrew 1990). Therefore, it is suggested that the avascular retina of the pecten oculi basic function is feeding (Kiama *et al* 1994). One of the functions of the pecten oculi is the formation of the blood retinal barrier (Wolburg 1999). The endothelia of the pectineal capillaries are continuous, possessing elaborate tight junctions. Also two barrier-specific proteins, that is, the HT7-antigen and the glucose transporter isoform GluT-1, are expressed by the endothelial cells (Gerhardt 1996).

The pecten oculi is found in the vitreous chamber of the eye of all avians (Rochon- Duvigneaud 1943) and it is considered an indirect retinal trophic system (Michaelson 1954, Puzzolo 1994), more effectively functioning during saccadic oscillations (Pettigrew *et al* 1990). It is composed of three different parts: the base, optic nerve head and the folds. Kuloğlu and Boydak (2019) reported that the partridge pecten oculi consists of three different parts. The base plays a relevant

mechanic role, as it provides strong insertion of the pecten on the adjacent ocular layers along a zigzag line (Puzzolo *et al* 1985). This arrangement seems to be more functional than a rectilinear one in increasing its mechanical stability and its ability to withstand the inertial forces of the adjacent vitreous body (Tucker 1975). Furthermore, it represents the site where the larger vessels (arterioles and venules) are found (Hossler and Olson 1984). In the budgerigar these vessels are placed along the basal part, close to the optic nerve fibers (Kiama *et al* 1994, Braekevelt 1998, Rahman *et al* 2010), is composed only by capillaries. In this study, chukar partridge of pecten oculi was observed to have blood vessels of different sizes. Kuloğlu and Boydak (2019) reported that the pecten oculi of the partridge have blood vessels of different sizes.

As to the folds, a relationship was proposed between the number of the pleats and the circadian activity and/ or the visual requirements of the single species (Braekevelt, 1998). In fact, a large and complicated pecten with 15–20 pleats is generally observed in photically active and visually oriented avians, whereas a pecten provided of smaller size and 4–5 pleats is found in avians with crepuscular or nocturnal habits and with reduced visual acuity. The location of the pecten oculi in *Alectoris chukar* used in this study conformed to that reported in other bird species. We observed that *Alectoris chukar* had a pleated-type pecten oculi which displayed folded structure. Kuloğlu and Boydak (2019) reported that the partridge has a serpentine type pecten oculi, which is consistent with the location reported in other bird species and exhibits a serpentine structure. In the researches showed that in other diurnal species such as in malard pecten oculi has 12-14 (Braekevelt 1990), great blue heron has 14-15 (Braekevelt 1991), emu has 3-4 (Braekevelt 1993), American crow has 22-25 (Braekevelt 1994), Australian galah has 20-25 (Braekevelt 1996), black kite has 12-13 (Kiama *et al* 1994, Kiama *et al* 2001), domestic poultry has 16-18 (Kiama *et al* 2001), jungle crow has 24-25 (Rahman *et al* 2010), quail has 19 (Orhan *et al* 2011), common buzzard has 17-18 (Gultiken *et al* 2012), budgerigar has 10-12 (Micali *et al* 2012), duck has 12, pigeon has 13-14, turkey has 21-22, starling has 17 (Dayan and Ozaydin 2013), stork has 15-17 (Onuk *et al* 2013) and partridge has 13-14 (Kuloğlu and Boydak, 2019) folds. However, nocturnal birds have small pectens such as nighthawk that has 4-5 (Braekevelt 1984), barred owl that has 8–10 (Smith *et al* 1996) and spotted eagle owl that has 5-6 (Kiama *et al* 2001) folds.

Although the functional morphology of pecten oculi is related to the life style of the avian (Kiama *et al* 2001), previous studies (Kiama *et al* 2006; Kuloğlu and Boydak, 2019) show that pecten oculi mainly consists of numerous capillaries, large blood vessels and pigment cells in various avian species. The capillaries are surrounded by thick basal membrane in pecten oculi of all investigated species in partridge as described in pervious study (Braekevelt 1988, Braekevelt 1990, Braekevelt 1994, Braekevelt 1996, Dayan and Ozaydin 2013, Kuloğlu and Boydak, 2019). It has been suggested that the thickened basal layer may support fragile endothelial cells with very thin cell bodies and numerous microfolds (Braekevelt 1988, Braekevelt 1996). The close relationship between pigment cells and capillary vessels has been reported in the black kite (Kiama *et al* 2001), ostrich (Kiama *et al* 2006), and jungle crow (Rahman *et al* 2010), quail (Orhan *et al* 2011), storks (Onuk *et al* 2013), duck, pigeon, turkey, and starling (Dayan and Ozaydin 2013), partridge (*Alectoris chukar*) (Kuloğlu and Boydak, 2019). It

has suggested that pigmented cells provide the structural reinforcement to pecten oculi for keeping it firmly erectile within the gel-like vitreous and also protect the blood vessels against damage from ultraviolet light (Braekevelt 1988, Kiama *et al* 1994, Braekevelt 1996). Kuloğlu and Boydak (2019) applied Periodic Acid Schiff (PAS) and (Gordon Sweeth) GS staining methods on partridge pecten oculi. They reported that PAS positive reaction was observed around blood vessels, capillaries and pigment cells in the PAS staining method. However, they reported that reticular fibers were not observed in the Gordon Sweet staining method (Kuloğlu and Boydak, 2019).

Optic Nerve: Nervus opticus (Cr2) is the second of 12 cranial nerves known as Nervi craniales (encephalici) and transmits visual information from the retina to the brain. Since it originates from embryonic retinal ganglion cells, which is a diverticulum located in the diencephalon, it cannot regenerate after being cut (Oğul, 1996; Anderson, 1969). Nervus opticus (Cr2) carries special somatic afferent nerve fibers related to the sense of sight. Afferent nerve fibers originate from multipolar ganglion cells in the retina. There are also a small amount of efferent fibers, but their origin is not clear. Cr2 contains an average of 1,200,000 fibers. Nervus opticus (Cr2), which is approximately 4 cm long, consists of four parts: pars intraocularis (1 mm), pars intraorbitalis (25-35 mm), pars intracanalicularis (7 mm) and pars intracranialis (10-15 mm) (Arıcı & Elhan, 1997; Williams *et al.*, 1995; Snell, 2000; Radius, 1994). Nervus opticus is surrounded by the cerebral cortex. In other words, the "Dura mater", "Arachnoid" and "Piamater" layers that make up the cerebral cortex also surround the optic nerve. The retinal nerve fiber layer gradually becomes thinner and extends from the optic disc to the periphery of the retina. If nerve fibers forming the visual pathways in the optic nerve are damaged in any region for any reason such as tumor, cut, bleeding, the damaged area cannot transmit bio-electrical nerve impulses forward. As a result, since the brain cannot perceive the stimuli of the retina passing through that region, it cannot see a certain region of the visual field of the eye (Duus, 2001). Therefore, knowing the cellular organization of the optic nerve very well is very important in the precautions to be taken against optic nerve damage.

In general, a nerve fiber consists of axons surrounded by a special sheath derived from cells of ectodermal origin. Nerve fibers differ in their sheaths depending on whether they are located in the peripheral or central nervous system. All the axons of the peripheral nervous system are surrounded by squamous cells called Schwann cells lined up along the extension. Schwann cells form a multilayered membranous wrap around most axons. This wrapping is called myelin, and those wrapped around it are called myelinated fibers. There are no Schwann cells in the central nervous system. Here, glia cells (oligodendrocytes) form the myelin sheath (Soydan, 1992; Junqueira *et al.*, 1998). The myelin sheaths of axons in Cr2 are not formed by Schwann cells as in other cranial nerves, but by oligodendrocytes as in the central nervous system (Taner, 2002; Burkitt *et al.*, 1993; Leeson *et al.*, 1985). An artery and a vein, which are the vessels of the retina, pass through the center of the nervus opticus (Cr2). The arteria centralis retinae, which progresses towards the bulbus oculi, is separated from the arteria ophthalmica, and the vena centralis retinae pours into the arteria ophthalmica (Krstic, 1991; Taner, 2002). Kuloğlu (2022), reported numerous vascularizations in

the connective tissue located in the center of the optic nerve in the partridge nerve (Cr2) in their study.

Nervus opticus (Cr2) is known as a tract that lies between the ganglion cells in the retina and the diencephalon and actually belongs to the central nervous system. Since it develops from the diencephalon embryologically and is surrounded by meningeal structures throughout its course, it is considered as an extension of the central nervous system, not a peripheral nervous system (Gökmen, 2003; Arıncı, 1994). It is known that the nervus opticus (Cr2) has a cylindrical structure in intraorbital sections (Wagner *et al.*, 1997; Arıncı & Elhan, 1993). In the study conducted on partridge (*Alectoris chukar*) optic nervus (Cr2), it was reported that the optic nervus has a cylindrical structure (Kuloğlu, 2022).

Harderian Gland: In the research conducted by Brownschidle and Niewenhuis (1978) on albino rats and Watanabe (1980) on mice, two distinct epithelial structures, Type A and B, were identified in the Harderian gland. They noted that Type A cells are more abundant than Type B cells. While Type A cells contain large secretory granules with a lipid-like and filamentous substance, Type B cells generally possess smaller secretory granules. Both cell types feature short microvilli on their apical surfaces. These cells are also referred to as light and dark cells (Woodhouse and Rhodin 1963, Tsutsumi *et al.* 1966, Bucana and Nadakavukaren 1973). However, some researchers (Chemes *et al.* 1977, Sinowitz and Amselgrober 1986) suggested that the two cell types arise from errors during preparation, while others (Tsutsumi *et al.* 1966, Lopez *et al.* 1992) argued that they represent the same cell in different metabolic stages (Kuloğlu, 2022).

The Harderian gland in poultry can be categorized into three types according to their lobular structures and the epithelial cells lining the glandular corpus and ducts (Burns 1992). Type I Harderian gland, primarily found in domestic birds like chickens, is tubuloalveolar and comprises a single lobe made up of prismatic epithelial cells. Type II Harderian gland, commonly observed in ducks, features prismatic structures with dark cells and consists of single-lobed tubular formations. Type III Harderian gland exhibits both tubular and tubuloalveolar structures and is frequently found in crows (Burns 1992). In poultry, the ducts of the Harderian gland are categorized into primary, secondary, and central ducts. The secretions from the corpus glandulas located in the lobules are drained into the central ducts via the primary and secondary ducts. Both the primary and secondary ducts have two cell types: one type consists of cubic cells with microvilli on their apical surfaces, while the other type comprises polymorphic cells situated beneath and between these cubic cells. These polymorphic cells are referred to as dark cells due to the dense staining of their nuclei and cytoplasm (Olah *et al.* 1992). Additionally, plasma cells, plasmablasts, and lymphocyte infiltrations are present in these ducts (Burns and Maxwell 1979; Kuloğlu, 2022).

Many researchers (Shinoda 1958, Sakai 1981, Payne 1994, Willem *et al.* 2007) have noted that the Harderian gland typically has a single draining duct, whereas the lacrimal and nictitant glands possess multiple draining ducts (Sakai 1981). Loewenthal (1896) studied the Harderian and nictitant glands across various mammalian species (including cats, dogs, sheep, calves, horses, pigs, rabbits, hedgehogs, guinea pigs, and white mice) and proposed that the number of draining

ducts could be a significant factor in their differentiation. In research on deer, Miessner (1900) observed that the single duct of the Harderian gland bifurcates and opens at two points on the bulbar surface of the palpebra tertia (PT). Additionally, Pütter (1903) stated that whales also have a considerable number of draining ducts in their Harderian glands. Sakai (1981) indicated that the ducts responsible for transporting secretions in the Harderian gland should not be considered, as their origins and numbers vary significantly across species. He argued that the Harderian gland functions as an independent structure separate from the palpebra tertia (PT) due to the differences in their openings into the PT. Plasma cells derived from the bursa of Fabricii have been identified in the Harderian gland (Wight *et al.* 1971, Burns 1975, Glick and Olah 1981, King and McLelland 1984).

