Kocatepe Veterinary Journal

https://doi.org/10.30607/kvj.1713275

Research Article

Macroscopic and Microscopic Examination of Uropygial Gland in Young and Adult Quails *(Coturnix japonica)*

Genç ve Erişkin Bıldırcınlarda *(Coturnix japonica)* Üropigial Bezin Makroskopik ve Mikroskopik İncelenmesi

Banu KANDİL[1,*], Fatma İŞBİLİR[2], Muhammed Zahid ATLI[2]

[1]Department of Histology and Embryology, Faculty of Veterinary Medicine, Siirt University, Siirt, Türkiye
[2]Department of Anatomy, Faculty of Veterinary Medicine, Siirt University, Siirt, Türkiye

Corresponding Author:
Banu KANDİL
*banukandil@siirt.edu.tr

ORCID:
BK:0000-0002-7821-2180
Fİ:0000-0002-6110-1302
MZA:0009-0007-3139-1453

Received: 04.06.2025
Accepted: 13.01.2026
Published: 15.03.2026

Citation:
Kandil B. İşbilir F. Atlı MZ. Macroscopic and Microscopic Examination of Uropygial Gland in Young and Adult Quails (Coturnix Japonica). Kocatepe Veterinary Journal (2026) 19(1):1-13

Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY-NC 4.0) license.

Abstract

This study aimed to evaluate the anatomical and histological aspects of the uropygial gland of young and adult quails *(Coturnix japonica)*. Uropygial glands of 20-30 day-old (young, n: 6) and 150-200 day-old (adult, n: 6) quails were used as tissue material. Tissue samples were fixed in 10% formaldehyde for histological examination. After routine procedures, Crossmon's trichrome staining was performed on tissue sections. Live weight (LW), gland weight (GW), glandula uropygialis width (GUW) and length (GUL), and papilla uropygialis width (PUW) and length (PUH) measurements were performed for morphological evaluations. Additionally, relative gland weight index (RGWI), lobus glandula uropygialis index (LGUI), and glandula uropygialis length index (GULI) values were calculated. LW and GW were higher in the adult quails ($p<0.05$). However, GUW, GUL, PUW, PUH, RGWI, LGUI, and GULI did not differ between young and adult quails ($p>0.05$). In both periods, the glandula uropygialis consisted of two lobes. Each lobe had a central cavity and an excretory duct. Tubules were divided into peripheral and central. The tubules were lined with stratified epithelium containing basal, intermediate, secretory, and degenerative cells. Peripheral tubules were more dominant in both periods. In the adult quails, the central cavity grew larger, and tubular structures and the connective tissue between the tubules showed more development. The number of secretory cell layers in both the central and peripheral tubules increased. Also, fat droplets were observed in many secretory cells in the peripheral tubules. Consequently, secretion increased, and structural changes formed in the uropygial glands of adult quails.

Key Words: Adult period, Histology, Morphology, Quail, Uropygial gland, Young period

Öz

Bu çalışma genç ve yetişkin bıldırcınların *(Coturnix japonica)* üropigial bezinin anatomik ve histolojik özelliklerinin belirlenmesi amaçladı. 20-30 günlük (genç, n:6) ve 150-200 günlük (yetişkin, n: 6) bıldırcınların üropigial bezleri doku materyali olarak kullanıldı. Histolojik inceleme için doku örnekleri %10 formaldehitte tespit edildi. Rutin işlemlerde sonra, doku kesitlerine Crossmon'un üçlü boyaması yapıldı. Morfolojik değerlendirmeler için canlı ağırlık (LW), bez ağırlığı (GW), glandula üropigial genişliği (GUW) ve uzunluğu (GUL) ile papilla üropigial genişliği (PUW) ve uzunluğu (PUH) ölçümleri alındı. Ayrıca, relatif bez ağırlık indeksi (RGWI), lobus glandula üropigial indeksi (LGUI) ve glandula üropigial uzunluk indeksi (GULI) değerleri hesaplandı. LW ve GW yetişkin bıldırcınlarda daha yüksekti ($p<0.05$). Ancak, GUW, GUL, PUW, PUH, RGWI, LGUI, and GULI genç ve yetişkin bıldırcınlar arasında farklı değildi ($p>0.05$). Her iki dönemde, üropigial bez iki lobdan oluşuyordu. Her bir lob bir merkezi boşluğa ve akıtıcı kanala sahipti. Tubuller periferal ve merkez olarak ikiye ayrıldı. Tubuller bazal, intermediyer, sekretorik ve dejeneratif hücrelerden oluşan çok katlı epitel ile kaplıydı. Periferal tubuller her iki dönem de baskındı. Yetişkin bıldırcınlarda, merkezi boşluk büyüdü ve tubuller arasındaki bağ dokusu ve tubuller daha fazla gelişme gösterdi. Hem merkezi hem de perifer tubullerdeki sekretorik hücre katmanlarının sayısı arttı. Ayrıca, perifer tubullerdeki birçok sekretorik hücresinde yağ damlacıkları gözlenlendi. Sonuç olarak, yetişkin bıldırcınların üropigial bezlerinde salgı olayı arttı ve yapısal değişiklikler şekillendi.

