



A Comparative Histological and Histochemical Study of the Neck, Abdomen, and Tail Regions of Skin in *Gazella Subgutturosa*

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Abstract | The study was conducted to compare between histological and histochemical characteristics of different skin regions (neck, abdomen and tail) responsible for the protection, sensory, thermoregulation and excretion in *Gazella subgutturosa*. Twenty skin samples from 10 males and 10 females of *Gazella subgutturosa* were collected from the ventral, lateral and dorsal parts of the neck, abdomen and tail regions. The results of thickness of epidermis in male appeared greater than in female, while the neck skin showed the maximum thickness in epidermis. The epidermis was a thin portion and composed of four layers: stratum basal, stratum spinosum, stratum granulosum and stratum corneum. The stratum basal was consisted of columnar cells and melanocytes. Whereas, the stratum spinosum was consisted of polyhedral cells. As well as, the stratum granulosum was appeared containing several layers of cells with lipid granules. While the stratum corneum was covered by keratinized stratified squamous epithelium in all regions of skin (neck and tail) except in abdomen was non-keratinized. The dermis of the abdomen skin of males was thicker than in females, while the dermal thickness of females in both neck and tail skin was higher than in males. The results of hypodermis showed high loose connective tissues and adipose tissues. Whereas, the tail region was contained a large amount of skeletal muscle fibers. Furthermore, sweat and sebaceous glands had a positive reaction to Periodic Acid-Schiff staining, while with alcian blue stain appeared sebaceous glands only. From this study concluded the layers thickness of *Gazella subgutturosa* skin were differed according to the body regions and gender. As well as, the skin acted as a protective barrier by utilizing its diverse cellular coalition.

Keywords | Skin, Gazelle, Histological, Histochemical staining, Periodic acid-schiff (PAS) staining

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INTRODUCTION

Gazelles are inhabiting the hot, dry and deserts. They are varified in meat, hides, mythology culture and regarded as a representation of elegance, beauty and speed. In addition,

Gazelles represented in folklore and traditional dance frequently stands for life, liberty and peace between people and the natural world. They are supported the growth of plants and the survival of other herbivores, as well as, they are shared their habitats by consuming a variety of veg-

etation and distributing seeds through their droppings. Additionally, they were sustained lots of predators lead to maintaining the stability of the food chain (Kingdon, 1997; Al-Abbas *et al.*, 1999). One of the main issues of living in a desert was controlled bodily water content. However, through the radiation, convection, and conduction, the animals skin was regulated body temperature, influenced water absorption and prevented the water loss (Standby *et al.*, 2003). The skin is one of the largest and most important organs of the animal body and it acted as a barrier between the internal and external environment (Fournau *et al.*, 2020). The skin covered the entire outer surface of the animal body, it is responsible for protecting, immunological defense, external sensory awareness, thermoregulation, wound healing, perception, and excretion. It's also an effective barrier and had the ability in preventing the desiccation of electrolytes and macromolecules from the animal body (Sexena, 1994; An sari *et al.*, 2010; Razvi *et al.*, 2014). The skin is a complex structure that consisted of the epidermis, dermis, and hypodermis (Morays *et al.*, 2001; Ershad *et al.*, 2016). Thin skin covered the majority of the body, however thick skin is presented in the soles and tails of animals, epidermis consisted of stratified squamous epithelium, and it regenerated continually from the basal layer at the basement membrane toward the skin surface with or without keratinized cells made up the 95% of epidermis, but 5% made up the melanocytes, langerhans, and merkel cells. The dermis is made up of sweat glands, sebaceous glands, hair follicles and connective tissue. Furthermore, the hypodermis is made up of vascularized, loose connective tissue as well as adipose tissue, which they are stored the fats lead to acted as a cushion and insulator for the integument (Daglioglu *et al.*, 2001; Ozfiz *et al.*, 2002). In mammals, all the appendages of the skin which are covered the dermis, such as the hair follicle, sebaceous glands and sweat glands are played an important role in providing a specializing physiological functions to individuals (Aslan *et al.*, 2004). The sweat glands secreted the fluid, consisted of water and salts lead to regulating the animal's body temperature. The hair on body is few and helped in this exchange between the water and the animal's body (Ali, 2008; Mir Shabir *et al.*, 2011). The sebum helped the animal skin to remain soft and moist, also it acted as an antibacterial and antifungal barrier lead to reducing the friction and insulation, vitamin D forming and preventing the water entry to the hair and skin (Aktaş and Daglioglu, 2009; McManus *et al.*, 2011). Up to date, there is little literature published on the features of the gazelle skin in Iraq. The aim of this study is to compare among the normal gazelle skin structures in different regions of body between male and female to understand the dermatological illnesses.

MATERIALS AND METHODS

ETHICS STATEMENT

All applicable were carried out accordance to the animal

care by using a committee of Veterinary Medicine College, Al-Muthanna University, on May 6, 2023.

SAMPLES COLLECTION

Twenty fresh skin specimens of healthy black-tailed gazelles (*Gazella subgutturosa*) aged 2-3 years were collected from ten males and ten females. The animals were obtained alive from Sawa station (affiliated with the ministry of agriculture) in Al-Muthanna city. They are given overdose of a ketamine and xylazine overdose and then the animals were sacrificed, the samples were collected from the different regions (neck, abdomen, and tail) of skin, the animals were gathered right away following their slaughter at AL Muthanna abattoir. The depilatory sodium sulfide ointment was worked for seven to ten minutes to eliminate the skin's hair (Al-Abbas, 1999).