These cells play a crucial role in protecting the eye from infections by producing antibodies in response to local antigenic stimulation (King and McLelland 1984). In domestic poultry, the Harderian gland is thought to serve as an alternative central lymphoid organ to the bursa of Fabricii (Glick and Olah 1981). Plasma cells in the poultry Harderian gland are found within the interlobular connective tissue. It has been noted that the B-lymphocytes generated here migrate to secondary lymphoid organs (Bang and Bang 1968, Aitken and Survashe 1977). Rothwell *et al.* (1972) found that the plasma cells in poultry exhibit ultrastructural similarities to mammalian plasma cells and share common histochemical characteristics. It has been noted that plasma cells in the Harderian gland are capable of synthesizing IgA (Mueller *et al.* 1971, Russel 1993, Russel and Koch 1993) and IgG (Russel 1993, Russel and Koch 1993), making the gland a crucial organ for producing lacrimal IgA against the Newcastle virus. One of the unique characteristics of the poultry Harderian gland is the aggregation of plasma cells within the connective tissue. The number of plasma cells is greater in Type I Harderian gland compared to Type II. An increase in plasma cell numbers with age is seen only in Type I Harderian glands (Wight *et al.* 1971). In Type III Harderian glands, plasma cells are found solely in the tubuloalveolar regions. It has been suggested that the development of Harderian glands is influenced more by the evolutionary progress of the species than by environmental conditions, with Type II Harderian glands appearing in more primitive poultry (ducks) and Type III in more advanced poultry (crows) (Burns 1975).

In a study examining various mammalian species (Aitken and Survashe 1977), plasma cells in the Harderian gland were found to be clustered in hamsters, gerbils, and pigs, but were present in very small quantities in rats and mice. Loewenthal (1892a) published the first article on the Harderian gland, detailing its histology in hedgehogs. In a subsequent study (Loewenthal 1892b), he provided significant information into the histology of the Harderian glands in various species, including white mice, pigs, rats, guinea pigs, calves, sheep, and horses. Both studies noted the presence of flattened, squamous nucleus between the connective tissue and the secretory epithelium, although they did not identify these as myoepithelial cells (Loewenthal 1892a; b). Over the next two decades, the histology and embryology of the Harderian gland were investigated by numerous researchers (Loewenthal 1896, 1900, Taddei 1900, Sundwall 1907, Loewenthal 1912, 1913a, 1913b, Mobilio 1913, Loewenthal 1916), but myoepithelial cells were not mentioned in their findings. It was Hauschild (1914) who first referred to these cells, albeit categorizing

them as connective tissue cells. The first description of myoepithelial cells in the Harderian gland of rats was provided by Derrien and Turchini (1924).

Sakai (1981) noted that nerve endings are associated with the cells of the corpus glandula or myoepithelial cells in rabbits and hamsters. It was reported that myoepithelial cells are between the secretory epithelium and their basal lamina in camels (Fathel-Bab *et al.* 1991), turkeys (Maxwell *et al.* 1986), and domestic poultry (Rothwell *et al.* 1972). Möllendorf (1927) indicated that myoepithelial cells occupy a position similar to those in salivary, sweat, mammary, and lacrimal glands, specifically between the secretory epithelium and the basement membrane. Chiquoine (1958) described these cells as star- or spider-shaped, featuring a nucleus and numerous cytoplasmic extensions, and positioned between the secretory epithelial cells and the basement membrane. He also noted that the nuclei of myoepithelial cells are distinctly visible under phase-contrast microscopy. Kuloğlu (2016) stated that the Harderian gland of henna partridges is located at the medial angle of the eye within the bulbus oculi. She described the gland as light pink in color, with convex and concave surfaces that correspond to the shape of the bulbus oculi, having a smooth surface resembling a crescent moon, and noted that it is not associated with the cartilage palpebra tertia (CPT) (Kuloğlu, 2016; Kuloğlu and Boydak, 2024). Çalışlar (1984) observed that the Harderian gland in chickens was also not associated with the CPT, unlike in other domestic animals such as cattle and pigs. He found that it was much larger and more developed than the lacrimal gland, displaying pinkish, light brown, or reddish colours and an irregular rectangular shape that conforms to the bulbus oculi. Similar descriptions of the gland's structure were reported by Fourman and Ballatyn (1967) in geese, Brobby (1972) in domestic ducks, Altunay and Kozlu (2004) in ostriches, Boydak and Aydın (2009) in domestic geese, Mobini (2012) in domestic chickens, Önal and Çınar (2013) in henna partridges, Bejdic *et al.* (2014) in laying hens, and Kleckowska *et al.* (2015) in Bilgorajska geese.

Çalışlar (1984) noted that in chickens, the Harderian gland is encased in a weak connective tissue capsule and features a main duct running along its longitudinal length. In a study on domestic ducks, Brobby (1972) reported that the Harderian gland is surrounded by a connective tissue capsule containing smooth muscle cells, tight collagen fibers, nerve fibers and blood vessels. Similar findings were presented by Boydak and Aydın (2009) in domestic geese, Kozlu *et al.* (2010) in ostriches, and Mobini (2012) in domestic chickens, all stating that the Harderian gland is covered by a thin connective tissue capsule. Mobini (2012) also identified blood vessels, parasympathetic nerve fibers, as well as collagen, elastic, and reticular fibers within the Harderian gland of domestic chickens. Boydak and Aydın (2009) observed collagen and reticular fibers in the connective tissue capsule of the Harderian gland in domestic geese, while Kozlu *et al.* (2010) made similar findings in ostriches. Liman and Gülmez (1996) found in their study on French white geese that the volume and size of the organ increased by the 21st day of hatching, along with thickening of the connective tissue between the lobules and the capsule. Kuloğlu (2016) pointed out that henna partridge Harderian gland is encased in a thin connective tissue capsule with smooth muscle fibers, nerve fibers, tight collagen fibers, reticular fibers and blood vessels (Kuloğlu 2016; Kuloğlu and Boydak, 2024). Studies have reported that the capsule surrounding the Harderian gland divides the gland into

lobes and lobules in various species, including mice (Watanabe 1980), rats (Djeridane 1994), French white geese (Liman and Gülmez 1996), desert lizards (Sabry and Al-Ghaith 2000), ostriches (Altunay and Kozlu 2004), mallard ducks (Dimitrov and Nikiforov 2005), armadillos (Marcos and Affanni 2005), piglets (Munkeby *et al.* 2006), broiler and domestic chickens (Khan *et al.* 2007), domestic geese (Boydak and Aydın 2009), ospreys (Kozlu *et al.* 2010), domestic chickens (Mobini 2012), and henna partridges (Önal and Çınar 2013). In her study on henna partridges, Kuloğlu (2016) observed that the connective tissue capsule surrounding the organ extends septa into the gland, dividing it into lobes. Thinner connective tissue septa, distinct from the interlobar septum, further subdivide the lobes into smaller lobules. She also noted the presence of medium-sized blood vessels and nerve fibers at the junctions where the lobes come into contact. Studies have indicated that the Harderian gland features a compound tubuloalveolar structure in various species, including mice (Watanabe 1980), rats (Djeridane 1994), French white geese (Liman and Gülmez 1996), desert lizards (Sabry and Al-Ghaith 2000), tree mice (Pradidarcheep *et al.* 2003), ostriches (Altunay and Kozlu 2004), ospreys (Kozlu *et al.* 2010), mallard ducks (Dimitrov and Nikiforov 2005), armadillos (Marcos and Affanni 2005), piglets (Munkeby *et al.* 2006), broiler and domestic chickens (Khan *et al.* 2007), dolphins (Ortiz *et al.* 2007), domestic geese (Boydak and Aydın 2009), domestic chickens (Mobini 2012), henna partridges (Önal and Çınar 2013), and henna partridges (Kuloğlu 2016; Kuloğlu and Boydak, 2024). Brooby (1972) observed that the corpus glandulae of the Harderian gland in domestic ducks are branched, allowing their secretions to flow into a central lumen. Boydak and Aydın (2009) noted that in domestic geese, the Harderian gland folds into the lumen of the corpus glandula. According to Sakai (1981), the Harderian gland comprises multiple lobes arranged around a central duct, with each lobe containing its own central lumen and corpus glandula, where the corpus glandulae are oriented radially towards the lumen. In her research on henna partridges, Kuloğlu (2016) found that the corpus glandulae of their Harderian gland are also branched, with epithelial cells draining their secretions into the central lumen. She indicated that the Harderian gland of the henna partridge consists of several lobes surrounding a primary draining duct, with each lobe having its own primary duct and the corpus glandulas positioned around this duct (Kuloğlu 2016; Kuloğlu and Boydak, 2024).

Studies have shown that the corpus glandulas of the Harderian glands are lined with high columnar epithelial cells, as reported by Maxwell *et al.* (1986) in turkeys, Liman and Gülmez (1996) in French white geese, Altunay and Kozlu (2004) in ostriches, Yaren (2008) in female pheasants, Boydak and Aydın (2009) in domestic geese, Kozlu *et al.* (2010) in ospreys, and Mobini (2012) in domestic chickens. Önal and Çınar (2013), Kuloğlu (2016), Kuloğlu and Boydak (2024) noted that the corpus glandulas in the Harderian gland of henna partridges are made up of either low or high prismatic epithelial cells. Fathel-Bab *et al.* (1991) found myoepithelial cells between the secretory epithelial cells and the basement membrane in camels. In their study on turkeys, Maxwell *et al.* (1986) noted that myoepithelial cells are located beneath the columnar secretory epithelium and are associated with the basement membrane. Similarly, Rothwell *et al.* (1972) observed that in domestic chickens, myoepithelial cells are localized between the secretory epithelium and the basal

lamina. In contrast, Kuloğlu (2016) and Kuloğlu and Boydak (2024) found that myoepithelial cells were present on the basal surfaces of the epithelial cells lining the walls of the corpus glandula and draining ducts in the Harderian gland of henna partridges.

In studies conducted by Boydak and Aydın (2009) on domestic geese, Kozlu *et al.* (2010) on ospreys, and Mobini (2012) on domestic chickens, no goblet cells were identified among the epithelial cells of the corpus glandula. Kuloğlu (2016) and Kuloğlu and Boydak (2024) also noted the absence of goblet cells between the corpus glandula in the Harderian gland of henna partridges. However, goblet cells were observed among the epithelial cells of the main draining duct (Kuloğlu 2016; Kuloğlu and Boydak, 2024). Additionally, research by Yaren (2008) on female pheasants, Boydak and Aydın (2009) on domestic geese, Kozlu *et al.* (2010) on ospreys, Mobini (2012) on domestic chickens, Önal and Çınar (2013), Kuloğlu (2016) and Kuloğlu and Boydak (2024) on henna partridges, the presence of a single central duct with a large lumen in each lobe of the Harderian gland, alongside the primary draining duct was reported. Yaren (2008) found that the epithelial cells in the primary duct exhibit a single-layered columnar structure, whereas those in the main draining duct have a single-layer cuboidal epithelium. In contrast, Önal and Çınar (2013), Kuloğlu (2016), Kuloğlu and Boydak (2024) stated that the epithelial cells in both the main draining duct and primary draining duct of the henna partridge Harderian gland display characteristics of a single-layered cuboidal epithelium. Studies on turkeys and ducks (Maxwell and Burns 1979), chickens (Scott *et al.* 1993), broilers and domestic chickens (Khan *et al.* 2007), domestic geese (Boydak and Aydın 2009), ospreys (Kozlu *et al.* 2010), and henna partridges (Önal and Çınar 2013) reported a significant presence of plasma cells located just beneath the connective tissue capsule surrounding the gland, within the septa separating from the capsule, and around the corpus glandula and draining ducts. Kuloğlu (2016) and Kuloğlu and Boydak (2024) noted that plasma cells were found in the connective tissue septa situated just below the connective tissue capsule of the henna partridge Harderian gland and around the corpus glandula. They also observed a substantial number of plasma cells surrounding the gland's primary ducts and the main draining duct (Kuloğlu 2016; Kuloğlu and Boydak, 2024).