Anahtar Kelimer: Bıldırcın, Genç dönem, Histoloji, Morfoloji, Üropigeal bez, Yetişkin dönem

Introduction

Mammals have many eccrine, apocrine, and sebaceous glands. However, birds have no specialised skin glands (İşbilir et al., 2024a; Yılmaz et al., 2018). The uropygial gland, which is of epidermal origin, is unique to birds (Aboud and Elbahi, 2021; Bride, 1978; Yılmaz and Yılmaz, 2020). This gland is analogous to the sebaceous glands found in mammals (Carril et al., 2020). The uropygial gland is also known as the preen gland, oil gland, rump gland, glandula uropygii, glandula caudae, or glandula sebacea (Jacob and Ziswiler, 1982).

The size, shape, and development of the glandula uropygialis vary among bird species (Liman and Alan, 2013; Salibian and Montalti, 2009). This gland is more developed in water birds than in land birds (Karaavci et al., 2024; Yılmaz and Yılmaz, 2020). The uropygial gland is absent in some species of pigeon *(Columbidae)* and parrot *(Psittacidae),* as well as in some species of ostrich *(Rheidae*) (İşbilir et al., 2024b; Yılmaz et al., 2018).

In birds, the uropygial gland is typically located in the region between the fourth caudal vertebrae and the pygostyle (Salibian and Montalti, 2009). It is a compound tubule-alveolar holocrine gland (Carril et al. 2020). Previous studies have described its histology, morphological features, secretions, and functions of the uropygial gland in different avian species (Carril et al., 2020; Harem et al., 2010; Hassanin et al., 2021; İşbilir et al., 2024a; İşbilir et al., 2024b; Kanasiye et al., 2016; Karaavci et al., 2024; Kelenk and Çınar, 2009; Mohamed, 2019; Sawad, 2006; Shafiian and Mobini, 2014; Yılmaz et al., 2018; Yılmaz and Yılmaz, 2020).

The uropygial gland is surrounded by a capsule that is composed of connective tissue. It is known that the gland is usually two-lobed, with the lobes divided by an interlobular septum that extends into the capsule (Moreno-Rueda, 2017). The lobes have a central cavity, and radially extending secretory tubules are located around it. The central cavity collects the secretion produced in the secretory tubules. This secretion is then transported to the papilla,which is usually a single, narrow structure, via excretory ducts (Jacob and Ziswiler, 1982; Karaavci et al., 2024; Salibian and Montalti, 2009).

The secretion of the uropygial gland is composed of various substances, including waxes made up of fatty acid esters, long- and short-chain fatty acids, triglycerides, phospholipids, enzymes involved in fat synthesis, and cell debris (Burger et al., 2004; Karaavci et al., 2024; Kelek and Çınar, 2009). The uropygial gland secretes a substantial quantity of both volatile and non-volatile compounds, primarily in the form of a waxy, oily fluid. These secretions are distributed across the plumage during preening, playing a crucial role in feather maintenance and waterproofing (Hirao et al., 2009). The secretion of the uropygial gland not only imparts water-repellent and feather-softening properties to the plumage but may also play roles in pheromone signaling, maintaining hygiene, providing thermal insulation, and protection against bacteria and predators (Burger et al., 2004; Chiale et al., 2014). The chemical composition of uropygial gland secretions is known to vary, with these changes being influenced by factors such as sex, age, and diet (Hirao et al., 2009; Sandilands et al., 2004; Soini et al., 2007).

Many studies have investigated the histological and morphological features of uropygial glands in birds such as budgerigars *(Melopsittacus undulatus)* (İşbilir et al., 2024b), Aseel roosters and hens (Yılmaz et al., 2018), barn owls (*Tyto alba)* (Yılmaz and Yılmaz, 2020), moorhens (*G. gallinula C. Choropus)* (Sawad, 2006), geese (*Anser anser)* (Shafiian and Mobini, 2014), ducks (*Anas platyrhynchos)* and pigeons *(Columba livia)* (Hassanin et al., 2021) or turkeys *(Meleagris gallopavo)* (İşbilir et al., 2024a). However, there are limited studies that reveal structural changes in the uropygial glands of birds during the developmental process (Massoud et al., 2025). Kelenk and Çınar (2009) conducted a study to identify the histological and histochemical characteristics of the uropygial glands in adult male and female quails. However, no study had previously determined the morphological and histological features of the uropygial glands during the developmental

process of quails. This study was therefore designed to determine the anatomical and histological features of the uropygial glands in young and adult quails.

Materials and Methods

Animals

The quails *(Coturnix japonica)* used in this study were obtained from Siirt University Wild Animals Protection, Rehabilitation Application and Research Center. The study used glandula uropygialis from a total of 12 quails: six animals in the young period (20-30 days old) and six animals in the adult period (150-200 days old). This study was approved by the Siirt University Local Ethics Committee for Animal Experiments (Decision No: 2025/03/16).

Macroscopic Examination

In the study, the presence of the uropygial gland was determined in all birds. The body weight of the birds was determined using a precision balance. In macroscopic examination, the topographic position of the gland was noted first. The glands' weights, carefully dissected from the surrounding tissues, were determined with a precision balance (Weightlab WL-300L). A digital caliper (Mitutoyo, CDN-20C, Japan) and ImageJ (1.4) software were used for morphometric measurements of the gland. Four indices were calculated from the morphometric measurements. Morphometric measurements and calculations were performed using the study by İşbilir et al. (2024a, b) as a guide. The internal structure of the glands was also examined under a stereomicroscope (Olympus SZ61, Japan). Nomina Anatomica Avium (Baumel et al., 1993) was used for the nomenclature of anatomical terms. Morphometric measurement parameters and abbreviations are described below and shown in Figure 1.