METHODS OF HISTOLOGY

The cleaned skin specimens were fixed in 10% formalin for 48 hours, then they were treated by using routine histological method, dehydration and series spiraling of ethyl alcohol. The specimens were evaporated by using xylen, after that they were infiltrated, embedded by paraffin wax (60 °C) and sectioned to 5-7µm by microtome (Kocamis and Aslan 2004; Suvarna *et al.*, 2018). Several stains were used to color the skin sections included: Hematoxylin and eosin (H and E) to demonstrate the general components of the tissue, Masson's trichrome for detection of smooth muscles and collagen fibers, Periodic acid Schiff (PAS); to carbohydrate, glycoprotein, mucopolysaccharides, and basement membrane, Alcian blue, pH 2.5 to acid mucopolysaccharides and finally Companing the alcian blue plus periodic acid Schiff (AB-PAS) to compare the neutral and acidic mucopolysaccharides (Suvarna *et al.*, 2018; Vanderwolf *et al.*, 2023). The calibrated ocular micrometer was used for histological measurements such as the thickness of layers which they are composed from epidermis (corneum, granulosum - spinosum, basal) and dermis (papillary and reticular layers) (Vanderwolf *et al.*, 2023).

STATISTICAL ANALYSES

The mean and standard error for ten sections from each sample were calculated for each region of the skin. Statistical significance was assessed by (t-test) for comparison of parametric variances of skin. The significance level set at $P < 0.05$ (Al-Rawi and Al-Kala, 1980).

RESULTS AND DISCUSSION

The gazelle skin like the skin of other mammals, it was divided into three layers: the thin epidermis, thick dermis and hypodermis. Epidermis; consisted of four layers; from the inner to the outer as; the basal, spinosum, granulosum and corneal layers in each of neck, abdomen and tail regions skin for both male and female (Pourlis and Christoulopoulos, 2008).

(2009), but in Bakerwali goat and cattle, the skin described consisted of only two layers: epidermis and dermis in study recorded by Saxena *et al.* (1994).

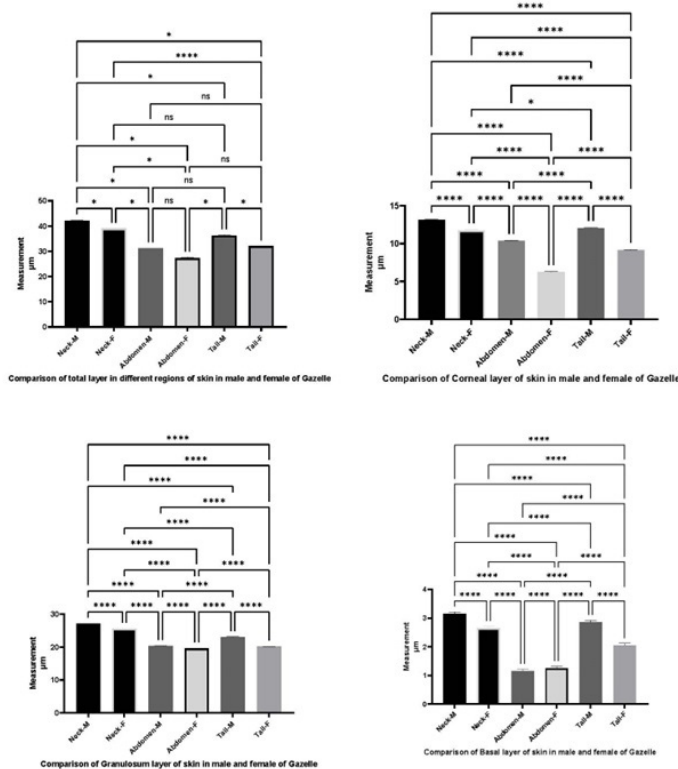


Figure 1: Comparison of different layers in males and females of gazelles.

The greatest variation in thickness was seen in the stratum corneum as in (Figures 1 and 2), the majority cells in the epidermis were keratinocytes, they are consisted from necessary lipids and keratin lead to building the epidermal water barrier (Figures 3, 4 and 5), within this layer, dead keratinocytes were secreted defending materials, which they are a component of immune defense system. Additionally, keratinocytes helped in controlling calcium levels by facilitating the skin's absorption of ultraviolet rays, which it is necessary for the activation of vitamin D. When the skin was exposed to ultraviolet ray's radiation the keratinocytes converted 7-dehydrocholesterol to vitamin D. In addition to expressing the vitamin D receptor, these cells included enzymes that activated vitamin D, which it is necessary for keratinocyte proliferation and differentiation (Nixon *et al.*, 2002). The corneal layer of the epidermis was less related to gender and age changes than the other cell layers (Sandby *et al.*, 2003). There was no clear differentiation between the spinosum and granulosa layers of the epidermis as in (Figures 3, 4 and 5), this results were in agreement with findings recorded by Al-Abbas *et al.* (1999), furthermore, this characteristic was made the skin more flexible and robust. In addition, the basal layer was consisted from simple columnar cells and elongated nuclei, they were appeared as dark in color, contained melanocytes in the basal layer of the epidermis and created the epidermal melanin units. As well as, the melanin pigment granules extended downward around the hair follicle bulbs, as described in other animal species in other study mentioned by Aktaş and Daglıoğlu