Tongue: The diversity of food sources has led to various adaptations in bird species living in different habitats (El-Bakary, 2011). Therefore, birds differ in the development of their beak, tongue and palate (King and McLelland, 1984; Dehkordi *et al.*, 2010). As a reflection of different lifestyles, the tongue plays an important role in food intake and swallowing and shows significant morphological differences (Dehkordi *et al.*, 2010; Parchami *et al.*, 2010). Gardner (1926) classified poultry tongues into two groups based on their function and adaptations; Harrison (1964) into five groups based on their specialization for eating, tasting, touching, swallowing and collecting food; and King and McLelland (1984) and O'Malley (2005) into three groups based according to the way they collect, process and swallow food. As a result, as in mammals, feeding habits vary greatly in the microscopic structure of the poultry tongue (Dehkordi *et al.*, 2010; Parchami *et al.*, 2010). Histological and histochemical characteristics of poultry tongue glands have been determined by studies on domestic poultry (Gargiulo *et al.*, 1991; Taib and Jarrar, 1998; Arthitvong *et al.*, 1999; Liman *et al.*, 2001; Kum, 2002), game

animals (Crole and Soley, 2010; Pasve *et al.*, 2010; Santos *et al.*, 2011) and some wild birds (Jackowiak and Godynicki, 2005; Al-Mansour and Jarrar, 2007; Dehkordi *et al.*, 2010). Although the structure of the glands in the upper digestive tract of many bird species has been described, there is no consensus on the localization and nomenclature of the tongue glands (Crole and Soley, 2009, 2010). Liman *et al.* (2001) named the tongue glands as preglottal and laryngeal glands in a study on quail tongue. In chicken (Hodges, 1974; Nickel *et al.*, 1977) they classified the tongue glands as anterior and posterior. In this study, as in chicken (Hodges, 1974; Nickel *et al.*, 1977) and quail (Capacchietti *et al.*, 2009), the glands located in the body of the tongue were named as anterior tongue glands and the glands located in the root were named as posterior tongue glands.

Although the most common gland type in bird species is tubular, there are also simple branched tubuloalveolar, alveolar and compound alveolar gland structures (Crole and Soley, 2010). Kuloğlu (2016) reported that the tongue glands of the partridge (*Alectoris chukar*) have a simple branched tubular gland structure and that the anterior tongue glands are serous and seromucous, while the posterior tongue glands are mucous. In quail (Taib and Jarrar, 1998; Liman *et al.*, 2001), rostral tongue glands gave a PAS-negative reaction while caudal tongue glands gave a PAS-positive reaction. In chickens, anterior and posterior tongue glands were reported to give a strong PAS-positive reaction (Gargiulo *et al.*, 1991; Arthitvong *et al.*, 1999; Kum, 2002). Kuloğlu (2016) reported that anterior tongue glands gave a stronger PAS-positive reaction than posterior tongue glands in the tongue glands of partridge in PAS staining method. While Taib and Jarrar (2001) reported that no reaction was observed in the anterior glands in the AB pH=2.5 staining method in adult quail (*Coturnix coturnix*) tongue glands, Kuloğlu (2016) reported that the anterior tongue glands gave a stronger AB-positive reaction than the posterior tongue glands in chukar partridge tongue using AB pH=2.5 staining method.

Liver: The liver is a multifaceted organ that processes nutrients absorbed from the digestive tract, storing them for use by other parts of the body or releasing them into the bloodstream. It serves as a crucial transition point between the digestive system and the circulatory system. Most substances absorbed from the small intestine reach the liver through the portal vein, while lipids are transported via the lymphatic vessels. Nutrient-rich blood from the digestive organs is carried to the liver sinusoids through the portal vein, where it then diffuses into neighboring hepatocytes. As the largest gland in the body, the liver plays a central role in maintaining energy supply. It functions as both an endocrine and exocrine gland, and is involved in the metabolism of proteins, fats, and carbohydrates, the synthesis and secretion of bile, and detoxification processes. In poultry, the liver is situated in the Cavum peritonei hepatis ventralis and is divided into two lobes: the larger right lobe (lobus hepatis dexter) and the smaller left lobe (lobus hepatis sinister). Generally, the liver tends to be larger in insectivorous and piscivorous species, while it is smaller in carnivorous and granivorous species.

The liver is covered by membranes known as the tunica serosa on the outside and the tunica fibrosa, which tightly encases the organ's parenchyma on the inside. The lobes' shapes vary among species: the left lobe is ellipsoid in chickens, bean-shaped in ducks, and wide yet shorter than the right lobe in

geese. The right lobe, on the other hand, is heart-shaped in chickens and tongue-shaped in ducks, while in geese, it is wider and longer than the left lobe. In poultry, the two liver lobes are connected at the midline by a parenchymal bridge. In many species, such as pigeons and ostriches, the right lobe is typically larger than the left. However, in some species, the lobes may be equal in size, and the left lobe is further divided into ventral and dorsal sections in domestic chickens. While the liver parenchyma of poultry resembles that of mammals, there are notable histological differences between the two (Çıraklı and Kuloğlu, 2022). In the studies by Selman (2013) in Eurasian coots, Faraj and Al-Baurity (2016) in starlings, Karan *et al.* (2018) in Japanese quail, it was observed that the liver consists of two lobes and has a dark red-brown color and that the two lobes are joined by a parenchymal bridge in the midline.

Moslem (2015) reported that the liver of ostriches and poultry is dark red-brown in both species and that the liver of ostriches consists of four lobes, while chickens consists of two lobes. Çıraklı and Kuloğlu (2024), similar findings was observed that the liver of the Chinese goose (*Anser cygnoides*) is dark red brown in color and consists of two lobes, lobus hepatitis dexter and lobus hepatitis sinister and these two lobes are joined by a parenchymal bridge in the middle of the liver. Bahadır *et al.* (1992) found that the liver is between the 2nd and 8th costa in domestic geese, between the 3rd and the last costa in domestic duck and starts from the 4th costa and exceeds the last costa in Pekin. Çıraklı and Kuloğlu (2024), it was determined that Chinese goose (*Anser cygnoides*) liver is between the 2nd and 8th costa as in domestic goose. Çıraklı and Kuloğlu (2024), it was determined that the right lobe is larger than the left lobe as reported by Nickel and Seiferle (1977) in domestic birds, Bahadır *et al.* (1992) in domestic ducks, domestic geese and pekin, Denbow (2015) in Turkeys, Taşçı *et al.* (2018) in hawks, Karan *et al.* (2018) in Japanese quail, Zaefarian *et al.* (2019) in domestic poultry. However, in the studies by Taşbaş (1978) in turkeys and Klasing (1999) in birds, it was reported that both lobes are of equal size.

Nickel and Seiferle (1977) found that the right lobe is longer than the left lobe in ducks and geese and Karan *et al.* (2018) found that both lobes are of equal length in Japanese quails. Çıraklı and Kuloğlu (2024), it was observed that the right lobe is longer than the left lobe. In the studies by Taşbaş (1978) in chickens, roosters and turkeys, Denbow (2015) in domestic birds and turkeys, Karan *et al.* (2018) in Japanese quails, Zaefarian *et al.* (2019) in domestic poultry and turkeys, it was reported that the right lobe of the liver is in one piece, while the left lobe is divided into two lobes, lateral and medial, with a notch. Similar findings were also found in the Çıraklı and Kuloğlu (2024) in Chinese goose (*Anser cygnoides*), the right lobe being one piece and the left lobe is divided into two lobes, lateral and medial, with a notch. Taşbaş (1978) reported that the gallbladder is spindleshaped in chickens, as reported by Karan *et al.* (2018) in Japanese quail. Nickel and Seiferle (1977) stated that the gallbladder is pear-shaped in domestic birds. Çıraklı and Kuloğlu (2024), it was observed that the gallbladder of the Chinese goose (*Anser cygnoides*) is in the form of an elongated tube. In the studies by Bahadır *et al.* (1992) in ducks and geese, Taşbaş (1978) in chickens and turkeys, it was reported that the gallbladder is located on the dorsal surface of the right lobe of the liver and does not pass through the caudal part. In their study in Japanese quail, Karan *et al.* (2018) reported that the gallbladder was on the dorsal

surface of the right lobe of the liver and passed through the caudal part. Çıraklı and Kuloğlu (2024), it was observed that the gallbladder is on the dorsal surface of the right lobe of the liver and does not pass through the caudal part.

In the studies by Selman (2013) in Eurasian coot and Al-Abdulla (2014) in mallard ducks, it was reported that the liver consists of many lobules, which are separated by a thin connective tissue. Çıraklı and Kuloğlu (2024), it was observed that the Chinese goose (*Anser cygnoides*) liver consists of many lobules separated from each other by a thin connective tissue. Çıraklı and Kuloğlu (2024), it was observed that liver of Chinese goose (*Anser cygnoides*) does not have the typical lobule structure, as reported by Swatland (1994) in poultry. In the studies by Selman (2013) in Eurasian coots, Hamodi *et al.* (2013) in guinea fowl, lovebirds and gulls, Iqbal *et al.* (2014) in chickens, Al-A'Aaraji (2015) in male wild turkeys, Faraj and Al-Baurity (2016) in starlings, Karan *et al.* (2018) in Japanese quail, Zaefarian *et al.* (2019) in domestic poultry and turkeys, they observed oval and centrally located hepatocytes, remark cords consisting of radially arranged hepatocytes, sinusoids separating remark cords, phagocytically active Kupffer cells, bile ducts consisting of single-layer prismatic cells involved in secretion production and hepatic artery portal vein and central vein involved in circulation. Çıraklı and Kuloğlu (2024), hepatocytes, remark cords, sinusoids, hepatic artery forming the Kiernan's space, portal vein and bile duct, kupffer cells and central vein were observed in the liver of Chinese goose (*Anser cygnoides*). In their study in poultry, Zaefarian *et al.* (2019) found that hepatocytes in the liver have a complex cell structure with large nuclei and abundant mitochondria. Similarly, Çıraklı and Kuloğlu (2024), hepatocytes were determined to have a complex cell structure with large nuclei and abundant mitochondria.

Bursa Fabricii: The Bursa Fabricii is a spherical organ encased in connective tissue known as the "capsule" (Lupetti *et al.* 1990). This capsule features connective tissue trabeculae that divide the lymph follicles within the organ (Criaco *et al.* 2003). Structurally, the wall of the Bursa Fabricii comprises three layers: tunica mucosa, tunica muscularis, and tunica serosa, arranged from the innermost to the outermost layer. The mucosa is the thickest layer, characterized by folds (plicae) that extend into the organ's lumen (Tanyolaç 1999). Lymph follicles unique to the Bursa Fabricii are located within these mucosal folds. The epithelium of the tunica mucosa consists of two types: pseudostratified columnar epithelium in the interfollicular region (IFE) and a specialized epithelium (FAE) rich in lymphocytes that lacks a basement membrane over the follicles (Lupetti *et al.* 1990; Olah *et al.* Glick 1992; Kuloğlu, 2022). Aside from the interfollicular epithelium (IFE) that lines the inner surfaces of the plicae facing the lumen, each lymph follicle is covered by specialized epithelium known as follicle-associated epithelium (FAE) (Glick and Olah 1993). Scanning electron microscopy (SEM) reveals FAE cells appearing as circular spots interspersed among IFE cells (Davenport and Allen 1995). Notably, these FAE cells lack a basal lamina and are characterized by their prismatic shape. They are described as being more loosely attached to the underlying connective tissue compared to the pseudostratified columnar epithelial cells covering the plicae surfaces (Saifuddin *et al.* 1988).

