

## Morphological and morphometrical characteristics of the interdigital gland in Kivircik sheep

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**Abstract:** The purpose of this study was to determine the morphological and morphometric characteristics of the interdigital gland in Kivircik sheep. The interdigital glands in the forefeet and hind feet of the 16 male Kivircik sheep were examined in terms of morphometric and morphological characteristics. Four lengths (length of duct and corpus, diameter of duct and corpus) and 2 angles (angle of internal and external flexure) were measured in the interdigital glands located between 2 digits after dissection. The interdigital gland contained orifice, excretory duct, flexure, and corpus sections. Lengths and widths of corpus and excretory ducts of the interdigital gland were 2.19, 2.68, 0.47, and 0.20 cm, respectively. The diameter of the excretory duct, external angle, diameter of corpus, and diameter of excretory duct in the right interdigital glands of the Kivircik sheep were higher than those of the left interdigital glands, a statistically significant difference. The apocrine gland secretion was PAS- and AB-positive.

**Key words:** Foot, interdigital gland, Kivircik sheep, skin gland

### 1. Introduction

The Kivircik sheep is a major sheep breed in western parts of the Aegean Region, Thrace, and East Marmara, and it is superior among sheep races in terms of meat taste (1).

Secretions of skin gland located in specific areas of body, such as the tarsal, interdigital, and infraorbital areas in the ungulates, are closely related to reproductive activities (2). The interdigital gland in the artiodactyla is a skin gland located in the hoof; it secretes apocrine and holocrine (3). This gland has been defined as a foot skin organ by Raesfeld (4), a growing organ by Shivachelven et al. (5), and an interdigital sinus by Bavdek (6). The secretions from interdigital glands have various densities and compositions (7–9). Parillo and Diverio (10) have stated that the secretion of the interdigital gland works as a pheromone in the social life of animals. Moreover, Abbasi et al. (3) have indicated that the gland has fungicidal and bactericidal effects, and protects against UV radiation.

In the literature (3,5,7,9,11–14), although numerous studies were found on the morphology of interdigital gland, there has been no study regarding the interdigital gland in Kivircik sheep. For this reason, the purpose of this study was to determine morphological and morphometric properties of the interdigital gland in Kivircik sheep.

### 2. Materials and methods

The interdigital glands in the forefeet and hind feet of 16 male Kivircik sheep (12 months old) were examined in terms of morphometric and morphological characteristics. The feet of the Kivircik sheep were obtained from the Manisa Municipality Slaughterhouse. The feet of 10 sheep were used for gross dissection and morphometric measurements, and the feet of 6 sheep were used for histological and histochemical examination. Measurements of 4 lengths (length of duct and corpus, diameter of duct and corpus) and 2 angles (angle of internal and external flexure) were taken of the interdigital glands after dissection. These values were standardized as ratios of duct and corpus lengths, duct and corpus diameters, and internal and external flexure angles. The Image J program was used to make the measurement after the process of photography. The Mann–Whitney U test was used in SPSS version 17.0 to conduct statistical analysis. Statistical significance was established at  $P < 0.05$ . *Nomina Anatomica Veterinaria* (15) was also used for terminology.

#### 2.1. Histological and histochemical procedures

The interdigital gland samples were kept in 10% formalin for 24 h. The routine procedure was applied and then they were embedded in paraffin. Serial sections with a

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thickness of 5 µm were cut from paraffin blocks. Mallory's modified triple staining was used to demonstrate general structure of the interdigital gland. Periodic acid-Schiff (PAS) staining for glycogen demonstration and Alcian blue (AB) (pH 2.5) staining for demonstration of both carboxylated and sulfated acidic mucosubstances were applied to the sections. The sections were examined with a light microscope (Olympus BX51, Japan).

### 3. Results

#### 3.1. Macroanatomical examination

It was determined that the interdigital gland in all of the feet of the Kivircik sheep was located between 2 digits. The interdigital gland contained orifice, excretory duct, flexure, and corpus sections (Figures 1-3). The gland stretched from



**Figure 1.** Medial view of the interdigital region in Kivircik sheep. 1. Orifice, 2. excretory duct, 3. flexure, 4. corpus, a. interdigital ligament.