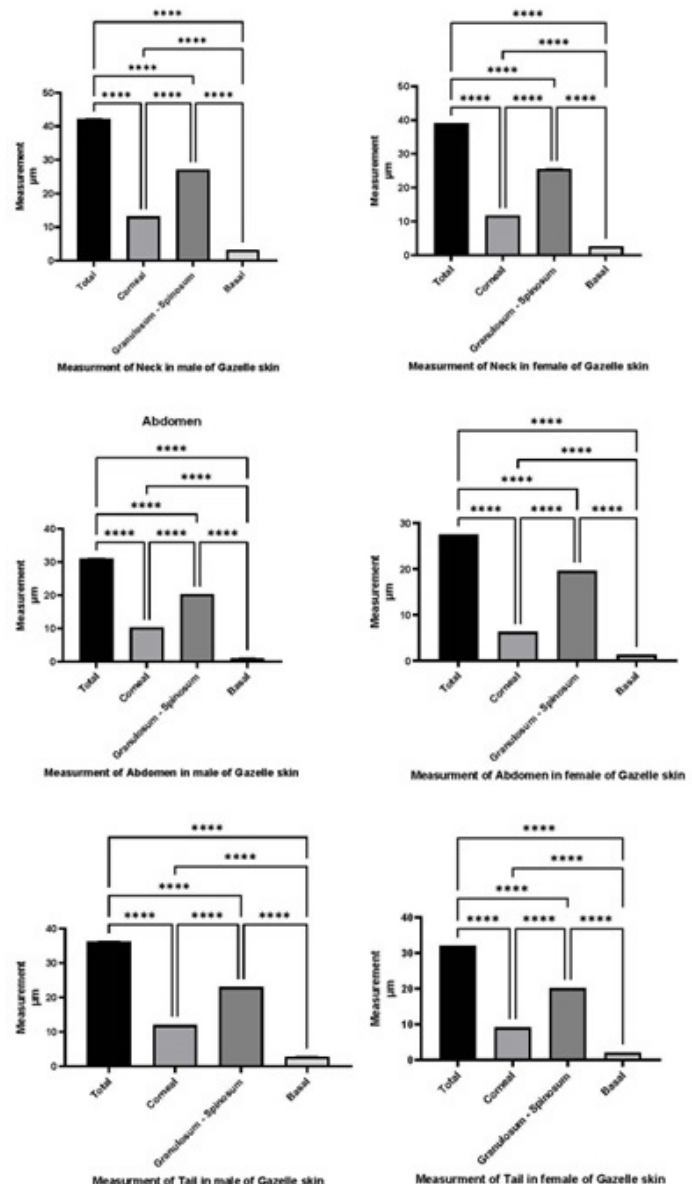


Figure 2: Comparison of different layers in different regions of males and females of gazelles.

The thickness of the epidermis of males was appeared thicker than that of females with significant differences ($p \leq 0.05$), the statistical analysis showed a significant difference ($p \leq 0.05$) in the thickness of the epidermis in the neck, abdomen, and tail regions skin of the males and females (Table 1). The epidermis of neck skin had the thickest keratinized layer, the thinnest keratinized layer was seen in the skin of the abdominal region as in (Figures 1 and 2), they were referred to a significant difference in the thickness of basal layer between the neck, abdomen and tail regions skin in each sex and there is a significant difference in the thickness layer between male and female skin. While, the spinosum layer consisted from several polyhedral cells, granulosa layer and it was as broken patches of

the cells, the cells were appeared a flat also containing large nuclei and prominent basophilic granules. The cells of the granular layer characterized by ascending into spinosum layer, outbuilding their cytoplasmic organelles and nuclei, transforming into keratohyaline granules and keratinized squamous of the next layer. The granules function acted as a water sealant and secreted a lipid-rich liquid, this explanation is agreed with study recorded by Pourlis and Christouloupoulos (2008). In addition, the cells of the stratum spinosum are joined by desmosomes and they begin the keratinization process and proceed into the stratum granulosum, with little space between them, so that there was no clear differentiation between the spinosum layer and the granulosum layer of epidermis.

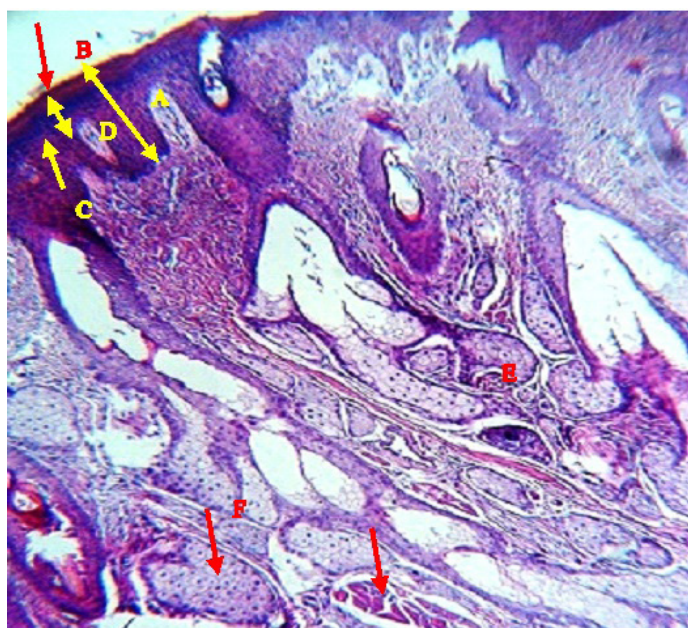


Figure 3: Cross section of the male gazelle neck skin, epidermis (A), Corneal (B), basal (C), Granulosum - Spinosum (D), dermis (E), Sebaceous gland (F), muscle (G), H&E X100.

These desmosomes served as the anchors between the cells and the cytoskeleton's intermediate filaments hold them together. Prickly cells have been gotten their name from the fact that when these cells somewhat shrunk after fixation and desmosomes lead to extending it from the nearby cells and it was remained closely and binding each one to another lead to giving the appearance of 'prickles'. The granulosum, the sub-corneal layer, was a prominent and continuous layer, which it made the skin more flexible and robust. Table (1) indicated that there was a significant difference in the thickness of each of the granulosum and spinosum layers between males and females, and among the neck, abdomen, and tail regions of the skin of each sex. The final thick corneal layer showed in the form of several cornified layers of dead cells, lead to reducing the flattened scaly or squamous layers. These cells were appeared as flat, hard, a network appearance and filled with densely keratin as in (Figures 3, 4 and 5). Furthermore, there was a significant

difference in the thickness of the corneal layer between the neck, abdomen and tail regions of the skin. As well as, there was a significant difference in the thickness between male and female skin (Figures 1 and 2).