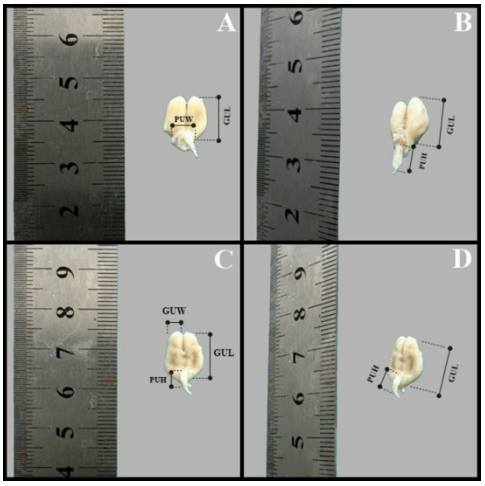


Figure 1. The uropygial glands of young (A, B) and adult (C, D) quails. Dorsal (A, C) and lateral (B, D) views. GUL: glandula uropygialis length; GUW: glandula uropygialis width; PUH: papilla uropygialis height; PUW: papilla uropygialis width.

Morphometric parameters:

LW: live weight

GW: gland weight

GUW: glandula uropygialis width

GUL: glandula uropygialis length

PUW: papilla uropygialis width

PUH: papilla uropygialis height

Index parameters:

Relative gland weight index (RGWI) = gland weight (GW) × 100/live weight (LW)

Lobus glandula uropygialis index (LGUI) = glandula uropygialis length (GUL)/glandula uropygialis width (GUW)

Papilla uropygialis index (PUI) = papilla uropygialis height (PUH)/papilla uropygialis width (PUW)

Glandula uropygialis length index (GULI) = glandula uropygialis length (GUL)/papilla uropygialis width (PUW)

Microscopic Examination

Tissues were fixed in 10% formaldehyde solution at room temperature for 24 hours. They were then embedded in paraffin, following routine histological methods. Sections of 5 μm thickness were obtained from the tissue blocks. The tissue sections were mounted on slides and stained with Crossmon's (1937) trichrome staining for general histological evaluation. The prepared sections were examined under a light microscope (DM750; Leica) equipped with a camera (MC170; Leica), and photographs were taken.

Statistical Analyses

Statistical analysis of the measurement data was performed using the IBM SPSS Statistics 23.0 software. The data obtained as a result of measurement parameters and index calculations were analysed with the Independent Samples t-test and the Mann-Whitney U test to determine the differences between the periods.

Results

Macroscopic Results

In our study, the presence of the uropygial gland was observed in all quails. The uropygial gland was located dorsal to the last sacral and first caudal vertebrae, adjacent to the caudal muscles. There was no layer of adipose tissue around the gland, while the upper part was covered with a thin skin. In both periods, the gland consisted of two heart-shaped lobes (lobes merged caudally) and a short papilla system caudally, which were observed to be symmetrical on macroscopic examination. The glands were generally dorsoventrally flattened, with a slight convexity on the ventral surface and a flatter dorsal surface (Figure 2). Numerous holes (*porus glandulae uropygialis*) were observed on the papillae, and many hair structures were observed in these holes. The lobes of the gland examined under a stereomicroscope were separated by the septum interlobare. A light colored secretory material with a dense consistency was observed inside the lobes (Figure 3). Descriptive statistical values and p-values of morphometric measurements and index calculations of young and adult quails are presented in Tables 1 and 2, respectively.

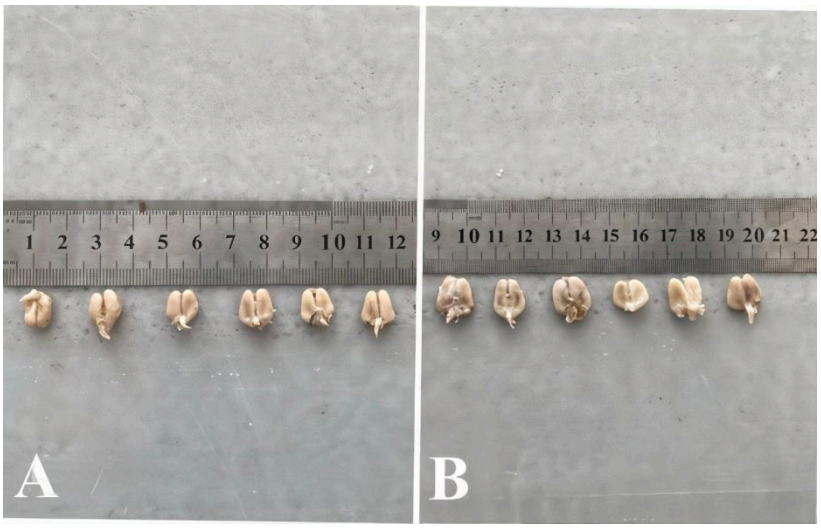


Figure 2. Dorsal view of uropygial glands of young (A) and adult (B) quails.



Figure 3. Internal view of glandula uropygialis in adult quail (under stereomicroscope). *: interlobular septum; S: secretion; P; *papillae uropygialis*; arrow: papilla feathers (*pluma*).

Table 1. Descriptive statistics and p-values of morphometric measurement parameters of the uropygial gland in young and adult quails.