**Figure 2.** View of the interdigital gland in Kivircik sheep. 1. Orifice, 2. excretory duct, 3. flexure, 4. corpus, 5. internal angle, 6. external angle.



**Figure 3.** Sagittal section view of interdigital gland in Kivircik sheep. 1. Orifice, 2. excretory duct, 3. flexure, 4. corpus, 5. internal angle, 6. external angle, 7. secretion of the interdigital gland.

dorsal to foot at the level of distal extremity of the proximal phalanx, on average 1 cm proximal to the corona region of the toe (Figure 1). The excretory duct of the gland was identified between the upper sections of proximal interphalangeal joint and the distal extremity of the medial phalanx. The flexure of the gland reclined to the interdigital ligament at the level of the distal extremity of the medial phalanx. The corpus division of the gland extended in a dorso-palmar (plantar) direction between the proximal extremities of the medial phalanx and the proximal interphalangeal joint.

The latero-lateral view of the gland was pipe-like. In the sagittal section, it was seen that 1/3 of the palmaro-(plantaro-) distal portion of the corpus and 1/3 of the distal portions of the flexure and excretory duct of the glands were thicker than the other gland sections (Figure 3). The lumen of the gland was covered by hair in the direction of secretion, and hairs were concentrated in flexure (Figure 3). Moreover, a distinct ridge was found on the surface of the lateral wall of the corpus (Figure 3).

### 3.2. Morphometric examination

The Table illustrates the morphometric values of the interdigital glands of the fore-, hind, right, and left feet in Kivircik sheep.

### 3.3. Histological and histochemical examination

The wall structure of the interdigital gland of the Kivircik sheep was composed of the epidermis, dermis, and a capsule of connective tissue. The epidermis consisted of keratinized stratified squamous epithelium. Sebaceous glands, sweat glands, muscle fibers, nerve plexus, hair follicles, and also apocrine glands close to the capsule in the dermis were observed (Figure 4). The secretion of the apocrine glands, basal membranes of the epithelium cells,

and muscle fibers were PAS-positive (Figure 5). At the same time, secretions of the glands were AB-positive (pH 2.5) (Figure 6).

### 4. Discussion

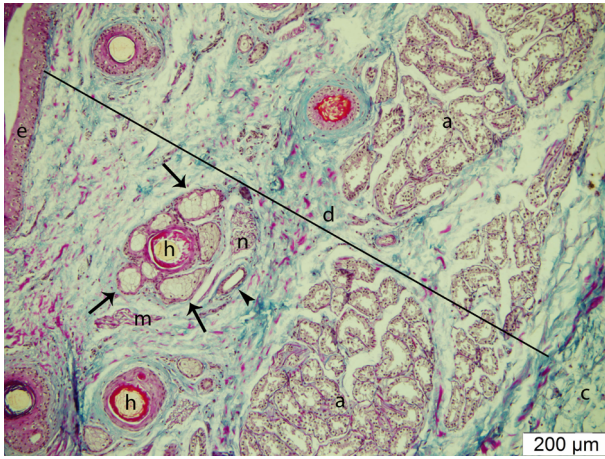
The interdigital gland is found between digits in the forefeet and hind feet, and its excretory duct is open to the proximo-dorsal section of the interdigital region (3,7,12). Although Abbasi et al. (3) indicated that the gland extended between the distal section of the proximal phalanx and the proximal section of the medial phalanx, Janicki et al. (13) referred to a gland extending between half of the proximal phalanx and the distal phalanx. The sagittal section of the interdigital gland is pipe-like, and the gland is divided into 2 parts: excretory and secretory. The lumen of the gland was filled with many hairs and material from secretion (3). Accordingly, it was determined that the results of our study were in parallel with results of the literature (3,7,12).

Abbasi et al. (3) compared interdigital glands in terms of season (sexual and nonsexual) and sex. This study revealed that the volumetric and weight values of the interdigital gland in male animals during the sexual season were higher than in other groups. In light of the literature, only males were used in our study. In the literature (3,7,12), it is stated that the interdigital glands of forefeet are higher than ones in the hind feet in terms of morphometric values.