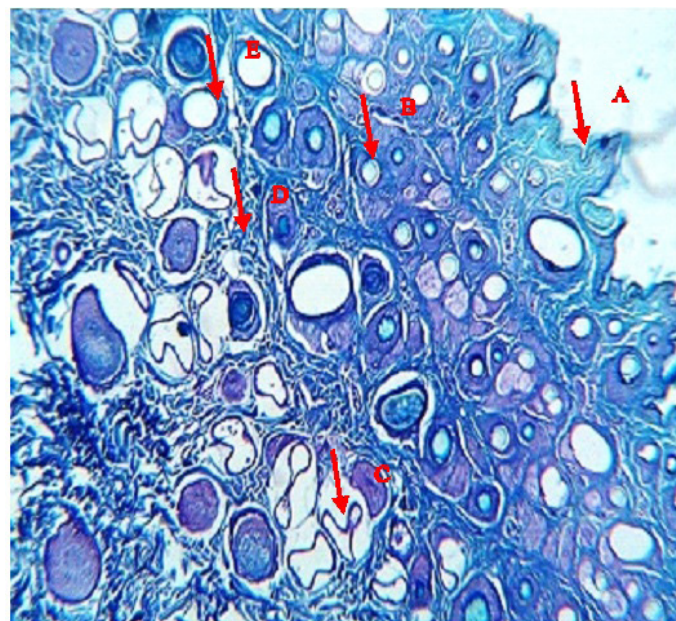


Figure 4: Cross section of the female gazelle neck skin, epidermis (A), hair follicle (B), Sweat gland (C), collagen fibers (D), adipose tissue (F), AB X100.

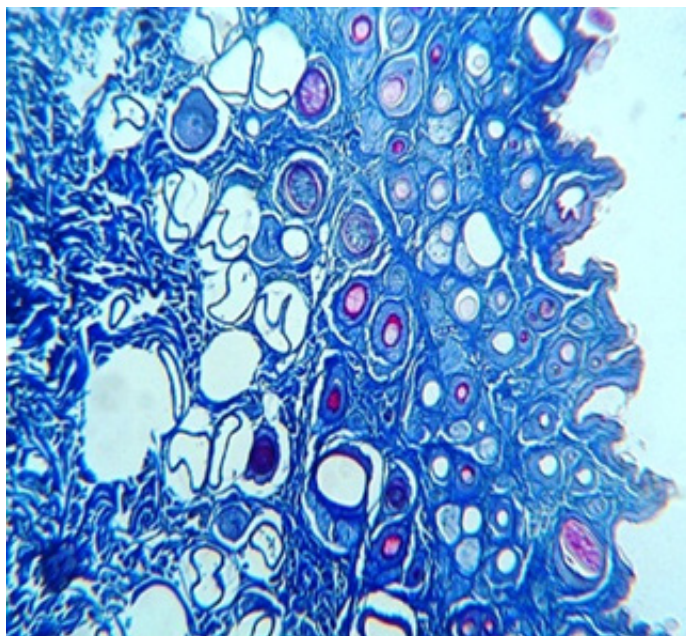


Figure 5: Cross section of the female gazelle abdomen skin, epidermis (A), hair follicle (B), Sweat gland (C), Sebaceous gland (D), collagen fibers (E), adipose tissue (H), Masson, X100.

The epidermis was covered externally by a thick layer of keratinized squamous epithelial cells, especially in the neck and tail regions, while skin keratinization was found in a small amount of the abdomen skin, these differences in skin may be attributed to the water retention found of the hair

Table 1: Measurement of the thickness of the skin wall layers of the gazelle (μm).

Parts	Gender	Epidermis				Dermis	Hypodermis
		Total	Corneum	Granulosum-Spinosum	Basal		
Neck	Male	42.3 $\pm$ 0.1	13.2 $\pm$ 0.03	27.1 $\pm$ 0.01	3.2 $\pm$ 0.04	171.1 $\pm$ 0.1	81.1 $\pm$ 0.1
	Female	39.1 $\pm$ 0.5	11.8 $\pm$ 0.02	25.6 $\pm$ 0.02	2.7 $\pm$ 0.02	182.1 $\pm$ 4.2	92.1 $\pm$ 4.2
Abdomen	Male	31.2 $\pm$ 0.3	10.4 $\pm$ 0.05	20.4 $\pm$ 0.04	1.2 $\pm$ 0.01	211.6 $\pm$ 3.2	101.6 $\pm$ 3.2
	Female	27.5 $\pm$ 0.1	6.3 $\pm$ 0.02	19.6 $\pm$ 0.02	1.3 $\pm$ 0.03	202.6 $\pm$ 1.3	96.6 $\pm$ 1.3
Tail	Male	36.4 $\pm$ 0.2	12.1 $\pm$ 0.03	23.1 $\pm$ 0.05	2.9 $\pm$ 0.02	164.1 $\pm$ 2.3	84.1 $\pm$ 2.3
	Female	32.1 $\pm$ 0.4	9.2 $\pm$ 0.02	20.2 $\pm$ 0.01	2.1 $\pm$ 0.04	187.1 $\pm$ 1.4	91.1 $\pm$ 1.4