FAE is supported by 2-5 layers of epithelial cells that stack on top of one another, which are extensions of corticomedullary

border cells (CMBC). Desmosomes connect the FAE to the supporting cells beneath it (Olah and Glick 1992; Kuloğlu 2022). Each plica contains numerous polyhedral follicles, with small amounts of connective tissue separating them. The tops of these follicles are supported by a network of reticular fibers and reticular cells (Hodges 1974). Each follicle consists of two functionally distinct regions: the cortex and the medulla. The medulla houses various cell types, including secretory cells, predominantly B lymphocytes, dendritic reticulum cells, macrophages, and T lymphocytes (Hodges 1974, Ratcliffe 1985). The cortex appears darker due to its high density of tightly packed small lymphocytes (Hodges 1974). Corticomedullary border cells (CMBCs) create a separation between the cortex and medulla, with a network of capillaries located just beneath the basement membrane (Hodges 1974, Tizard 1983, Bacha 1990). The pseudostratified columnar epithelial cells of the IFE that line the inner surfaces of the plicae extend into the follicles, merging with the lymphatic follicles. These follicles are flattened and positioned between the cortex and medulla, with their basement membranes interspersed (Maxwell 1985). Histologically, the absence of capillaries in the medulla of the follicles, combined with the presence of corticomedullary border cells (CMBC) resting on a prominent basement membrane at the cortex-medulla boundary, suggests the existence of a blood-bursa barrier between the blood supply and the medulla of the lymphatic follicles in the Bursa Fabricii during the period before involution (Hodges 1974, Kocaöz *et al.* 1997; Kuloğlu 2022). The tunica muscularis comprises two layers of smooth muscle cells: an outer longitudinal layer and an inner circular layer. Major branches of blood vessels are found between these muscle layers at the base of each plica, providing nourishment to the organ and extending along the plicae. These blood vessels reach the innermost layer of muscle (Hodges 1974). Externally, the tunica muscularis is covered by a thin layer of tunica serosa, with loose connective tissue (subserosa) situated between the tunica serosa and tunica muscularis (Tanyolaç 1999).

The histological development of the Bursa Fabricii is nearly complete prior to hatching (Lupetti *et al.* 1990; Shiojiri and Takahishi 1991). Following hatching, the lymph follicles within the organ, which have reached their developmental maturity, enlarge during the initial weeks. However, no new lymphatic follicles are formed during this time. It has been estimated that upon completion of its development, the organ contains approximately ten thousand lymph follicles within its lamina propria (Ratcliffe 1985; Kuloğlu 2022). The wall structure of the Bursa Fabricii comprises three layers: tunica mucosa, tunica muscularis, and tunica serosa. This has been documented in various studies, including those by Ciriaco *et al.* (1985) on pigeons, Kocaöz (1993) on chickens, Onyeausi *et al.* (1993) on guinea fowl, Gülmez and Aslan (1999) on domestic geese, Sarı and Kurtdede (2007) on turkeys, and Dirik (2011) on rock partridges, as well as in recent studies by Kuloğlu (2016) and Kuloğlu and Boydak (2024) on henna partridges. Research has shown that the tunica mucosa of the Bursa Fabricii features folds extending into the lumen, as reported in studies by Ciriaco *et al.* (1985) on pigeons, Kocaöz (1993) on chickens, Onyeausi *et al.* (1993) on guinea fowls, Gülmez and Aslan (1999) on domestic geese, Sarı and Kurtdede (2007) on turkeys, Dirik (2011) on rock partridges, Khenenou *et al.* (2012) on broilers, Kuloğlu (2016) and Kuloğlu and Boydak (2024) on henna partridges.

Additionally, the lamina epithelium of the Bursa Fabricii is composed of two distinct types of epithelium: interfollicular epithelium (IFE) and follicle-associated epithelium (FAE), which was noted in the studies of Ciriaco *et al.* (1985) on pigeons, Kocaöz (1993) on chickens, Onyeausi *et al.* (1993) on guinea fowls, Hupaya (1995) on broilers, Gülmez and Aslan (1999) on domestic geese, Sarı and Kurtdede (2007) on turkeys, Dirik (2011) on rock partridges, Khenenou *et al.* (2012) on broilers, Kuloğlu (2016) and Kuloğlu and Boydak (2024) on henna partridges. Research has confirmed the presence of lymph follicles containing cortex and medulla regions within the plicae of Bursa Fabricii. This has been documented in studies by Hashimoto and Sugimura (1976) on Peking ducks, Ciriaco *et al.* (1985) on pigeons, Onyeausi *et al.* (1993) on guinea fowls, Kocaöz (1993) on chickens, Hupaya (1995) on broilers, Gülmez and Aslan (1999) on domestic geese, Sarı and Kurtdede (2007) on turkeys, Dirik (2011) on rock partridges, Khenenou *et al.* (2012) on broilers, Kuloğlu (2016) and Kuloğlu and Boydak (2024) in henna partridges. Sarı and Kurtdede (2007) reported the presence of lymphocytes, lymphoblasts, reticular epithelial cells (RECs), and macrophages in both the medulla and cortex of the Bursa Fabricii in turkeys. Similarly, Kuloğlu (2016) and Kuloğlu and Boydak (2024) observed lymphocytes, lymphoblasts, and macrophages within the cortex and medulla of the henna partridge Bursa Fabricii.

Thymus: The thymus gland is situated beneath the thyroid gland, in front of the thoracic cavity, and is encased by a thin connective tissue capsule (Şenol, Yeşil, 2022). Within the thymus lobes, reticular cells and lymphocytes are present, with variations in the number of lobes between the right and left sides, as well as among different poultry species (Sarica, Karataş, and Gözalan, 2009). This gland plays a crucial role in activating lymphocytes shortly before and after birth, helping to protect the body from infections (Sarica, Karataş, and Gözalan, 2009). Specifically in poultry, the thymus is responsible for the maturation of T lymphocytes, the elimination of autoreactive T cells, and the synthesis of thymic hormones (Sarica, Karataş, and Gözalan, 2009). In poultry, the thymus is located on either side of the neck and consists of several lobes that are spaced along the sulcus jugularis. These lobes, which are flat-oval in shape, are embedded in subcutaneous connective tissue and typically number around seven on each side of the neck. The thymus begins at the level of the third cervical vertebra and extends down to the thyroid gland in the thoracic cavity. The lobes on the right side form the right half of the organ, while those on the left comprise the left half. The arrangement of the lobes on both sides aligns with the pathways of the N. vagus and V. jugularis in the neck region (Berktaş, 2014).

Each lobe of the gland is encased in a connective tissue capsule, which consists of loose connective tissue and adipose tissue on the outside. The inner part of the capsule contains connective tissue threads and elastic fibers. Fine connective tissue separates the lobes into smaller lobules, and blood vessels that supply these lobules primarily run where the connective tissue compartments meet the capsule. Thin branches from these vessels extend into the connective tissue compartments, reaching the lobules (Berktaş, 2014; Çınar *et al.* 2022). While the cortex and medulla can be distinguished within the lobules, the border between them is not sharply defined. Both the cortex and medulla form a porous structure made up of a network of reticulum cells supported by reticular

fibers. Reticulum cells feature round, oval, or elongated oval nuclei with one or two nucleoli and finely dispersed heterochromatin. The pores in this network are filled with a mass of lymphocytes, predominantly small lymphocytes, especially in the cortex. The high density of lymphocytes in the cortex gives it a dark basophilic appearance in histological preparations (Berktaş, 2014). The medulla contains fewer lymphocytes, resulting in a paler staining. The low density of lymphocytes allows for clearer visibility of the nuclei of the reticulum cells. Similar to mammals, round-shaped Hassall bodies are rarely found in the medulla of thymus lobules in poultry (Berktaş, 2014; Çinar *et al.* 2022). Cystic structures, often referred to as diffuse Hassall bodies, arise from changes in reticulum cells within the thymus. Their formation begins with the development of small vesicles in the cytoplasm of certain reticulum cells in the medulla. As these vesicles fuse, they create large, round vacuoles which can completely fill the cell cytoplasm. The merging of multiple vacuoles leads to the formation of very large vacuoles and cystic structures. Typically, the lumens of these structures are filled with an eosinophilic substance, and their walls consist of reticulum cells. In addition to non-degenerated lymphocytes, the cyst content may also include cellular debris, such as dark basophilic granules derived from degenerated lymphocyte nuclei. These cystic structures, predominantly found in the medulla of the poultry thymus and identified as diffuse Hassall bodies, are considered to form during the destruction of lymphocytes rather than from degenerating reticulum cells (Berktaş, 2014). The majority of epithelial-derived reticulum cells in the medulla are associated with these medullary cysts. Some cyst lumens contain PAS-positive material, while others may be empty. These large cysts can vary significantly in shape, and their lumens are often surrounded by numerous epithelial reticulum cells. Most cyst lumens are filled with a colloidal or granular substance, which includes remnants from cell destruction (Berktaş, 2014; Çinar *et al.* 2022).

REFERENCES

Aitken ID, Survashe BD, 1977. Plasma cells in Vertebrate Paraocular Glands. *Int Archs Allergy appl Immun*, 53, 62-67.

Aksoy A., Yardımcı H., Kafes Kuşlarında Kullanılan Aşılar H. Bahri Dağdaş Hayvancılık Araştırma Dergisi 61:43-50, 2017.

Al-A'araji, A.S. 2015. Study of some anatomical and histological characteristics in liver of male indigenous Turkey Meleagris gallopava. *Basrah Jurnal of Veterinary Research*. 142: 150-157.

Al-Abdulla, M.A. 2014. Histological and histochemical study of the liver of iraqi local ducks. *Basrah Jurnal of Veterinary Research*. 141: 70-78.

Al-Mansouri M.I., Jarrar B.M., 2007. Morphological, histological ve histochemical study of the lingual salivary glands of the Little Egret, *Egretta garzetta*. *Saudi Journal of Biological Sciences*, 14: 75-81.

Altunay H, Kozlu T, 2004. The fine structure of the Harderian gland in the ostrich *Struthio camelus*. *Anat Histol Embryol*, 33, 141-145.

Akgöz, D., (2006). Köpeklerin Konjunktivasında Bulunan Mast Hücrelerinin Histokimyasal, Enzim Histokimyasal ve İmmunohistokimyasal Özellikleri, Yüksek Lisans Tezi, Erciyes Üniversitesi, Kayseri.

Anderson, D.R. 1969. Ultrastructure of human and monkey lamina cribrosa and optic nerve head. *Arch Ophthalmol.*, 82, 800-814.

Arıcı, K., Elhan, A. 1997. *Anatomy*. Ankara: Güneş.

Arıncı, K. 1994. Sobotta, *Atlas of Human Anatomy*. Istanbul, Beta

Arthitvong S., Makmee N., Suprasert A., 1999. Histochemical detection of glycoconjugates in the anterior lingual salivary glands of the domestic fowl. *Kasetsart Journal National Science*, 33: 243-250.