	Average			Young Quail (n=6)	Adult Quail (n=6)	
Parameters	**Mean±SE**	**Min.**	**Max.**	**Mean±SE**	**Mean±SE**	**p**
LW (g)	195.41±20.02	110	310	132.50±4.78	258.33±12.56	<0.05
GW (g)	0.16±0.17	0.09	0.26	1.11±0.008	0.22±0.01	<0.05
PUH (mm)	3.44±0.15	2.56	4.26	3.18±0.15	3.70±0.23	0.09
PUW (mm)	5.20±0.31	4.09	7.34	4.63±0.21	5.77±0.50	0.06
GUL (mm)	11.78±0.37	9.66	13.45	11.53±0.51	12.02±0.57	0.54
GUW (mm)	3.91±0.17	3.07	5.22	3.63±0.19	4.18±0.25	0.12

Table 2. Uropygial gland index values in young and adult quails.

	Average			Young Quail (n=6)	Adult Quail (n=6)	
Parameters	**Mean±SE**	**Min.**	**Max.**	**Mean±SE**	**Mean±SE**	**p**
RGWI	0.16±0.01	0.08	0.10	0.08±0.004	0.08±0.0009	0.39
PUI	0.67±0.02	0.57	0.81	0.69±0.03	0.65±0.03	0.09
LGUI	3.02±0.15	2.44	4.30	3.21±0.22	2.83±0.18	0.46
GULI	2.32±0.13	1.51	3.15	2.49±0.15	2.15±0.19	0.22

According to the morphometric measurement data, the gland weights were determined as 1.15±0.07 g and 2.21±0.11 g in young and adult quails, respectively. As a result of the statistical evaluation, LW and GW parameters were observed to be significantly different between the young and adult periods. As expected, these parameters were larger in adult quails. There were no differences in other morphometric parameters or index values between young and adult quails ($p>0.05$).

Microscopic Results

In both young and adult quails, the uropygial glands were surrounded by a capsule composed of connective tissue (Figure 4A). The glands were bilobed, comprising a right and a left lobe. Each lobe had a large excretory duct (Figure 5A and 6B) and a central cavity (Figure 4A, B, and 6A). Extensions of the capsule penetrated the organ and formed an interlobular septum composed of connective tissue, dividing the organ into two lobes. Blood and lymph vessels, nerve plexuses, and adipocytes were observed in the interlobular septum (Figure 4B). In the connective tissue of the caudal part of the gland, dense adipose tissue, feather follicles, Herbst corpuscles, smooth muscle fibers, nerve plexuses, blood and lymph vessels were observed (Figure 5). In addition, lymphoid tissue cell communities were identified towards the central space (Figure 6A) and around the excretory ducts (Figure 6B). The excretory ducts were lined with stratified squamous epithelium (Figure 6B).

In both young and adult periods, the tubules extended from the periphery to the centre, opening into the central cavity (Figure 4). The tubules were separated from each other by connective tissue. The development of tubular structures was more advanced in the adult quails compared to the young quails. The connective

tissue between the tubules was denser in the adult quails (Figure 7). In addition, the central space was also enlarged in the adult quails.

The tubules were divided into two groups: the peripheral and the central. In samples from both periods, peripheral tubules were located close to the capsule, and central tubules were located close to the central cavity. The peripheral tubules had no lumen, whereas the central tubules had one. During both periods, peripheral tubules were more dominant in the uropygial gland (Figure 4, 7). The tubules were lined with a stratified epithelial layer. The epithelial layer of the tubules consisted of four cell layers: basal cell layer, intermediate cell layer, secretory cell layer, and degenerative cell layer (Figure 7).

In both young and adult quails, the basal cell layer of the peripheral and central tubules consisted of flat cells with basophilic cytoplasm that were located on the basement membrane. The intermediate cell layer was situated above the germinative layer and comprised of polyhedral-shaped cells with eosinophilic cytoplasm. The secretory cell layer consisted of larger polyhedral-shaped cells with basophilic cytoplasm. The borders of the secretory cells were clearly defined. Small degenerated cells with pyknotic nuclei formed the degenerative cell layer. The number of secretory cell layers in both the central and peripheral tubules was increased in the adult period compared to the young period (Figure 7). In young quails, the cytoplasm of only a few secretory cells in the peripheral tubules contained fat droplets, whereas in adult quails, fat droplets were present in the cytoplasm of many secretory cells in the peripheral tubules. Furthermore, the fat droplets were larger in the adult period (Figure 7A, B). No fat droplets were observed in the cytoplasm of the secretory cells of the central tubules in either period (Figure 7C, D).

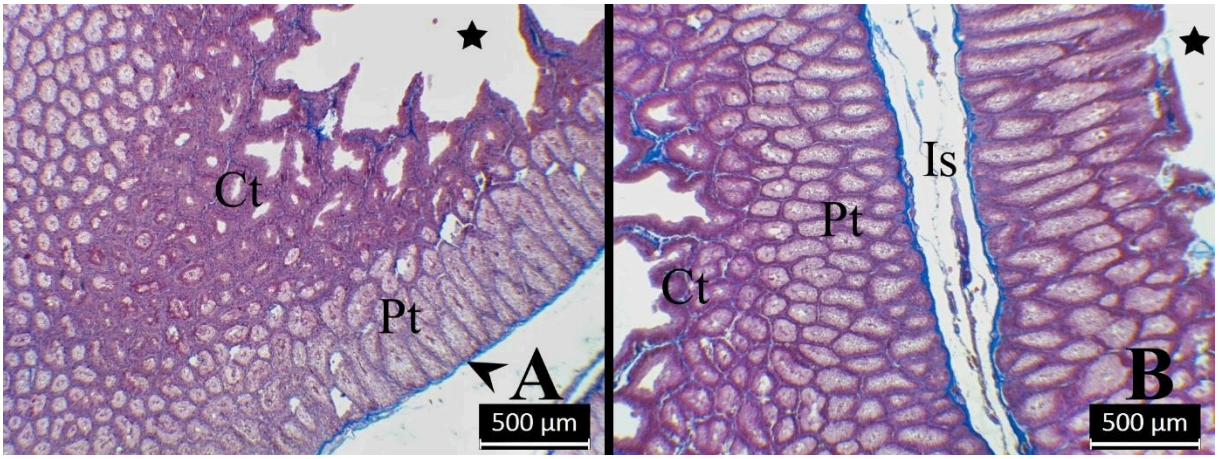


Figure 4. Light microscopic images of uropygial glands of young (A) and adult (B) quails. Ct: central tubule; Is: Interlobular septum; Pt: peripheral tubule; black arrowhead: capsule; black star: central space. Bar: 500 µm. Crossmon's trichrome staining.