follicles and absorption of light by the neck region. Furthermore, the hairs on the body aided in the exchange of water with the animal's body. The senses of touch, smell and respiration were all dependent on hair follicles in animals and blood vessels on the skin's surface may be supported the sense of touch and control mucous discharges inadvertently, these results were in agreement with [Butler et al. \(1993\)](#) and [Macneil et al. \(2005\)](#). The stratum corneal played an important function in keeping hydration if dry skin can be occurred from insufficient water retention ([Mobini, 2012](#)). Other study recorded by [Branchet et al. \(1990\)](#) described the thickness of the epidermis in the different regions of the body according to gender and age. Also, these results were agreed with [Theerawatanasirikul et al. \(2010\)](#) when they mentioned the epidermis in females is thicker than that in males and in the older dogs is thicker than that in young dogs. These differences perhaps due to the protective role of the skin for preventing the water withdrawal. As well as, other study reported by [Mobini \(2012\)](#), mentioned skin thickness, size and number of secretory units of sweat and sebaceous glands were differed among all skin parts. The variations in skin thickness may be returned to the differences in the species, sex, age and environment of the animals. In the dry air habitat of camel, these changes in epidermis thickness allowed for significant water loss through sweat, the epidermal layers served as a barrier to prevent infection and damage from chemicals and heat between the animal's body lead to preventing water loss from the body ([Ansari et al., 2010](#)). The dermis layer consisted of dense connective tissues, hair follicles, blood vessels, sweat glands, sebaceous glands and arrector pili muscles and divided into two layers: papillary and reticular as in [Figure 6](#). The superficially papillary layer beneath the epidermis was made of loose connective tissue, it was highly vascular while the reticular layer was compact, consisted from dense connective and striated muscle fibers and made up the majority of the dermis, this layer is composed of dense irregular connective tissue mainly in the neck and tail regions of the skin and compact collagen bundles. While it was looser in the abdominal region skin, as in ([Figures 7, 8, 9, 10, 11, 12 and 13](#)). The results of sweat glands showed tubular glands aggregation in large numbers near the intersection of the papillary layer and reticular layer of the dermis, as well as,

it was lined by simple cuboidal cells in shape as in ([Figures 8 and 14](#)). In addition, sebaceous gland were simple or uni-lobular and small alveolar glands, always connected with hair follicles and positioned directly above the sweat glands, between the hair follicles and pili muscles, furthermore, it was lined by stratified cuboidal cells which was reacted positively to PAS and alcian blue in all skin regions ([Figures 11 and 13](#)).

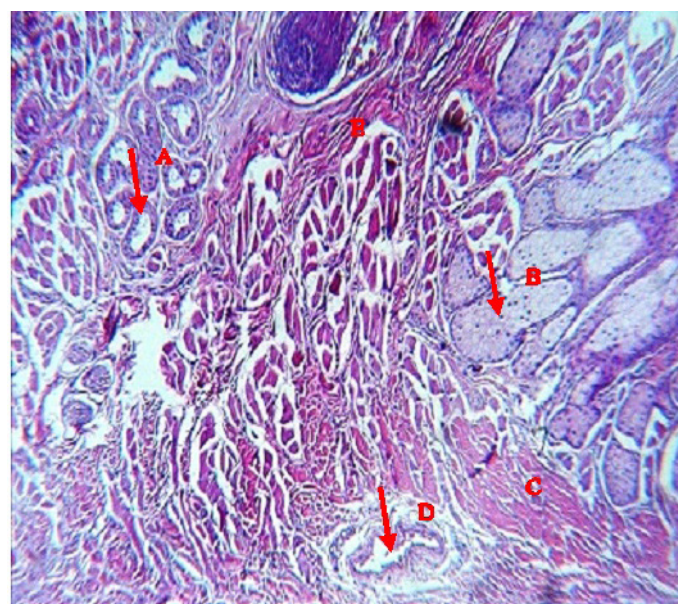


Figure 6: Cross section of the male gazelle abdomen skin, Sebaceous gland (A), sweat gland (B), muscles (C), blood vessels (D), connective tissue (E), H&E X100.

The dermis in male abdominal skin was thicker than that of females, while in both neck and tail skin the dermal thickness of females were higher than in males, the thickness of the dermis of the abdomen was greater than that of the neck and tail regions. As [Figure \(1\)](#) referred to a significant difference in thickness of the dermis among the neck, abdomen and tail regions of skin in the male and female skins. The thickest and thinnest hypodermis were measured in the abdomen and tail regions of the skin as in ([Figures 5 and 6](#)). The mean thickness of the hypodermis in the neck, abdomen and tail of females was thicker than that in male skin, with a significant difference between males and females as in ([Table 1](#)). The hypodermis con-

sisted of the loose connective tissues and adipose tissues. While, in the tail region of the skin, the hypodermis layer contained a large amount of the skeletal muscle fibers that surrounded hair follicles as in (Figure 14). Striated muscles are responsible for producing force, facilitating movement and maintaining the posture of the tail. The current investigation of this study revealed differences in the thickness of the skin layers based on the animal's gender and the specific locations of the body's skin (Figure 1). This result may be attributed to triglycerides and vitamin D are produced by metabolic processes in the adipose tissue of the hypodermis. There are seasonal fluctuations in the dermis. Furthermore, due to their requirement for water retention and the prevention of energy loss through heat, this explanation agreed with study recorded by Abdul Raheem and AL-Hety (1997), who is demonstrated the difference in skin thickness in various sections of some species, such as the goat, and difference in the location of the sweat and sebaceous glands. In addition to the insulating layer is mostly formed by short, robust and erect hairs with the longer hairs likely constituting an outside layer of protection and because of insensible perspiration and sweat production, the undercoat humidity was relatively high. as well as, the humid barrier prevented the heat loss via the skin and lead to supplied the energy storage that the animal needs when food is sparse, it may be able to limit the total evaporation and allowed gazelles to survive in the desert despite of having a thin epidermis (Saxena *et al.*, 1994).