Astley, R.A., Chodosh, J., 2005. Selective uptake of iron oxide by rabbit conjunctival lymphoid follicles. *Cornea*, 24, 334-336.

Aştı, R.N., Kurtdede, N., Altunay, H., Özen, A. (2000). Ankara keçilerinin konjunktiva ile ilişkili lenfoid dokusu (CALT) üzerinde ışık mikroskopik çalışmalar. *AÜ Vet. Fak. Derg.* 47: 31-37.

Aştı, R.N., Kurtdede, N., Altunay, H., Özen, A., 2000a. Electron microscopic studies on conjunctiva associated lymphoid tissue CALT in Angora goats. *Dtsch Tierarztl Wochenschr*, 107, 196-198.

Aştı, R.N., Kurtdede, N., Altunay, H., Özen, A., 2000b. Ankara keçilerinin konjunktiva ile ilişkili lenfoid dokusu CALT üzerinde ışık mikroskopik çalışmalar. *Ankara Üniv. Vet. Fak. Derg.*, 47, 31-37.

Aydemir, Ş.Ş. and Kuloğlu, H.Y. 2022. Functional And Histological Properties Of Pecten Oculi. 3. International Hasankeyf Scientific Research And Innovation Congress, 312-316. Full Text Publication/Oral Presentation

Bacha WJ, Wood LM, 1990. *Colour Atlas of Veterinary Histology*. Philadelphia, Lea & Febiger, p. 67.

Bahadır, A., Yıldız, B., Serbest, A. and Yılmaz, O. 1992. Evcil Su kuşlarından yerli kaz, yerli Ördek ve pekin Ördeğinin sindirim sistemleri Üzerinde karşılaştırılmalı makro-anatomik ve subgros araştırmalar. *Uludağ Üniversitesi Veteriner Fakültesi Dergisi Sayı:3, Cilt:11*.

Bang BG, Bang FB, 1968. Localized Lymphoid Tissues and Plazma Cells in Paraocular and Paranasal Organ Systems in Chickens. *Am J Pathol*, 53, 735-751.

Bayraktaroğlu, A.G., Aştı, R.N., 2009. Light and electron microscopic studies on conjunctiva associated lymphoid tissue CALT in cattle. *Revue Med. Vet.*, 1605, 252-257.

Bejdic P, Avdic R, Amidzic L, Cutahija V, Tandir F, Hadziomerovic N, 2014. Developmental changes of lymphoid tissue in the Harderian gland of laying hens. *Mac Vet Rev*, 37, 83-88.

Berktaş E.A., Sunset Yellow Fc'nin e110, Tavukların Timus ve Bursa Fabricii'sinin Embriyonik Gelişimi Üzerindeki Etkisinin Histolojik ve Enzim Histokimyasal Yöntemlerle Belirlenmesi Selçuk Üniversitesi Sağlık Bilimleri Enstitüsü Yüksek Lisans Tezi, 2014.

Boydak M, Aydın MF, 2009. Histology of the Harderian gland of domestic geese *Anser anser domesticus*. *Acta Veterinaria Brno*, 78, 199-204.

Brach V, 1977. The Functional Significance Of The Avian Pecten: A Review. *The Condor*, 79, 321-327.

Braekevelt CR, 1988. Fine structure of the pecten of the pigeon *Columba livia*. *Ophthalmologica*, 196 3, 151-159.

Braekevelt CR, 1988. Fine structure of the pecten of the pigeon *Columba livia*. *Ophthalmologica*, 196 3, 151-159.

Braekevelt CR, 1990. Fine structure of the pecten oculi of the mallard *Anas platyrhynchos*. *Canadian Journal of Zoology*, 68, 427-432.

- Braekevelt CR, 1991. Electron microscopic observations on the pecten of the great blue heron *Ardea herodias*. *Histology and Histopathology*, 6, 345-51.
- Braekevelt CR, 1993. Fine structure of the pecten oculi in the great horned owl *Bubo virginianus*. *Histology and Histopathology*, 81, 9-15.
- Braekevelt CR, 1994. Fine structure of the pecten oculi in the American crow *Corvus brachyrhynchos*. *Anatomy Histology Embryology*, 23, 357-66.
- Braekevelt CR, 1998. Fine structure of the pecten oculi of the emu *Dromaius novaehollandiae*. *Tissue Cell* 30, 157-165.
- Braekevelt CR, Richardson KC, 1996. Fine structure of the pecten oculi in the Australian galah *Eolophus roseicapillus* Aves. *Histology and Histopathology*, 11 3, 565-571.
- Broddy GW, 1972. On the Harderian Gland of the domestic duck *Anas Platyrhynchus*. *Zeitsch Zellforsch*, 133, 223-230.
- Brownschidle CM, Niewenhuis RJ, 1978. Ultrastructure of the Harderian gland in male Albino rats. *Anat Rec*, 190, 735-754.
- Bucana CD, Nadakavukaren MJ, 1973. Ultrastructural investigation of the postnatal development of the hamster Harderian gland. II. Male and female. *Zeitsch Zellforsch Mikros Anat*, 142, 1-12.
- Burkitt, H.G., Young, B., Heath, J.W. 1993. *Wheater's Functional Histology*. Longman Group Ltd, Honkong.
- Burns RB, 1975. Plasma cells in avian Harderian glands and morphology of the gland in the rock. *Can J Zool*, 53, 1258-1269.
- Burns RB, Maxwell MH, 1979. The structure of the Harderian gland and lakrimal gland ducts of the turkey, fowl and duck. A light microscope study. *J Anat*, 128, 285-292.
- Cain, C., Phillips, T.E., 2008. Developmental changes in conjunctiva-associated lymphoid tissue of the rabbit. *Invest. Ophthalmol. Vis. Sci.*, 49, 644-649.
- Capacchietti M., Sabbieti M.G., Agas D., Materazzi S., Mengni G. Marchetti L., 2009. Ultrastructure ve lectin cytochemistry of secretory cells in lingual glands of the Japanese quail *Coturnix coturnix japonica*. *Histology ve Histopathology*, 24: 1087-1096.
- Carlstedt, I., Sheehan J.K., Corfield, A.P., Gallagher, J.T., Mucous glycoproteins: A gel of a problem. *Essays Biochem*, 20, 40-76, 1985.
- Chemes HE, Dym M, Fawcett DW, Javadpour N, Sherins RJ, 1977. Patho-physiological observations of Sertori cells in patients with germinal aplasia or severe germ depletion. Ultrastructural findings and hormone levels. *Biol Reprod*, 17, 108-123.
- Chiquoine AD, 1958. The Identification and Electron Microscopy of Myoepithelial cells in the Harderian Gland. *Anat Rec*, 132, 569-583.
- Chodosh, J., & Kennedy, R. C. 2002. The conjunctival lymphoid follicle in mucosal immunology. *DNA and cell biology*, 215-6, 421-433.
- Ciriaco E, Gagliardi ME, Ciccirello R, Germana G, Bronzetti P, 1985. Development of the pigeon bursa of Fabricius. A scanning and transmission electron microscope study. *Ann Anat*, 159, 55-63.
- Ciriaco E, Pinera PP, Diaz-Esnal B, Laura L, 2003. Age-related changes in the avian primary lymphoid organs thymus and bursa of Fabricius. *Microsc Res Techniq*, 62, 251-253.
- Crole M.R., Soley J.T., 2009. Morphology of the tongue of the emu *Dromaius novaehollveiae*. II. Histological features. *Onderstepoort Journal of Veterinary Research*, 76, 347-361.
- Crole M.R., Soley J.T., 2010. Surface morphology of the emu *Dromaius novaehollveiae* tongue. *Anatomia Histologia Embryologia*, 39: 355-365.
- Çalışlar T, 1984. Tavukta Glandula Lakrimalis Accessoria Harder Bezi. *İÜ Vet Fak Derg*, 102, 51- 54.
- Çıtraklı, A.B. and Kuloğlu, H.Y. 2022. An Overview Of Poultry Liver. 3. International Hasankeyf Scientific Research And Innovation Congress, 321-325. Full Text Publication/Oral Presentation
- Çıtraklı, A.B. and Kuloğlu, H.Y. 2024. Anatomical, Histological and Transmission Electron Microscopic Examination of Liver in Chinese Goose (*Anser cygnoides*). *Indian Journal of Animal Research*. 587: 1127-1132. doi: 10.18805/IJAR.BF-1732.
- Çınar, E., İlgün R. and Kuloğlu, H.Y. 2022. Functional Histology Of Thymus In Poultry. 3. International Hasankeyf Scientific Research And Innovation Congress Full Text Publication/Oral Presentation.
- Davenport WD, Allen ER, 1995. Dome epithelium and follicle-associated basal lamina pores in the avian bursa of Fabricius. *Anat Rec*, 241, 155-62.
- Dayan M. O. , Özaydın T. , Farklı Kuş Türlerinde Pecten Oculi'nin Karşılaştırmalı Morfometrik Bir Çalışması Araştırma Makalesi cilt 2013, 22.05.2013.
- Dehkordi, R.A.F. Parchami, A. Bahadoran, S., 2010. Light ve scanning electron microscopic study of the tongue in the zebra finch *Carduelis carduelis* Aves: Passeriformes: Fringillidae. *Slovenian Veterinary Research*, 47: 139-144.
- Denbow, D.M. 2015. Gastrointestinal Anatomy and Physiology. In: Colin G. Scanes Editors. *Sturkie's Avian Physiology* 2015: 337-361.
- Derrien E, Turchini J, 1924. Sur l'accumulation d'une porphyrine dans la glande de Harder des rongeurs du genre Mus et son mode d'excretion. *C R Soc Biol*, 91, 637-639.
- Dimitrov DS ve Nikiforov IP, 2005. Histological and histochemical studies of Harderian gland, lakrimal gland and bursa of fabricius in mulard ducks *anas sterilis* with chlamydial infection. *Bulgarian Journal of Veterinary Medicine*, 8, 119-127.
- Dirik D, 2011. "Kaya keklikleri *Alectoris graeca*'nde kuluçka sonrası on iki haftalık dönemde bursa Fabricii'de görülen ışık mikroskopik değişiklikler". *Yüksek Lisans Tezi, Selçuk Üniv Sağlık Bilimleri Enstitüsü, Konya*.
- Djeridane Y, 1994. The Harderian gland and its excretory duct in the Wistar rat. A histological and ultrastructural study. *J Anat*, 184, 553-566.
- Duus, P. 2001. Nöroloji Tanıda Lokalizasyon. *Ankara, Palma*.
- El-Bakary N.E.R., 2011. Surface morphology of the tongue of the hoopoe *Upupa epops*. *Journal of American Science*, 7: 394-399.
- Elson, C.O., 1997. Advances in mucosal immunity. *Drugs Suppl.*, 1, 13-14.
- Faraj, S.S. and Al-Baurity, G.A. 2016. Morphological and histological study of the liver in migratory starling bird *Sturnus vulgaris*. *Al-Mustansiriyah Journal of Science*. 275: doi: 10.23851/mjs.v27i5.161.
- Fathel-Bab MR, Kamel G, Selim AA, Sayed RA, 1991. Histomorphological and Histochemical Studies of the Harderian Glands of the One-Humped Camel. *Assuit Vet Med J*, 23, 3-53.
- Fix, A.S., Arp, L.H., 1989. Conjunctiva-associated lymphoid tissue in normal and Bordetella avium-infected turkeys. *Vet. Pathol.*, 26, 222- 230.