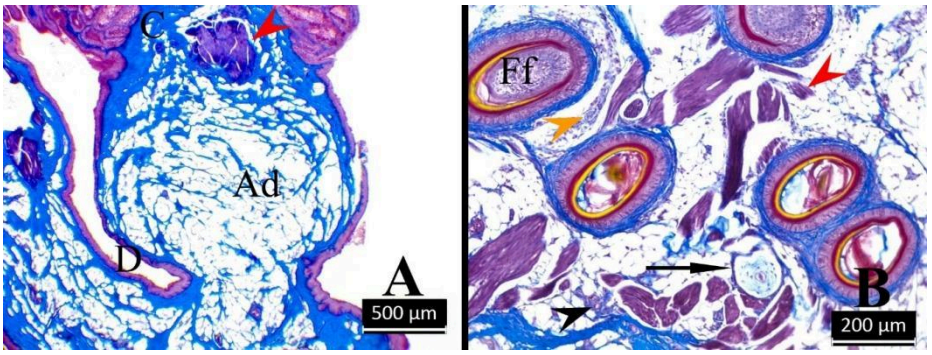


Figure 5. Light microscopic image of the cauda portion of the uropygial glands. Ad: Adipose tissue; C: connective tissue; D: excretory duct; Ff: feather follicle; orange arrowhead: nerve plexus; red arrowhead: smooth muscle fibers; black arrow: Herbst corpuscle; black arrowhead: blood vessel. Bar: A: 500 µm, B:200 µm. Crossmon's trichrome staining.

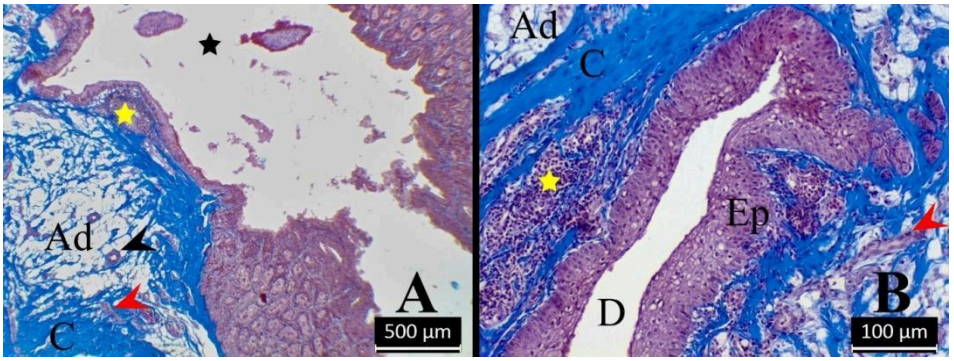


Figure 6. Lymphoid tissue cell communities (yellow star) identified in histological sections of uropygial glands. Ad: Adipose tissue; C: connective tissue; D: excretory duct; Ep: Epithelium; black star: central space; black arrowhead: blood vessel; red arrowhead: smooth muscle fibers. Bar: A: 500 µm, B: 100 µm. Crossmon's trichrome staining.

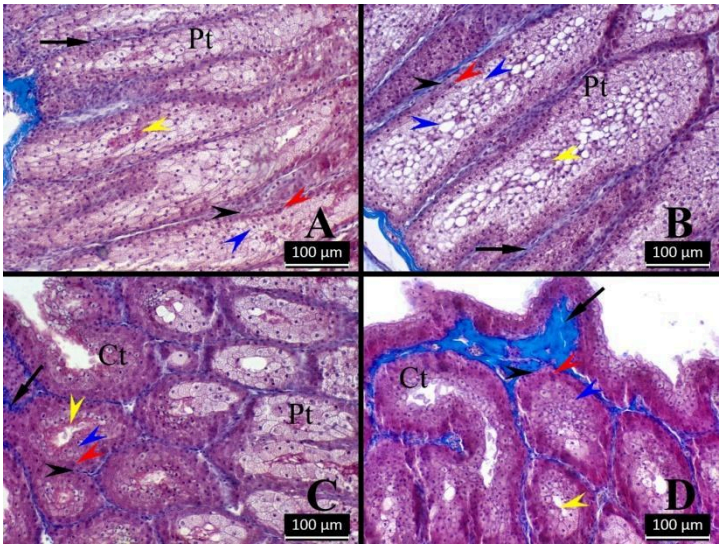


Figure 7. Peripheral and central tubules in the uropygial glands of young (A, C) and adult (B, D) quails. Ct: central tubule; Pt: peripheral tubule; black arrow: connective tissue; black arrowhead: basal cell; blue arrowhead: secretory cell; red arrowhead: intermediate cell; yellow arrowhead: degenerated cell. Bar: 100 µm. Crossmon's trichrome staining.