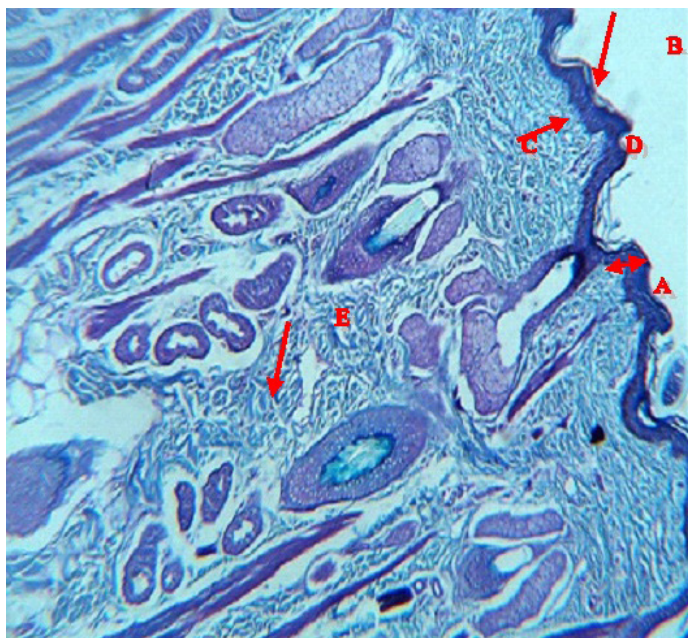


Figure 7: Cross section of the male gazelle tail skin, epidermis (A), Corneal (B), basal (C), Granulosum - Spinosum (D), connective tissue (F), AB X100.

Previous studies have been shown that thickness of the skin dermis depended on various factors such as age, ethnicity, gender, environment and nutrition (Ozfiliz *et al.*, 2002), the dermis layer thickness in the different parts of the animals

and the distribution of the sweat with sebaceous glands differed from other animals (Sandby *et al.*, 2003). This results may be regarded to the needing to the water retention and the avoidance of energy loss through the heat, the dermis was an important for the sensation, receptors the sense to pain, temperature, touch, pressure, protection, and thermoregulation (Theerawatanasirikul *et al.*, 2010; Ansari *et al.*, 2010). Whereas, the sebaceous glands were dependent on animals' environment, season, and gender (Adib *et al.*, 2000). The feed affects level of the sex hormones also played an important role in the distribution and number of the sebaceous glands (Genkovski and Gerchev, 2007; Abbasi *et al.*, 2008). In addition, there are large blood vessels around the hair follicles in the abdominal region and sebaceous glands, they were considered as an exocrine gland near the hair follicles and they secreted an oily or waxy material (sebum) to lubricate the skin and hair (Mobini, 2012). The thick layer of adipose tissue in abdominal region skin is not well developed in each of the neck and tail regions skin because of the hibernation in animals and the amount of blood vessels near to the hair follicles that it was supplied oxygen and nutrients to the skin (El-Ganaieny *et al.*, 2000).

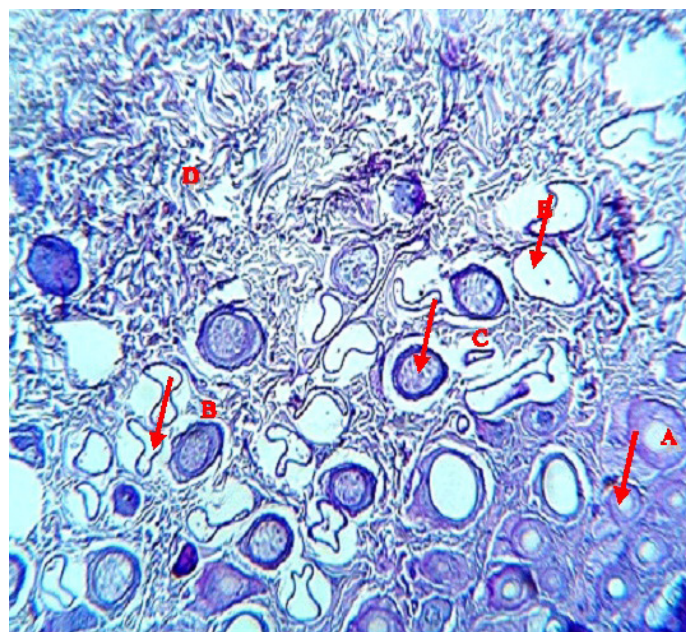


Figure 8: Cross section of the female gazelle tail skin, hair follicle (A), Sweat gland (B), Sebaceous gland (C), collagen fibers (D), adipose tissue (E), PAS X100.

Sweat glands in gazelle skin, are tubular and lined by cuboidal cells in shape and had PAS positive reaction as in (Figures 8 and 14); this result was similar to result recorded by Al-Abbas *et al.* (1999). The sweat glands secreted fluid to regulate the animal's body temperature. As the water in perspiration was evaporated lead to the skin's surface cools. Sweating also helped with gripping by moistening the skin somewhat (Raziv, *et al.*, 2014). The sweating regulated body temperature, while sebum production protects the skin. The Sebaceous glands and sweat were essential to exocrine

skin activities and the skin may be controlled the volume of water absorption and evaporation (Raziv *et al.*, 2014). Seasonal differences haad a major impact on the layers of skin structure and the dermis as well as, it,started off as adipose tissues at the beginning of winter and progressively changed into fibrous connective tissue. As the fat that has been stored is used up, the dermis was essentially fat-free by the summer. Consequently, the layer of fatty tissue acted as insulation against heat loss through the skin during the winter season and supplied the energy storage that the animal needed when vegetation is in short supplying (Fourneau *et al.*, 2020).