- Fix, A.S., Arp, L.H., 1991. Morphologic characterization of conjunctiva-associated lymphoid tissue in chickens. *Am. J. Vet. Res.*, 52, 1852-1859.
- Fourman J and Ballantyn B, 1967. Cholinesterase Activity in the Harderian Gland of *Anas domestica*. *Anat Rec*, 159, 17-28.
- Franklin, R.M., Remus, L.E., 1984. Conjunctival-associated lymphoid tissue: evidence a role in the secretory immune system. *Invest. Ophthalmol. Vis. Sci.*, 25, 181- 187.
- Gardner L.L., 1926. The adaptive modifications ve the taxonomic value of the tongue in birds. *Proceedings of the United States National Museum*, 19.
- Gargiulo A.M., Lorvik S., Ceccarelli P., Pedini V., 1991. Histological ve histochemical studies on the chicken lingual glands. *British Poultry Science*, 32: 693-702.
- Gasser, K., Fuchs-Baumgartinger, A., Tichy, A., Barbara, N., Investigations on the conjunctival goblet cells and on the characteristics of glands associated with the eye in the guinea pig, *Veterinary Ophthalmology*, 14(1), 26-40, 2011.
- Gebert, A., Rothkotter, H.J., Pabst, R., 1996. M cells in Peyer's patches of the intestine. *Int. Rev. Cytol.*, 167, 91-159.
- Gerhardt H, Liebner S, Wolburg H, 1996. The pecten oculi of the chicken as a new in vivo model of the blood-brain barrier. *Cell and Tissue Research*, 285 1, 91-100.
- Glick B, Olah I, 1981. Gut-associated-lymphoid tissue of the chicken. *Scanning Electron Microscopy*, 3, 99-108.
- Glick B, Olah I, 1993. Bursal sekretory dentic-like cell: A microenvironment issue. *Poultry Sci*, 72, 1262-6.
- Gomari, G., Gomari.s Aldehyde Fuchsin stain. In: *Cellular Pathology Technique* (C.F.A. Culling, R.T. Allison, and W.T. Barr, eds), pp.238, Butterworths, London 1952.
- Gökmen, G.F. 2003. *Sistematik Anatomi*. İzmir, Guven.
- Guiliano, E.A., Moore, C.P., Phillips, T.E., 2002. Morphological evidence of M cells in healthy canine conjunctiva-associated lymphoid tissue. *Greafes. Arch. Clin. Exp. Ophthalmol.*, 240, 220-226.
- Gultiken ME, Yildiz D, Onuk B, Karayigit MO, 2012. The morphology of the pecten oculi in the common buzzard *Buteo buteo*. *Veterinary Ophtalmology*, 2, 72-76.
- Gultiken ME, Yildiz D, Onuk B, Karayigit MO, 2012. The morphology of the pecten oculi in the common buzzard *Buteo buteo*. *Veterinary Ophtalmology*, 2, 72-76.
- Gülmez N, Aslan Ş, 1999. Histological and Histometrical Investigations on Bursa of Fabricius and Thymus of Native Geese. *Tr J of Veterinary and Animal Sciences*, 23,163-171.
- Hamodi, H.M., Abed, A.A. and Ameer, M.T. 2013. Comparative anatomical, histological and histochemical study of the liver in three species of birds. *Rafidain Journal of Science*. 245: 12-23.
- Hannant, D., 2002. Mucosal immunology: overview and potential in the Veterinary species. *Vet. Immunol. Immunopathol.*, 87, 265- 267.
- Harrison J.G., 1964. Tongue. Thomson A.L., *A New Dictionary of Birds*, London, 825-827.
- Hashimoto Y ve Sugimura M, 1976. Histologia and quantitative studies on the postnatal growt of the thymus and the bursa of fabricius of white pekin ducks. *Jap J vet*, 65-76.
- Hauschild MW, 1914. Zellstruktur und Sekretion in den Orbitaldrüsen der nager. *Anat Hefte*, 50, 531- 629.
- Hodges RD, 1974. *The Histology of the Fowl*. London, Academic Press, p. 205-21.
- Hodges, R.D., 1974. *The Histology of the Fowl*. London, New York, San Francisco, Academic Press.
- Hossler FE, Olson KR, 1984. Microvasculature of the avian eye: studies on the eye of the duckling with microcorrosion casting, scanning electron microscopy, and stereology. *Am J Anat* 170:205-221.
- Huang, A.J., Tseng, S., Kenyon, K.R., Morphogenesis of Rat Conjunctival Goblet Cells, *Investigative IOVS.*, 29(6). 969-975. 1988.
- Hupaya JR, 1995. "Evaluacion de la bursa de fabricio en pollos broilers", *Estudio anatomohistologico Thesis*. Peru.
- Jackowiak H., Godynicki S., 2005. Light ve scanning electron microscopic study of the tongue in the white tailed eagle *Haliaeetus albicilla*, *Accipitiridae*, *Aves*. *Annals of Anatomy*, 187: 251-259.
- Jones, M.P., Pierce K.E., Ward D.W., 2007. Avian Vision: A Review of Form and Function with Special Consideration to Birds of Prey. *Journal of Exotic Pet Medicine*, 16: 69-87.
- Junqueira, L.C, Carneiro, J., Kelley, R.O., 1995. *Basic Histology*. Eighth Edn. Appleton and Lange. Stamford: 448-65.
- Junqueira, L.C., Carneiro, J., Kelley, R.O. 1998. *Temel Histoloji*. Barış, İstanbul.
- Karan, M., Baygeldi, S.B., Özkan, Z. E., Timurkaan, S., Kanmaz, Y. A., Karaavcı, F.A. and Yılmaz, S. 2018. Japon Bildircinlarında *Coturnix coturnix japonica* Karaciğerin Morfolojik Yapısının incelenmesi. *Fırat Üniversitesi Sağlık Bilimleri Veteriner Dergisi Cilt* 32, Sayı 3, 209-212.
- Kelsall, B.L., Leon, F., Smythies, L.E., Smith, P.D., 2004. Antigen handling and presentation by mucosal dendritic cells and macrophages. *Mestecky J. Lamm ME. Strober W. Bienenstock J. Mcghee JR. MayeIn L. eds. Mucosal Immunology*. London: J. Academic Press, pp.105.
- Kern T.J., 2007. *Exotic Animal Ophthalmology*. In: Gelatt, K. N. ed, *Veterinary Ophthalmology*, 4th ed., BlackwellPublishing.
- Khan MZI, Jahan MR, Islam MN, Haque Z, Islam MR, Kon Y, 2007. Immunoglobulin Ig- containing plazma cells in the Harderian gland in broiler and native chickens of Bangladesh. *Tissue and Cell*, 39, 141-149.
- Khenenou T, Melizi M, Benzaoui H, 2012. Morpho-histological Study of the Bursa of Fabricius of Broiler Chickens during Post-hatching Age. *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*, 6, 12.
- Kiama SG, Bhattacharjee J, Maina JN, Weyrauch KD, 1994. A scanning electron microscope study of the pecten oculi of the black kite *Milvus migrans*: possible involvement of melanosomes in protecting the pecten against damage by ultraviolet light. *Journal of Anatomy*, 185 3, 637-642.
- Kiama SG, Bhattacharjee J, Maina JN, Weyrauch KD, 1994. A scanning electron microscope study of the pecten oculi of the black kite *Milvus migrans*: possible involvement of melanosomes in protecting the pecten against damage by ultraviolet light. *Journal of Anatomy*, 185 3, 637-642.
- Kiama SG, Maina JN, Bhattacharjee J, Mwangi DK, Macharia RG, K Weyrauch D, 2006. The morphology of the pecten oculi of the ostrich, *Struthio camelus*. *Annals of Anatomy*, 188 6, 519-528.
- Kiama SG, Maina JN, Bhattacharjee J, Mwangi DK, Macharia RG, K Weyrauch D, 2006. The morphology of the pecten oculi of the ostrich, *Struthio camelus*. *Annals of Anatomy*, 188 6, 519-528.
- Kiama SG, Maina JN, Bhattacharjee J, Weyrauch KD, 2001. Functional morphology of the pecten oculi in the nocturnal spotted eagle owl *Bubo bubo africanus*, and the diurnal black kite *Milvus migrans* and domestic fowl *Gallus gallus*