Discussion

The uropygial gland is known to be present in some avian species during the embryonic period, but it atrophies in adulthood. This gland is not present in species such as Struthionidae, Rheidae, Casuaridae, and Dromaidae (Salibian and Montalti, 2009). This study showed that the uropygial gland is present in quails during the young and adult periods.

The uropygial gland has been reported to be located between the fourth caudal vertebra and the middle of the pygostyle in ducks *(Anas platyrhynchos)* (Hassanin et al., 2021), pigeons *(Columba livia)* (Hassanin et al., 2021), Aseel roosters and hens (Yılmaz et al., 2018). In turkeys *(Meleagris gallopavo),* İşbilir et al. (2024a) reported that the gland's topographical location is on the last caudal vertebrae. The uropygial gland in quails found to be located dorsal to the last sacral and first caudal vertebrae, adjacent to the caudal muscles, which was consistent with the literature.

The shape of the uropygial gland varies among different species of bird (Salibian and Montalti, 2009). The gland has been reported to be pear-shaped in pigeons *(Columba livia)* (Hassanin et al., 2021; Karaavci et al., 2024), sparrowhawks (Karaavci et al., 2024), barn owls *(Tyto alba)* (Yılmaz and Yılmaz, 2020), and V-shaped in ducks (Hassanin et al., 2021; Mohamed, 2019). The shape of the uropygeal gland of quails in young and adult periods was heart-shaped, as was previously observed in budgerigars *(Melopsittacus undulatus)* (İşbilir et al., 2024b), turkeys *(Meleagris gallopavo)* (İşbilir et al., 2024a), Aseel roosters and hens (Yılmaz et al., 2018).

Studies have been conducted on budgerigars (*Melopsittacus undulatus*) (İşbilir et al., 2024b), turkeys (*Meleagris gallopavo)* (İşbilir et al., 2024a), pigeons, geese, crows, sparrowhawks, eagles, and storks (Karaavci et al., 2024) to compare the morphometric values of their uropygial glands in females and males. In another study, the morphometric values of the glandula uropygialis were compared between Aseel roosters and hen species (Yılmaz et al., 2018). Yılmaz and Yılmaz (2020) also presented morphometric values of the uropygeal glands in barn owls *(Tyto alba)*. In this study, morphometric values such as LW, GW, GUW, GUL, PUW, PUH, and index parameters such as RGWI, LGUI, PUI, and GULI of the uropygeal glands of quails in the young and adult periods were presented. Although a statistical difference was found in the LW and GW values between the young and adult quails, no statistical difference was found in other morphometric parameters and index values.

This study showed that the uropygeal gland of quails is bilobed and has a single papilla system, as previously reported in budgerigars *(Melopsittacus undulatus)* (İşbilir et al., 2024b), Aseel roosters and hens (Yılmaz et al., 2018), mule ducks (Mohamed, 2019), monk parakeets (Carril et al., 2020), and turkeys *(Meleagris gallopavo)* (İşbilir et al., 2024a). As reported for ospreys *(Pandion Haliaetus)* (Harem et al., 2010) and mule ducks (Mohamed, 2019), histological examination in this study revealed that each lobe has a central cavity and an excretory duct.

Previous studies have described the presence of lymphoid tissue cell communities in histological sections of uropygial glands of species such as Kadaknath birds (Kanasiya et al., 2016), barn owls *(Tyto alba)* (Yılmaz and Yılmaz, 2020), and turkeys *(Meleagris gallopavo)* (İşbilir et al., 2024a). In this study, the lymphoid tissue cell communities were determined towards the central cavity and around the ducts in the uropygial gland of quails in the young and adult periods. The strategic positioning of lymphoid tissue cell populations near the central cavity and duct system suggests that they play a role in local immune defense by preventing microbial invasion through duct openings during both the young and adult stages.

In previous studies, the secretory tubules were divided into three zones in budgerigars *(Melopsittacus undulatus)* (İşbilir et al., 2024b), monk parakeets (Carril et al., 2020), and barn owls *(Tyto alba)* (Yılmaz and Yılmaz, 2020). In Aseel roosters and hens, tubules were divided into two parts, as a basal and an apical

region (Yılmaz et al., 2018). In geese *(Anser Anser)*, they were divided onto an outer sebaceous zone and an inner glycogen zone (Shafiian and Mobini, 2014). In the current study, the secretory tubules were divided into peripheral and central tubules, as in ospreys *(Pandion haliaetus)* (Harem et al., 2010), mule ducks (Mohamed, 2019), and turkeys *(Meleagris gallopavo)* (İşbilir et al., 2024a).

Secretory tubules are lined with a stratified epithelium (Jacob and Ziswiler, 1982; Salibian and Montalti, 2009). In mule ducks, Mohamed (2019) identified three different cell types in the epithelial layer: basal cells, intermediate cells, and secretory cells. However, in budgerigars *(Melopsittacus undulatus)* (İşbilir et al., 2024b), Kadaknath birds (Kanasiya et al., 2016), ospreys *(Pandion Haliaetus)* (Harem et al., 2010), barn owls *(Tyto alba)* (Yılmaz and Yılmaz, 2020), geese *(Anser Anser)* (Shafiian and Mobini, 2014), ducks *(Anas platyrhynchos)* (Hassanin et al., 2021), pigeons *(Columba livia)* (Hassanin et al., 2021) and turkeys *(Meleagris gallopavo)* (İşbilir et al., 2024a), the epithelial layer of the tubules was composed of four different cell types: basal cells, intermediate cells, secretory cells and degenerative cells. In this study, four different cell layers were identified in the epithelium of the tubules, consistent with the literature.