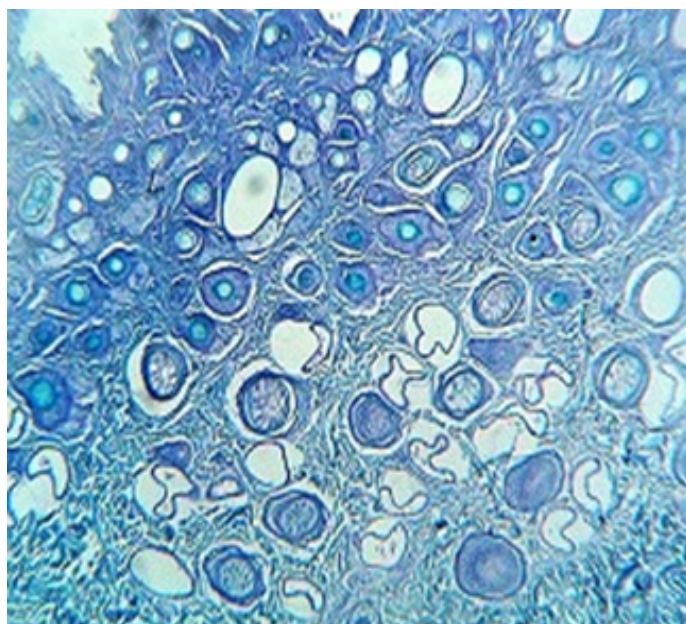


Figure 9: Cross section of the female gazelle abdomen skin, epidermis (A), sweat gland (B), Sebaceous gland (C), Collagen fibers (D), Hair follicle (E), Adipose tissue (F), AB-PAS X100.

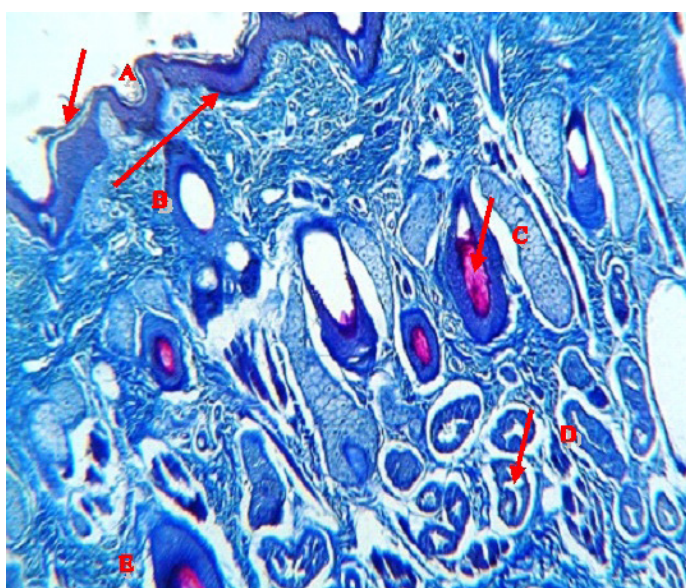


Figure 10: Cross section of the female gazelle tail skin, Corneal (A), Basal (B), Hair follicle (C), sweat gland (D), Collagen fibers (E), Masson, X100.

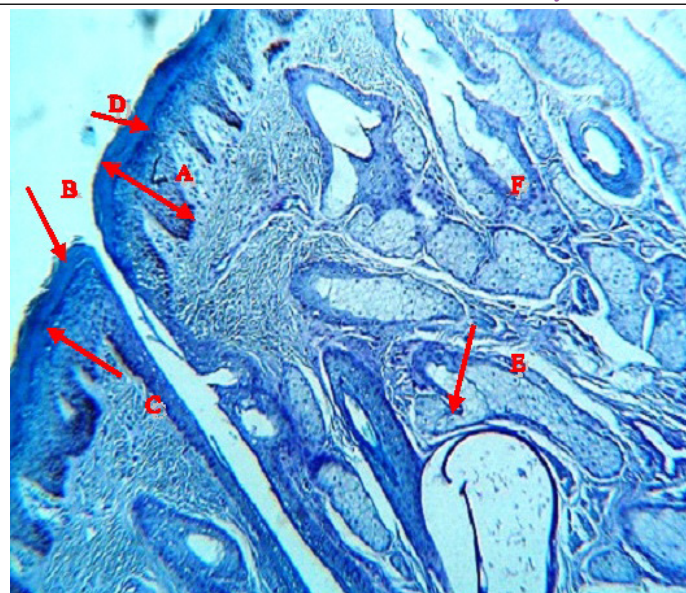


Figure 11: Cross section of the female gazelle neck skin, epidermis (A), Corneal (B), basal (C), Granulosum - Spinosum (D), sweat gland (E), Sebaceous gland (F), AB-PAS X100.

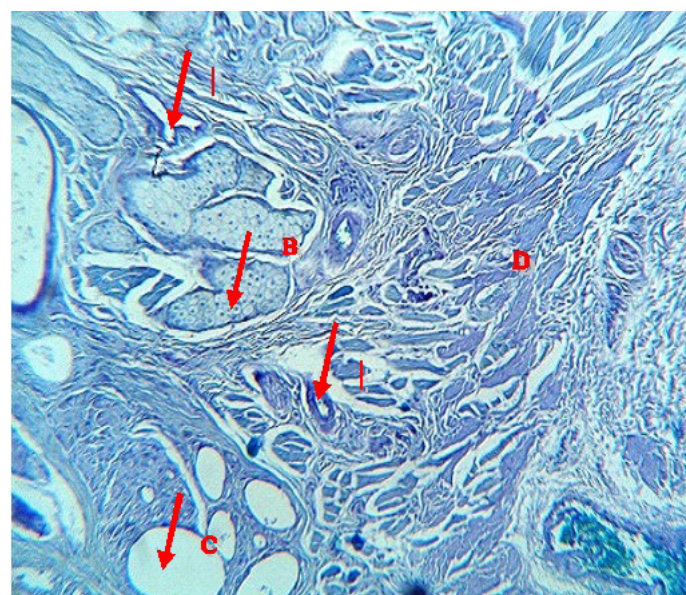


Figure 12: Cross section of the male gazelle abdomen skin, sweat gland (A), Sebaceous gland (B), adipose tissue (C), collagen fibers (D), blood vessels (E), AB-PAS X100.