- var. domesticus: a comparative study. Journal of Zoology, 254 4, 521–528.
- Kiama SG, Maina JN, Bhattacharjee J, Weyrauch KD, 2001. Functional morphology of the pecten oculi in the nocturnal spotted eagle owl *Bubo bubo africanus*, and the diurnal black kite *Milvus migrans* and domestic fowl *Gallus gallus* var. domesticus: a comparative study. Journal of Zoology, 254 4, 521–528.
- King A.S., McLelland J, 1984. Birds: Their Structure ve Function. 2nd ed, London: Bailliere Tindall, 89-90.
- King AS, McLelland J, 1984. Birds their structure and function. Second Edition. Balliere tindall, London, Philadelphia, Toronto, Mexico city, Rio de Janerio, Sydney, Tokyo, Hong Kong.
- Klasing, K.C. 1999. Avian Gastrointestinal Anatomy and physiology. Seminars in Avian and Exotic Pet Medicine. 8: 42-50.
- Kleckowska JN, Chiec A, Harlajczuk GK, Nowaczyk R, Barszcz K, 2015. Light and electron microscopic studies of the Harderian gland in Bilgorajska goose (*Anser anser*). Aca Biologica Hungarica, 3, 1.
- Knop, E., Knop, N., 2003. Eye-associated lymphoid tissue EALT is continuously spread throughout the ocular surface from the lacrimal gland to the lacrimal drainage system. Ophthalmologie, 11, 929- 942.
- Knop, E., Knop, N., 2003. Eye-associated lymphoid tissue EALT is continuously spread throughout the ocular surface from the lacrimal gland to the lacrimal drainage system. Ophthalmologie, 11, 929- 942.
- Knop, N., Knop, E., 2005. Ultrastructural anatomy of CALT follicles in the rabbit reveals characteristics of M-cells, germinal centres and high endothelial venules. J. Anat., 207, 409-426.
- Kocamış, Ö., (2005). Primer Piterjium Cerrahi Tedavisinde Serbest Konjonktival Otogreft. Dr. Lütfi Kırdar Kartal Eğitim ve Araştırma Hastanesi Uzmanlık Tezi, İstanbul.
- Kocaöz, N., 1993. “Pre ve postnatal dönemlerdeki kanatlı Bursa fabriciisi Cloacal bursa üzerinde ışık mikroskopik çalışmalar”. Yüksek Lisans Tezi, Selçuk Üniv Sağlık Bilimleri Enstitüsü, Konya.
- Kocaöz N, Çelik İ, Ünsal S, 1997. Tavuk bursa Fabricii’sinin embriyonel gelişmesi üzerine ışık mikroskopik çalışmalar. SÜ Vet Bil Derg, 13, 43-51.
- Koçak, Y.R. and Özyaydin, T. 2019. Kanatlı Sindirim Sisteminin Fonksiyonel Histolojisi. Dicle Ü. Vet. Fak. Der. 122: 157- 162.
- Kozlu, T., Bozkurt, Y.A., Altunay, H., Sari, E.K. 2010. Histological and histochemical studies on the Harderian gland of the osprey *Pandion haliaetus*. Journal of Animal and Veterinary Advances, 9, 1875–1879.
- Krstic, R.V. 1991. Human Microscopic Anatomy. Springer-Verlag, Berlin Heidelberg.
- Kuloğlu, H.Y. 2016. “Kımalı Keklik (*Alectoris chukar*) Harder Bezinin Alternatif Organ Olarak Bursa Fabricii’nin Gelişim Ve İnvolüsyon Dönemleriyle İlişkinin Histolojik Ve Histokimyasal Yöntemlerle Araştırılması”. Doktora Tezi, Selçuk Üniv Sağlık Bilimleri Enstitüsü, Konya.
- Kuloğlu, H.Y. 2016. Farklı Gelişim Dönemlerinde Kımalı Keklik (*Alectoris chukar*) Dil Bezlerinin Histolojik Gelişimi ve Histokimyasal Yapısı. Batman Üniversitesi Yaşam Bilimleri Dergisi, 61, 205-214.
- Kuloğlu, H.Y. 2016. Kımalı Keklik (*Alectoris chukar*) Lens’inin Işık Mikroskopik Düzeyde Araştırılması. Batman Üniversitesi Yaşam Bilimleri Dergisi, 61, 296-303.
- Kuloğlu, H.Y. 2022. Histochemical Structure Of The Lens In Chukar Partridge (*Alectoris chukar*). Advances in Biology and Earth Sciences, 73, 205-208.
- Kuloğlu, H.Y. (2018). Kımalı Keklikte Palpebral Konjunktivanın Işık Mikroskopik Düzeyde İncelenmesi. Sağlık Bilimleri Örnek Araştırmalar Kitabı. 279-285. Ed: İnci Gülmez, Duygu Sevim. ISBN: 978-605-7928-23-8
- Kuloğlu, H.Y. (2019). CALT (Conjunctiva Associated Lymphoid Tissue). Academic Studies In Health Sciences, 67-76. Ed: Prof. Dr. Nizami DURAN. ISBN: 978-9940-540-71-5
- Kuloğlu, H.Y. 2022. Anatomy, Histology And Embryology Of Harderian Gland. 3. International Hasankeyf Scientific Research And Innovation Congress, 326-339. Full Text Publication/Oral Presentation
- Kuloğlu, H.Y. 2022. Histological And Embryological Evaluation Of Bursa Fabricii. 3. International Hasankeyf Scientific Research And Innovation Congress, 340-348. Full Text Publication/Oral Presentation
- Kuloğlu, H.Y. 2022. Histological And Histochemical Structure Of Conjunctiva-Associated Lymphoid Tissue CALT In *Alectoris Chukar*. Research in: Agricultural & Veterinary Sciences, 63.
- Kuloğlu, H.Y. 2022. Histological Evaluation Of Avian Optic Nerve. Research in: Agricultural & Veterinary Sciences, 62.
- Kuloğlu, H.Y. & Boydak, M. 2024. A Periodic Comparison of Harderian Gland in Henna Partridge (*Alectoris chukar*) According to Different Developmental Stages. Iranian Journal of Veterinary Medicine, 183, 359- 376. <http://dx.doi.org/10.32598/ijvm.18.3.1005521>
- Kuloğlu, H.Y. & Boydak, M. 2023. Plasma Cell Proliferation In The Harderian Gland During The Development And Involution Stages of bursa of Fabricius. IOSR Journal of Agriculture and Veterinary Science IOSR-JAVS, 162, 28-34.
- Kuloğlu, H.Y. & Boydak, M. 2023. Comparison of the Development and Involution Periods of Bursa of Fabricius with Histological and Histochemical Methods. Turkish Journal of Agriculture - Food Science and Technology, 11 8, 1324-1330.
- Kuloğlu, H.Y. and Boydak, M. 2019. Histomorphology, Histometric And Histochemical Structure Of Partridge (*Alectoris chukar*) Of Pecten Oculi in Different Gender. International Journal of Agriculture, Environment and Bioresearch, 404, 21-29. Doi: 10.35410/IJAEB.2019.4403
- Kum S., 2002. Broylarlerde dil ve özofagus-proventrikulus arası bölge üzerinde histolojik ve histokimyasal çalışmalar. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 49, 165–171.
- Leeson, C.R., Leeson, T.S., Paparo, A.A. 1985. Textbook of Histology. W.B. Saunders Company, Philadelphia.
- Liebler-Tenorio, E., Pabst, R., 2006. MALT structure and function in farm animals. Vet. Res., 37, 257-280.
- Liman N, Gülmez N, 1996. Fransız Beyazı *Anser anser* ırkı kazlarda Harderian bezinin gelişimi üzerinde ışık mikroskopik incelemeler. Ankara Üniv Vet Fak Derg, 43, 25-30.
- Liman N., Bayram G., Kocak M., 2001. Histological ve histochemical studies on the lingual, preglottal ve laryngeal salivary glands of the Japanese quail *Coturnix coturnix japonica* at the posthatching period. Anatomia Histologia Embryologia, 30: 367–373.
- Loewenthal N, 1892a. Notiz über die Harder’sche Drüse des igels. Anatomischer Anzeiger, 7, 48-54.

- Loewenthal N, 1892b. Beitrag zur Kenntnis der Harder'schen Drüse bei den Säugetieren. *Anatomischer Anzeiger*, 7, 546-556.
- Loewenthal N, 1900. Die Glandula infraorbitalis und eine besondere der Parotis anliegende Drüse bei der weissen Ratte. *Drüsenstudien II, Arch Mikr Anat*, 56, 535-552.
- Loewenthal N, 1916. Weitere Beobachtungen über die Entwicklung der Augenhohlendrüsen. I. Zur Frage des erstens Auftretens der Tränendrüse beim Rind. *Ibid*, 49, 13-23.
- Loewenthal N. *Drüsenstudien I*, 1896. Die Harder'schen Drüse. *Internationale monatschrift für Anatomie und Physiologie*, 13, 27-65.
- Lopez JM, Tolivia J, Alvarez-Uria M, 1992. An ultrastructural study of myoepithelium maturation during postnatal development of the hamster Harderian gland. *Anat Embryol*, 186, 573-582.
- Lupetti M, Dolgi A and Michelucci S, 1990. Reappraisal of histogenesis in the bursal lymphoid follicle of the chicken. *Am J Anat*, 187, 287-302.
- Marcos HJA, Affanni JM, 2005. Anatomy, histology, histochemistry and fine structure of the Harderian gland in the South American armadillo *Chaetophractus villosus Xenarthra, Mammalia*. *Anat Embryol*, 209, 409-424.
- Maxwell MH, 1985. Granulocyte differentiation in the lymphoid organs of chick embryos after antigenic and mitogenic stimulation. *Dev Comp Immunol*, 9, 93-106.
- Maxwell MH, Burns RB, 1979. The ultrastructure of the epithelium of the ducts of the Harderian and lakrimal glands of the Turkey, fowl and duck. *Journal of Anatomy*, 128, 445-459.
- Maxwell MH, Rothwell B, Burns RB, 1986. A fine structural of the turkey Harderian gland. *J Anat*, 148, 147-157.
- Meyer DB, 1977. The avian eye and its adaptations. *Crescentelli Feds: In Handbook of Sensory Physiology, The Visual System of Vertebrates*, 5, Springer, Berlin, Germany, pp: 549-612.
- Micali A, Pisani A, Ventrici C, Puzzolo D, Roszkowska AM, Spinella R, Aragona P, 2012. Morphological and Morphometric Study of the Pecten Oculi in the Budgerigar *Melopsittacus undulatus*. *The Anatomical Record*, 295, 540-550.
- Michaelson IC, 1954. *Retinal circulation in man and animals*. Springfield: CC Thomas.
- Mobilio C, 1913. Risposta alle osservazioni di N. Loewenthal sui miei sullo sviluppo della glandola lakrimale e della glandola della terza palpebra nil bue. *Anat Anz*, 44, 218-224.
- Mobini B, 2012. Histological and histochemical studies on the Harderian gland in native chickens. *Veterinari Medicina*, 57, 404-409.
- Moslem, D. 2015. Histological study of the African ostrich liver and anatomical comparison of it with poultry liver. *Biological Forum-An International Journal* 71: 1185-1188.
- Möllendorf WV, 1927. *Handbuch der Mikroskopischen Anatomie des Menschen*. Berlin, 1, 187-189.
- Mueller AP, Sato K, Glick B, 1971. The chicken lakrimal gland, gland of Harder, caecal tonsil, and accessory spleens as sources of antibody producing cells. *Cell Immunol*, 2, 140-152.
- Munkeby BH, Smith HJ, Larssen EHW, Bjornerud A, Bjerkas I, 2006. Magnetic resonance imaging of the Harderian gland in piglets. *J Anat*, 209, 699-705.
- Nickel R., Schummer A., Seiferle E., 1977. *Anatomy of the Domestic Birds*. Berlin-Hamburg: Verlag Paul Parey.
- Nickel, R., Schummer, A. and Seiferle, E. 1977. *Anatomy of the domestic birds*. Berlin, Hamburg: Verlag Paul Parey 1977: 57-60.
- O'Malley B., 2005. *Clinical Anatomy ve Physiology of Exotic Species, Structure ve Function of Mammals, Birds, Reptiles, ve Amphibians*. 1st ed., Toronto: Elsevier Saunders, pp:118-125.
- O'sullivan, N.L., Montgomery, P.C., Sullivan, A.D. 2004. Ocular mucosal immunity. In: *Mucosal Immunology*. Vol II. Eds.: Mestecky, J., Lamm M.E., Strober, W., Bienenstock, J., Meghee, J.R., Mayer, L. London: Academic Press, Chapter 86.
- Oğul, E. 1996. *Temel ve Klinik Nöroloji*. Uludağ University, Bursa.
- Olah I and Glick B, 1992. Follicle-associated epithelium and medullary epithelial tissue of the bursa of Fabricius are two different compartments. *Anat Rec*, 233, 577-87.
- Onuk B, Tutuncu S, Alan A, Kabak M, Ince NG, 2013. Macroanatomic, light and scanning electron microscopic studies of the pecten oculi in the stork *Ciconia ciconia*. *Microscopic Resarch Techniques*, 76, 963-7.
- Onyeanusu BI, Ezeokoli CD, Onyeanusu JC, Ema AN, 1993. The anatomy of the cloacal bursa bursa of Fabricius in the helmeted guinea fowl *Numida meleagris galeata*. *Anat Histol Embryol*, 22, 212-21.
- Orhan IO, Ekim O, Bayraktaroglu AG, 2011. Morphological investigation of the pecten oculi in quail *Coturnix coturnix japonica*. *Ankara Univ Vet Fac Journal*, 58, 5-1.
- Orhan IO, Ekim O, Bayraktaroglu AG, 2011. Morphological investigation of the pecten oculi in quail *Coturnix coturnix japonica*. *Ankara Univ Vet Fac Journal*, 58, 5-1.
- Ortiz GG, Feria VA, Tarpley RL, Bitzer QOK, Rosales CSA, Velazquez BIE, Lopez NOG, Reiter RJ, 2007. The orbital Harderian gland of the Male Atlantic Bottlenose Dolphin *Tursiops truncatus*: A morphological study. *Anat Histol Embryol*, 36, 209-214.
- Önal Ö. ve Çınar K, 2013. Keklik (*Alectoris chukar*) Harder Bezi Üzerine Histolojik ve Histokimyasal Çalışmalar. *Fırat Üniversitesi Sağlık Bilimleri Vet Derg*, 27, 13 - 17.
- Özer, A., *Veteriner Özel Histoloji*. s.328, Nobel Yayınevi, Ankara, 2010.
- Öztabak, K.Ö., Lektinler ve Viscum album aglutinin (VAA)'nın antikarsinojen etkileri, *Erciyes Üniv. Vet. Fak. Derg*, 2, 55-59, 2005.
- Parchami A., Dehkordi R.A.F., Bahadoran S., 2010. Scanning electron microscopy of the tongue in the golden eagle *Aquila chrysaetos Aves: Falconiformes: Accipitridae*. *World Journal of Zoology*, 5: 257-263.
- Pasve A.P., Tadjalli M., Mansouri H., 2010. Microscopic study on the tongue of male ostrich. *European Journal of Biological Sciences*, 2: 24-31.
- Payne AP, 1994. The Harderian gland: a tercentennial review. *J Anat*, 185, 1-49.
- Pettigrew JD, Wallman J, Wildsoet CF, 1990. Saccadic oscillations facilitate ocular perfusion from the avian pecten. *Nature* 343, 362- 363.
- Pettigrew JD, Wallman J, Wildsoet CF, 1990. Saccadic oscillations facilitate ocular perfusion from the avian pecten. *Nature* 343, 362- 363.
- Pradidarcheep W, Asavapongpatana S, Mingsakul T, Poonkhum R, Nilbu NS, Somana R, 2003. Microscopic anatomy of the orbital Harderian gland in the Common Tree Shrew *Tupaia glis*. *J Morphol*, 255, 328-336.
- Puzzolo D, 1994. Morphological adaptation of the vertebrate eye to the environment. *It J Anat Embryol* 99, 17-100.