Harem et al. (2010) have reported that the peripheral tubules are the main site of lipid synthesis in the uropygial gland in ospreys *(Pandion haliaetus)*. In a study on roosters (Zık and Erdost, 2002), the basal region of the tubules was defined as the fat region, while the apical region was defined as the glycogen region. Although the researchers did not detect lipids in the cells of the first and second layers of tubules in the fat region using Oil-Red O staining, they determined the lipid content of cells extending towards the lumen. Similarly, the present study found no fat droplets in the basal and intermediate cell layers of peripheral tubules, but fat droplets were detected in the secretory cell layer. In this study, Oil Red O staining was not performed. Although Crossmon's trichrome staining applied to tissue sections does not specifically demonstrate lipids, the presence of fat droplets was determined based on their morphological characteristics. Using Best Carmin and PAS staining, Zık and Erdost (2002) determined that the apical region of the gland was rich in glycogen and defined this region as the glycogen region. In this study, fat droplets were detected in the secretory cells of the peripheral tubules, while fat droplets were not detected in the secretory cells of the central tubules. The secretion content of the central and peripheral tubules of the uropygial gland in quails may differ, and more detailed studies utilizing histochemical staining methods are required before any conclusions can be drawn on the secretion content.

Many studies have been conducted to reveal the anatomical and histological features of uropygial glands in various species of birds. However, studies on uropygial gland the development in birds are limited (Massoud et al., 2025). Massoud et al. (2025) reported that the secretory tubules of the uropygial glands exhibited greater development at the mature (24-week-old) and adult (1-year-old) stages compared to the juvenile (2-week-old) and newly hatched (1-day-old) domestic pigeons *(Columba livia)*. The researchers also noted that, compared to the juvenile and newly hatched animals, mature pigeons exhibited an expanded central space. Similarly, the current studyshowed that tubular structures were better developed and the central space was enlarged in the adult quails compared to young quails. In addition, there was an increase in the number of secretory cell layers in both the central and peripheral tubules of adult quails. The number of fat droplets in the secretory cells of the peripheral tubules were increased in the adult quails. These results may indicate that the secretory capacity of the uropygial gland increases and the gland becomes more active in the adult period.

Massoud et al. (2025) found that the stroma of the uropygial gland became more organised with increasing collagen fiber accumulation as pigeons developed. Similarly, in this study, it was determined that the connective tissue between the tubules was better developed in the adult quails compared to the young quails. This increase in connective tissue between the tubules during the adult period may reflect a structural adaptation to support gland's enhanced secretory activity.

Conclusion

This study revealed the anatomical and histological features of the uropygial gland in young and adult quails. The findings suggest that, by revealing the age-related morphological and histological developmental dynamics of the gland, this research holds potential implications for the fields of poultry science and developmental biology. In addition, results of this study show that the development of uropygial glands is more advanced and secretion events are increased in adult quails compared to young quails. These results suggest that the increase in secretory capacity with age affects the health, and water-repellent ability of birds' feathers, as well as their potential antimicrobial defence mechanisms. Further studies could investigate whether hormonal regulation, environmental conditions, or nutrition modulate these developmental differences.

Conflict of interest: The authors have no conflicts of interest to report.

Authors' Contributions: B.K.: Conceptualization, Data curation, Investigation, Methodology, Visualization, Writing - original draft, Writing - review & editing. **F.İ.:** Data curation, Investigation, Methodology, Visualization, Writing - original draft. **M.Z.A.:** Investigation, Methodology, Visualization.

Ethical approval: This study was approved by the Siirt University Local Ethics Committee for Animal Experiments (Decision No: 2025/03/16).

Funding: No institution or organization supported this study.

Availability of data and materials: The data for this study are available from the corresponding author.

References

Aboud, F. S., & Elbahi, A. M. (2021). Histological changes of uropygial gland in Indigenous chicken during summer and winter seasons. JOMS, 16(2), 9-14. doi:10.51984/joms.v16i2.1752

Baumel, J. J., King, A. S., Breasile, J. E., Evans, H. E., & Berge, J. C. V. (1993). Handbook of avian anatomy (Nomina anatomica avium). 2nd ed. Cambridge, Massachusetts: Publications of the Nuttall Ornithological Club, p.22-44.

Bride, J. (1978). Cytophysiologic differentiation in the epithelial region of the uropygial gland in the duck embryo Anas platyrhynchos. J Embryol Exp Morphol, 46, 21-35.

Burger, B. V., Reiter, B., Borzyk, O., & Du Plessis, M. A. (2004). Avian exocrine secretions. I. Chemical characterization of the volatile fraction of the uropygial secretion of the green woodhoopoe, *Phoeniculus purpureus*. J Chem Ecol, 30(8), 1603-1611. doi: 10.1023/b:joec.0000042071

Carril, J., Chiale, M. C., & Barbeito, C. G. (2020). The uropygial gland of the monk parakeet Myiopsitta monachus: Histology, morphogenesis, and evolution within Psittaciformes (Aves). Evol Dev, 22(3), 269-282. doi:10.1111/ede.12327

Chiale, M. C., Fernández, P. E., Gimeno, E. J., Barbeito, C., & Montalti, D. (2014). Morphology and histology of the uropygial gland in Antarctic birds: relationship with their contact with the aquatic environment?. Australian Journal of Zoology, 62(2), 157-165. doi:10.1071/ZO13103

Crossmon, G. (1937). A modification of Mallory's connective tissue stain with a discussion of the principles involved. Anat Rec, 69(1), 33-38. doi: 10.1002/ar.1090690105