Getty (16) stated that length of the interdigital gland in sheep was 2.5–3 cm, and its width was 6–7 mm. Abbasi et al. (3) and Atoji et al. (7) reported that the length and width of the interdigital gland and length of the excretory duct in the Japanese serow and Lori's sheep were 2.5–4, 1.4–2, and 1 cm and 1.58, 0.77, and 2.66 cm, respectively.

**Table.** Morphometric values of the interdigital gland in Kivircik sheep. R: mean  $\pm$  standard deviation of right fore- and hind feet. L: mean  $\pm$  standard deviation of left fore- and hind feet. F: mean  $\pm$  standard deviation of front right and left feet. H: mean  $\pm$  standard deviation of hind right and left feet. DL: length of excretory duct, CL: length of corpus, CD: diameter of corpus, DD: diameter of excretory duct, IA: internal angle of flexure, EA: external angle of flexure. \* P < 0.05.

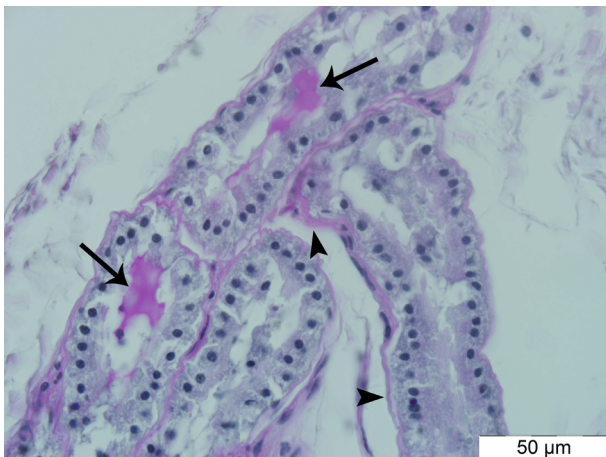
Parameters	R	L	Parameters	F	H
DL	25.86 $\pm$ 3.08	26.31 $\pm$ 4.07	DL	25.03 $\pm$ 3.74	27.13 $\pm$ 3.09
CL	22.85 $\pm$ 3.57	20.97 $\pm$ 4.47	CL	23.08 $\pm$ 4.36	20.74 $\pm$ 3.55
CD	4.57 $\pm$ 0.80	4.86 $\pm$ 1.41	CD	4.29 $\pm$ 0.55	5.14 $\pm$ 1.39
DD*	2.44 $\pm$ 0.54	1.63 $\pm$ 0.34	DD	2.01 $\pm$ 0.71	2.05 $\pm$ 0.55
IA	9.76 $\pm$ 1.09	9.44 $\pm$ 3.34	IA	9.33 $\pm$ 0.72	9.87 $\pm$ 3.43
EA*	14.31 $\pm$ 1.45	11.53 $\pm$ 1.77	EA	12.30 $\pm$ 1.32	13.54 $\pm$ 2.69
DL/CL	1.15 $\pm$ 0.15	1.30 $\pm$ 0.34	DL/CL	1.10 $\pm$ 0.14	1.34 $\pm$ 0.31
DD/CD*	0.54 $\pm$ 0.14	0.35 $\pm$ 0.08	DD/CD	0.47 $\pm$ 0.18	0.42 $\pm$ 0.13
IA/EA	0.69 $\pm$ 0.10	0.83 $\pm$ 0.33	IA/EA	0.76 $\pm$ 0.05	0.75 $\pm$ 0.35



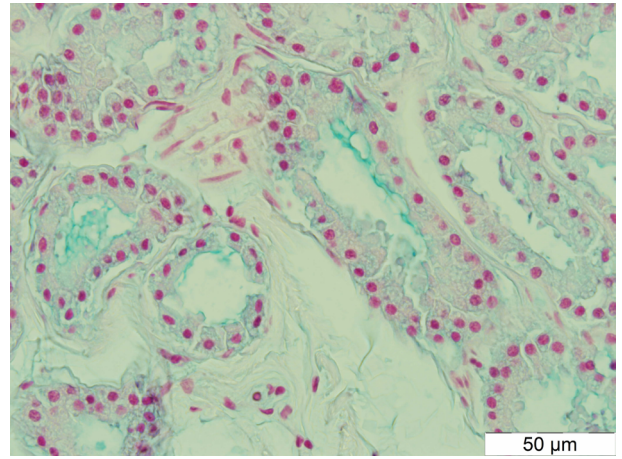
**Figure 4.** Interdigital gland of Kivircik sheep. e. Epidermis, d. dermis, c. capsule. Arrows: sebaceous glands, m. muscle fiber, n. nerve plexus, h. hair follicles and a. apocrine glands. Arrow head: sweat gland, triple.