- Puzzolo D, Micali A, Pisani A, Arco A, Cutroneo G, 1985. Scanning electron microscopic study on the relationship between the pecten oculi and the vitreous capsule in the eye of the adult chicken. *Quad Anat Prat* 61, 93-98.
- Pütter A, 1903. Die Augen der Wassersäugethiere. *Zool Jahrb abt Anat Ontogen*, 17, 99-402.
- Radius, R.L. 2001. Anatomy and embriology of the optic nerve. In Kaufmann PL, Mittag T.W., Yanoff M eds: *Ophthalmology*, Mosby, London, 1994 2.1-2.207. Duus P. Nöroloji Tamda Lokalizasyon. *Palme Yayıncılık*, Ankara.
- Rahman ML, Lee E, Aoyama M, Sugita S, 2010. Light and electronmicroscopy study of the pecten oculi of the jungle crow *Corvus macrorhynchos*. *Okajimas Folia Anatomica Japonica*, 87 3, 75-83.
- Ratcliffe MJ, 1985. The ontogeny and cloning of B cells in the bursa of Fabricius. *Immunol Today*, 6, 223-7.
- Reece, W., *Functional Anatomy and Physiology of Domestic Animal*, s. 592, Wiley- Blackwell, 2009.
- Rochon-Duvigneaud A, 1943. *Les yeux et la vision des Vertebres*. Paris: Masson et Cie.
- Rodieck RW, 1973. *The vertebrate retina. Principles of structure and function*. W.H. Freeman, San Francisco.
- Ross, M.H, Pawlina, W., 2006. *Histology A Text and Atlas. With correlated cell and molecular biology*. 5th ed., Lippincott Williams & Wilkins. Philadelphia: 417-844.
- Rothwell B, Wight PAL, Burns RB, Mackenzie GM, 1972. The Harderian glands of the domestic fowl. II Ultrastructure. *J Anat*, 112, 233-250.
- Russel PH, 1993. Newcastle disease virus: Virus replication in the Harderian gland stimulates lakrimal Ig A; the yolk sac provides early lakrimal Ig G. *Vet Immuno Immunopathol*, 37, 151 163.
- Russel PH, Koch G, 1989. Local antibody forming cell responses to the Hitcher and Ulster strains of Newcastle disease virus. *Vet Immunol Immunopathol*, 37, 165-180.
- Russell, M.W., Martin, M.H., Wu, H., Hollingshead, S.K., Moldoveanu, Z., Mestecky, J., 2000. Strategies immunization againts mucosal infections. *Vaccines*, 19, 122-127.
- Sabry I, Al-Ghaith L, 2000. The Harderian gland of the Dhub lizard *Uromastix microlepis* of the Kuwaiti desert: an ultrastructural approach. *Tissue and Cell*, 32, 71-78.
- Saifuddin MD, Manktelow BW, Moriarty KM, Christensen NH, Birtles MJ, 1988. Age-related functional changes in the follicle-associated epithelium of the bursa of Fabricius in Shaver Cockerels. *NZ Vet J*, 36, 108-11.
- Sakai T, Yohro T, 1981. A histological study of the Harderian gland of Mongolian gerbils. *Meriones meridianus*. *Anat Rec*, 100, 259-270.
- Samuelson D.A., 2007. *Ophthalmic Anatomy*. In: Gelatt, K. N. ed.. *Veterinary Ophthalmology*. 4th ed., Blackwell Publishing.
- Santos T.C., Fukuda K.Y., Guimaraes J.P., Oliveira M.F., Miglino M.A., Watanabe S., 2011. Light ve scanning electron microcopy study of the tongue in *Rhea americana*. *Zoological Science*, 28: 41-46.
- Sarı EK, Kurtdede N, 2007. Light and Electron Microscopic Studies of the Bursa of Fabricius in Turkeys. *Kafkas Üniv Vet Fak Derg*, 13, 177-184.
- Sarıca Ş., Karataş Ü., Gözalan R. *Kanatlılarda Bağışıklık Sistemi ve Bağışıklık Sistemini Etkileyen Besinsel Faktörler*. Gaziosmanpaşa Üniversitesi, Ziraat Fakültesi Dergisi, 262, 81-86, 2019.
- Scott TR, Savage ML, Olah I, 1993. Plazma Cells of the Chickens Harderian Gland. *Poul Sci*, 72, 1273-1279.
- Selman, H.A. 2013. Morphological and histological study for liver in local coot birds *fulica atra*. *Basrah Jurnal of Veterinary Research*. 121: doi: 10.33762/BVETR. 2013. 76197.
- Shatos, A.M., Rios, J.D., Horikawa, Y., Hodges R.R., Chang, E.L., Bernardino, C.R., Rubin P., Dartt, A., Isolation and Characterization of Cultured Human Conjunctival Goblet Cells, *IOVS.*, 44(6), 2477-2486, 2003.
- Shinoda S, 1958. Harder's gland in some mammals. *Acta Med*, 28, 4623-4635.
- Shiojiri N and Takahashi MC, 1991. Lymphoid follicle formation in the bursa of Fabricius of the chick embryo. *J Anat*, 175, 237-49.
- Sinowartz F, Amselgrober W, 1986. Postnatal development of the bovine Sertori cells. *Anat Embryol*, 174, 413-423.
- Smith BJ, Smith SA, Braekveelt CR, 1996. Fine structure of the pecten oculi of the barred owl *Strix varia*. *Histology and Histopathology*, 11 1, 89-96.
- Snell, R.S. 2000. *Functional Neuroanatomy for Medical Faculty Students Translation Editor: Yıldırım M.* Istanbul: Nobel Medical Bookstores and Yüce Publishing.
- Soydan, N. 1992. *Genel Histoloji*. Istanbul University, Istanbul.
- Sundwall J, 1907. The structure of the Harderian gland of the ox. *Anat Rec*, 1, 72-73.
- Swatland, H.J. 1994. *Structure and Development of Meat Animals and Poultry*. CRC Press. 624p.
- Şenol N., Yeşil Ö., Kınalı Keklik (*Alectoris chukar*) ve Sülün *Phasianus colchicus* Türlerinde Timus ve Bursa Fabricius Dokularının Histolojik Açından İncelenmesi Süleyman Demirel Üniversitesi Fen Edebiyat Fakültesi Fen Dergisi 172: 532-542, 2022
- Taddei D, 1900. Contributio all canascenca istofisiologica della ghiandola dell Harder nel coniglio. *Arch Sci Med*, 24, 319-336.
- Taib N.T., Jarrar B.M., 1998. Histological ve histochemical characterization of the lingual salivary glands of the quail, *Coturnix coturnix*. *Saudi Journal of Biological Sciences*, 5: 33-41.
- Taib N.T., Jarrar B.M., 2001. Histochemical characterization of the lingual salivary glands of the eurasian collared dove, *Streptopelia decaocta*. *Pakistan Journal of Biological Sciences*, 4:11, 1425-1428.
- Taner, D. 2002. *Functional Neuroanatomy*. METU Development Foundation Publishing and Communication Inc., Ankara.
- Tanyolaç A, 1999. *Özel Histoloji*. Ankara, Yorum Basın Yayın San Ltd Şti, s. 44.
- Taşbaş, M. 1978. Evcil Kanatlılardan Tavuk, Horoz *Gallus domesticus* ve hindinin *Meleagris gallopavo* Sindirim Sistemleri Üzerinde Karşılaştırmalı Makro-Anatomik ve Subgros Araştırmalar. *J. Fac. Vet. Med*. 500-516.
- Taşçı, S.K., Deprem, T. and Bingöl, S.A. 2018. The anatomical and histological structures of buzzard. *Kafkas Üniv Vet Fak Derg*. 241: 69-74.
- Tekelioğlu, M., 2002. *Özel Histoloji: İnce Yapı ve Gelişme*. Antıp A.Ş. Tıp Kitapları ve Bilimsel Yayınları. Ankara: 263-76.
- Tizard I, 1983. *An Introduction to Veterinary Immunology*. 2th ed. Rio de Janeiro, WB Saunders Company, p. 61-3.
- Tsutsumi A, Iwata K, Ogawa K, Matsuura K, 1966. Histochemical and electron microscopic observations on the Harderian gland of the albino rat. *Arch Histol Jap*, 27, 553-567.

- Tucker R, 1975. The surface of the pecten oculi in the pigeon. *Cell Tissue Res* 157, 457–465.
- Wagner, A.L., Murtagh, F.R., Hazlett, K.S., & Arrington, J.A. 1997. Measurement of the normal optic chiasm on coronal MR images. *American Journal of Neuroradiology*, 184, 723-726.
- Walls GL, 1942. The vertebrate eye and its adaptive radiation. Cranbrook Press, Bloomfield Hills.
- Watanabe M, 1980. An autoradiographic biochemical and morphological study of the Harderian gland of mouse. *J Morph*, 163, 349-365.
- Watanabe M, 1980. An autoradiographic biochemical and morphological study of the Harderian gland of mouse. *J Morph*, 163, 349-365.
- Wheater P.R., Burkitt H.G., Daniels V.G., 1987. *Functional Histology: A text and Colour Atlas*. 2nd ed. Churchill Livingstone Medical Division of Longman Group Ltd. Hong Kong: 318- 29.
- Wight PAL, Burns RB, Rothwell B, Mackenzie GM, 1971. The Harderian gland of the domestic fowl. I- Histology with reference to the genesis of plazma cells and Russell bodies. *J Anat*, 100, 307- 315.
- Willem JH, Darryl AP, Susan JR, 2007. “A new lachrymal gland with an excretory duct in red and fallow deer” by Johann Jacob Harder 1694: English translation and historical perspective. *Ann Anat*, 189, 423-433.
- Williams, P.L., Bannister, L.H., Berry, M.M., Collins, P., Dyson, M., Dussek, J.E., & Ferguson, M.W.J. 1995. *The anatomical basis of medicine and surgery*. Gray's Anatomy, 38111, 512-514.
- Wolburg H, Liebner S, Reichenbach A, Gerhardt H, 1999. The pecten oculi of the chicken: A model system for vascular differentiation and barrier maturation. *International Review of Cytology*, 187, 111–159.
- Woodhouse MA, Rhodin JAG, 1963. The ultrastructure of the Harderian gland of the mouse with particular reference to the formation of its secretory product. *J Ultrastr Res*, 9, 76-98.
- Yaren FM, 2008. “Dişi sülün Phasianus colchicus’lerin Harder bezi üzerinde histolojik ve histokimyasal çalışmalar”. Yüksek Lisans Tezi, Selçuk Üniv Sağlık Bilimleri Enstitüsü, Konya.
- Zaefarian, F., Abdollahi, M. R., Cowieson, A. and Ravindran, V. 2019. Avian Liver: The Forgotten Organ. *Multidisciplinary Publishing Institute Journal*. 92: 63. doi: 10.3390/ani9020063.