Harem, I. S., Kocak-Harem, M., Turan-Kozlu, T., Akaydin-Bozkurt, Y., Karadag-Sari, E., & Altunay, H. (2010). Histologic structure of the uropygial gland of the osprey *(Pandion haliaetus)*. Journal of Zoo and Wildlife Medicine, 41(1), 148-151. doi:10.1638/2008-0205.1

Hassanin, A., Shoeib, M., & Massoud, D. (2021). Micro and macroanatomical features of the uropygial gland of duck *(Anas platyrhynchos)* and pigeon *(Columba livia)*. Biotech Histochem, 96(3), 213-222. doi:10.1080/10520295.2020.1782990

Hirao, A., Aoyama, M., & Sugita, S. (2009). The role of uropygial gland on sexual behavior in domestic chicken Gallus gallus domesticus. Behav Processes, 80(2), 115-120. doi: 10.1016/j.beproc.2008.10.006.

İşbilir, F., Özgüden Akkoç, C. G., İsbilir, İ., Özöner, Ö., Güzel, B. C., Arıcan, I., Atalgın, Şükrü Hakan, Can, M., & Bekmezci, S. (2024a). Morphometric, macroscopic and microscopic investigation of glandulae uropygiale in turkeys *(Meleagris gallopavo).* Microsc Res Tech, 87(11), 2707-2719. doi:10.1002/jemt.24642

İşbilir, F., Küpeli, Z. A., İşbilir, İ., Arıcan, İ., & Özyiğit, Ö. (2024b). Macroscopic and microscopic characteristics of uropygial gland of budgerigars *(Melopsittacus undulatus).* TJVR, 8(1), 43-51. doi: 10.47748/tjvr.1393777

Jacob, J., & Ziswiler, V. (1982). The uropygial gland. In: Avian Biol, p.199-324.

Kanasiya, S., Karmore, S. K., Barhaiya, R. K., Deshmukh, S. K., & Joshi, S. K. (2016). Histological and histochemical study on the uropygial gland of Kadaknath breed of poultry. Veterinary Practitioner, 17(2), 195-197.

Karaavci, F. A., Dortbudak, M. B., Demircioglu, M., & Kocyigit, A. (2024). Investigation of glandula uropygialis in different avian species using morphometric and histological methods. Anat Histol Embryol, 53(5), e13107. doi: 10.1111/ahe.13107.

Kelek, S., & Çınar, K. (2009). The Histological and histochemical structures of uropygial gland of the female and male quail *(Coturnix coturnix japonica).* EÜFBED, 2(2), 229-238.

Liman, N., & Alan, E. (2013). The process of apoptosis in a holocrine gland as shown by the avian uropygial gland. Anatl Rec, 296(3), 504-520. doi: 10.1002/ar.22645.

Massoud, D., AbdRabou, M. A., Faddladdeen, K. A. J., El-Kott, A. F., Abumandour, M. M. A, & Khalil, E. K. (2025). Age-related histological and histochemical changes of the Uropygial gland in the Domestic Pigeon *(Columba livia)*. Microsc Microanal, 31(2), ozaf021. doi: 10.1093/mam/ozaf021.

Mohamed, R. (2019). Macro and microanatomical study on the uropygial gland of the mule duck. Inter J Vet Sci, 8(2), 96-100.

Moreno-Rueda, G. (2017). Preen oil and bird fitness: a critical review of the evidence. Biol Rev Camb Philos Soc, 92(4), 2131-2143. doi: 10.1111/brv.12324

Sandilands, V., Powell, K., Keeling, L., & Savory, C. J. (2004). Preen gland function in layer fowls: factors affecting preen oil fatty acid composition. Br Poult Sci, 45(1), 109-115. doi: 10.1080/00071660410001668932.

Salibian, A., & Montalti, D. (2009). Physiological and biochemical aspects of the avian uropygial gland. Braz J Biol, 69(2), 437-46. doi: 10.1590/s1519-69842009000200029.

Sawad, A. A. (2006). Morphological and histological study of uropygial gland in Moorhen (G. gallinula C. Choropus). International Journal of Poultry Science, 5(10), 931-934.

Shafiian, A. H. & Mobini, B. (2014). Histological and histochemical study on the uropygial gland of the goose (*Anser anser).* Bulg J Vet Med, 17(1), 1-8.

Soini, H. A., Schrock, S. E., Bruce, K. E., Wiesler, D., Ketterson, E. D., & Novotny, M. V. (2007). Seasonal variation in volatile compound profiles of preen gland secretions of the Dark-eyed Junco (*Junco hyemalis).* J Chem Ecol, 33, 183-198. doi: 10.1007/s10886-006-9210-0

Yılmaz, B., Harem, İ. Ş., Demircioğlu, I., Özyiğit, G., & Bozkaya, F. (2018). Anatomic, morphometric and histological features of glandula uropygialis in Aseel roosters and hens. Eurasian J Vet Sci, 34(2), 65-70. doi: 10.15312/EurasianJVetSci.2018.182

Yılmaz, B., & Yılmaz, R. (2020). Morphological and histological analysis of the Uropygial Gland in Barn owls *(Tyto alba).* J Res Vet Med, 39(2) 143-148. doi:10.30782/jrvm.813008

Zık, B., & Erdost, H. (2002). Histological investigations on the effects of feeding with a diet containing red hot pepper on the uropygial gland of a rooster. Turk J Vet Anim Sci, 26(6), 1223-1232.