Several studies have been shown that the hypodermis thickness depended on a several factors, including the skin region, gender, age, pigmentation and the amount of the blood supply. This layer was not developed in the neck and tail this result is agreed with (Sexena *et al.*, 1994; Kurtdele and Asti, 1999; Vanderwolf *et al.*, 2023). Because of hibernation in some animals, the hypoderm was crucial layer in controlling the temperature, thermal insulation, metabolism regulation, fat storage, shock absorption, the pathway for blood vessels between the skin and rest of the body and the nutrient storage. It also secreted some important hormones such as leptin, which it is derived from adipose

tissues and regulated the energy balance (Sultan, 2006). Other study recorded by Datta *et al.* (2022), mentioned that the skin is currently recognized as one of the most important endocrine organs. It had versions of the hypothalamo-pituitary-adrenal, hypothalamo-pituitary-thyroid axes, and the skin appendages produced various hormones such as sex steroids, retinoids and opioids.

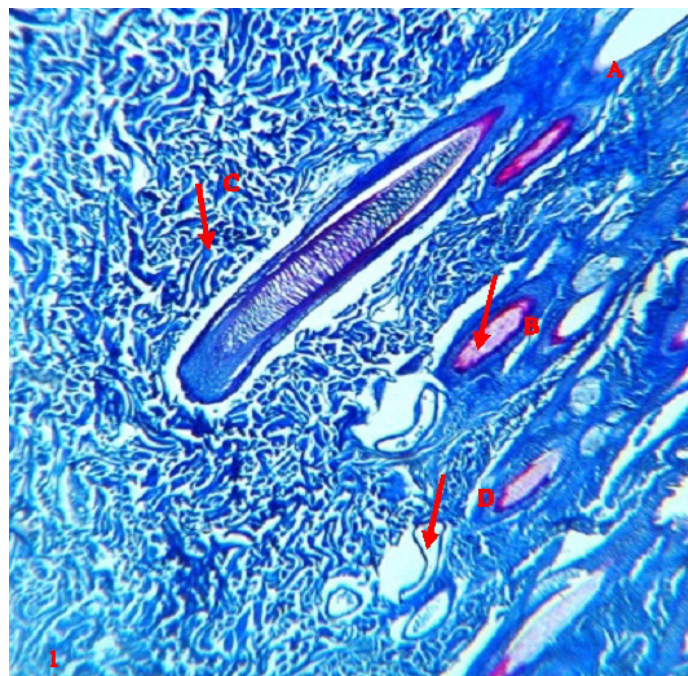


Figure 13: Cross section of the male gazelle muzzle skin, epidermis (A), Hair follicle (B), connective tissue (C), sweat gland (D), Masson X100.

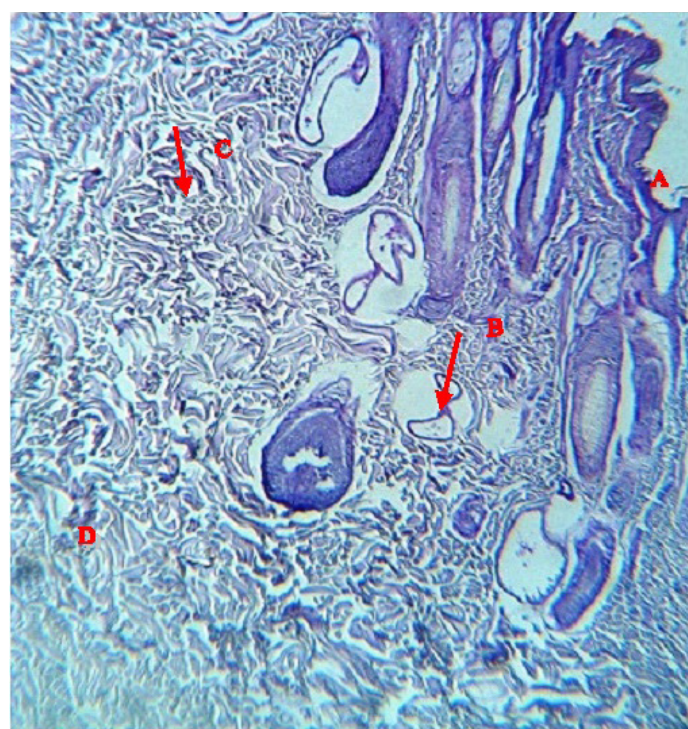


Figure 14: Cross section of the female gazelle muzzle skin, epidermis (A), sweat gland (B), connective tissue (C), hypodermis (D), PAS X100.

The present study explained the normal gazelle skin structure by histological and histochemical methods. This knowledge is essential for understanding the pathology, physiology, and other sciences and enabled the viewing of the tissue structures and any distinctive changes that may have been occurred.

The skin is the biggest organ in the body which it is played an important role in controlling body temperature, providing touch sensitivity, and shielding the body from pathogens. The skin layers thickness were related to the gender, body region, and blood content. Male skin is greasier and thicker and it looked firmer with tighter because it has more collagen in it, the region of body that exposure to sunlight has been thicker epidermis. The biological madeup and function of the skin are altered significantly by the skin area which it was in turn affects the tissue's mechanical characteristics.

CONCLUSIONS AND RECOMMENDATIONS

The present study concluded the normal structure of gazelle skin, as well as the gender effect on skin structure and the skin in male is thicker. Comprehending the histology and function of the skin is essential for the management of ailments in all branches of medicine and in order to preserve the body's homeostasis, the skin acted as a protective barrier, utilizing its diverse cellular coalition, especially keratinocytes and to fend off infections with non-infectious dangers. Layers of skin are vulnerable to a variety of issues like rashes, wrinkles and skin cancer, the study recommended further researches are required to determine the quantitative and mechanistic links between the mechanical function, cellular responses to wound healing and changes in the microstructure of the skin. Also, the study recommended comparing the skin of the gazelle with other ruminants skin.

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NOVELTY STATEMENT

The novelty of the study is focus on the compare the skin of the gazelle with that of other ruminants by histological and histochemical methods and knowledge of the gender effect on skin structure.

AUTHOR'S CONTRIBUTIONS

All authors contributed equally.

The authors have no competing interests to declare that are relevant to this article's content.

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