Calislar (17) specified that the lengths of the body and neck of this gland in Akkaraman sheep were 0.9 and 2.3 cm, respectively. Furthermore, Nickel et al. (18) declared that the length of the excretory duct was 1.8–2 cm. While Nickel et al. (18) reported the length of this duct as 0.2–0.4 cm, Abbasi et al. (3) determined that the said length was 0.49 cm. Avdic et al. (12) reported that the length of the excretory duct was 1.5–1.8 cm. In our study, it was observed that the lengths and widths of the corpus and excretory ducts of interdigital glands were 2.19, 2.68, 0.47, and 0.20 cm, respectively.

The external angles between the body and neck of the gland in the forefeet and hind feet were 30° and 20°, respectively (17). In our study, these angles were 12.30° and 13.54°.



**Figure 5.** Interdigital gland of Kivircik sheep. Arrows: apocrine gland secretion, arrow head: basal membranes of the epithelium cells. PAS.



**Figure 6.** Interdigital gland of Kivircik sheep. AB (pH 2.5).

Although Avdic et al. (12) divided the interdigital gland into the corpus, collum, and fundus, Abbasi et al. (3) defined the interdigital gland as part of the excretory and secretory systems. Meanwhile, Janicki et al. (13) divided the interdigital gland into deep, middle, and excretory sections, while Karahan et al. (14) described this gland with the terms body, neck, and flexure. In the present study, the interdigital gland had divisions of orifice, excretory duct, flexure, and corpus, as in the literature.

While Janicki et al. (13) reported that the interdigital gland was found only in the hind feet of the roebuck, other researchers (3,4,7,12,17) specified that the interdigital gland was found in all of the Lori's sheep, Douchke sheep, Japanese serow, Akkaraman sheep, antelope, and moufflon. Although Bahadir and Yakisik (19) stated that the interdigital gland was a rudiment in the native hair goat, Calislar (17) revealed that the interdigital gland was not found in the hair and Angora goats. In the present study, a developed interdigital gland was encountered in the forefeet and hind feet of Kivircik sheep.

Few studies exist on the histology of the gland in native sheep breeds, such as Lori's (3), Yankasa (5), Tuj (11), Akkaraman (14), and Karagouniko (20). Pourlis (20) suggested that the ovine interdigital sinus possesses a sweat glandular component that exhibits double secretor activity. The wall structure of the Kivircik sheep's interdigital gland was composed of epidermis, dermis, and a capsule of connective tissue like Lori's (3) and Akkaraman (14) sheep. Although the sebaceous, sweat, and apocrine glands, muscle fibers, nerve plexus, and hair follicles were present in the dermis of the Kivircik sheep, lymph follicles were not observed as described in Tuj (11) sheep.

It was reported that the interdigital tubular glands secreted neutral glycoproteins, which were detected with PAS staining (9,10). The apocrine gland secretion was PAS-negative in Lori's (3) sheep and AB-negative (pH 2.5) in fallow deer; however, our study revealed that the

secretion was PAS-positive and AB-positive (pH 2.5) in the interdigital gland of Kivircik sheep. The basal membranes of the epithelium cells and muscle fibers were also PAS-positive.

Consequently, according to the morphometric values, it was observed that the diameter of the excretory duct,

the external angle, the diameter of the corpus, and the diameter of the excretory duct in the right interdigital gland of Kivircik sheep were higher than those of the left interdigital gland, a difference that was statistically significant ( $P < 0.05$ ). Moreover, the secretion of this gland was PAS- and AB-positive.

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