





# Composition and structure of the skin of dromedary (*Camelus dromedarius*, L. 1758) young adult from two Algerian populations



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**Abstract** In the face of climate change, the eco-dromedary seems to adapt to meteorological constraints. This work compares the skin of the forehead, the hump, and the axillary part of two populations of Algerian dromedaries, namely the Sahraoui and Targui. We worked on six young adult dromedaries of two populations and two sexes genders. We removed the skin from the forehead, the hump, and the axillary part; they were fixed in 10% of formalin. After 48 hours of fixation, the different samples were subjected to different stages of histological techniques. Sections were stained with hematoxylin-eosin. After mounting the slides, we proceeded to microscopic observations and calculations of each layer of skin thickness. The different skin layers were similar in all body regions dromedaries for the two populations. By comparing the thickness of the skin layers of two sexes and two populations, we notice that the skin from the axillary part of male Sahraoui dromedary is the thickest with the measures  $0.0413 \pm 0.0222$  cm,  $0.9789 \pm 0.1397$  cm, and  $2.8119 \pm 0.1266$  cm for epidermis, dermis, and hypodermis, respectively. The thinnest skin was found in the forehead of the male Targui dromedary with  $0.0494 \pm 0.0095$  cm,  $0.2191 \pm 0.0536$  cm, and  $0.3302 \pm 0.0835$  cm for epidermis, dermis, and hypodermis, respectively. The thickness variation of the skin parts of dromedary between sexes in the same population and between the populations suggests an implication of the adaptation system of dromedary to climatic conditions.

**Keywords:** Algeria, camel, epidermis, Sahraoui, Targui

## 1. Introduction

Dromedaries present a major and valuable interest in desert communities due to their ability to produce milk, meat, wool, and leather; their ability to travel long distances, and their resistance to high and arid temperatures (AlAskar et al 2020; Faraz et al 2019). There are eight populations of dromedaries in Algeria among them the Targui population and the Sahraoui population (Benaissa 1989).

The population of Targui is an animal of the saddle by excellence. It is distributed through the Hoggar and Central Sahara. The Sahraoui population is an excellent mehari. Its territory goes from great Western Erg to the Center of the Sahara (Meghelli et al 2020; Belkhirbr and Faye 2013; Benyoucef and Bouzegag 2006; Benaissa 1989). The two populations are subject to the same high constraints of the desertic environment (Babelhadj et al 2016).

The skin is a complex organ that provides a protecting physical barrier between the body and the environment. It prevents the loss of water and electrolytes and protects against pathogenic microorganisms. The skin regulates body

temperature and ensures immunologic monitoring (Khavkin and Ellis 2011).

The skin consists of three layers. The most superficial of these is the epidermis. It is a stratified squamous keratinized epithelium. The dermis is the second layer, an underlying fibrous collagen-elastic tissue that hosts vessels, nerves, and sensory receptors. The hypodermis is the third layer as well as the subcutaneous tissue. It consists for the most part of pads of fatty tissue (Arda et al 2014; Khavkin and Ellis 2011; Kolarsick et al 2011).

It was shown that the temperature of dromedaries' skin varies from one part to another. The temperature is higher at the hump compared to the axillary regions and the flank (Abdoun et al 2012). It has also been shown that the hump and the hip can function as thermal regulators (Samara 2019).

The dromedary has a set of anatomical particularities (thickness of the dermis, nature of the appendages, structure of the sweat glands, blood network in the sinuses) which contribute to its resistance to thermal variations, characteristics of desert environments (Lee and Schmidt-Nielsen 1962; Faye and Ratovonahary 1995). It adapts to

dehydration conditions thanks to the concentration of fat reserves at the level of the hump (Delavaud et al 2002; Sayed-Ahmed et al 2005; Delavaud et al 2013).

In this context, our work aims to establish a comparison of the skin of the hump, the forehead, and the axillary part of two populations of Algerian dromedaries namely the Sahraoui and the Targui populations. This comparison will be made according to the age and sex of the population.

## 2. Materials and Methods

Animal care and handling procedures followed the guidelines of the Ethics Committee on the Use of Animals in Experiments. It is post slaughtered in the slaughterhouse. This animal is intended for butchery for food consumption (see Supplementary Material).

### 2.1. Animal samples

We studied six dromedary populations (2 Sahraoui and 4 Targui). The dromedaries are chosen according to their sex (male and female) and their age (young adult). Among them one young-adult Sahraoui dromedaries male and female, 2 young-adult Targui dromedaries male and female.

### 2.2. Skin samples

The six dromedaries were slaughtered at the slaughterhouse of the commune of Ouargla. For each dromedary, three anatomical slices of skin were taken, namely: the forehead, the hump, and the axillary region.

### 2.3. Histological examinations

The six fresh slices of skin were collected from the forehead, the hump, and the axillary region after the slaughtering of dromedaries. The hairs on the skin were removed using scissors. The cleaned skin was fixed in 10% formalin for 48 hours then processed through the various serial steps of histological examinations. The tissue specimens were then dehydrated in ethanol series and cleared with xylene then impregnated in the paraffin melted at 56 °C. The histological sections were made using a microtome with a diameter of 3 µm. For staining the histological slides, the Harris hematoxylin and eosin are used (Luna et al 1968; Umeri and Mamoori 2016).

The histological measurements were taken by use of calibrated ocular micrometers using object-oriented lenses to measure the thickness of various layers of the skin (epidermis, dermis, and hypodermis).

### 2.4. Data analysis

Data were expressed as mean ± standard error. We have done a paired T-test to compare thickness' skin parts of male and female Sahraoui and Targui dromedaries. The statistics data were analyzed with Excel Stat software.

## 3. Results

The results showed that the skin of the young adult dromedaries, Sahraoui and Targui, male and female consisted of three layers; the epidermis, dermis, and hypodermis.

### 3.1. Epidermis

A superficial layer of skin that covers the dermis. It is a simple layer of unistratified cells. Composed of keratinocytes and many mucus-producing cells (Figure 1, Figure 2). The permeability capacity of the epidermis allows numerous exchanges between the internal and the external environment. The thickness of the epidermis is the thinnest of all the layers of the skin. In the dromedary, the thickness of this layer varies according to the sex and the anatomical region of the Sahraoui and the Targui population.

According to our results on the thickness of the layers of the skin of the dromedaries studied, we found that the larger epidermis is in the hump of the Targui male dromedaries ( $0.0607 \pm 0.009$  cm), and the weakest is in the axillary part of the same population ( $0.0148 \pm 0.0138$  cm) (Table 2).

### 3.2. Dermis

A deep layer of skin, covered by the epidermis, is formed of irregular connective tissue made up of elastic fibers, collagen, and reticular fibers. It is divided into two layers: the superficial papillary layer located under the epidermis and the reticular layer. The reticular layer is located in the depth of the dermis above the hypodermis. It contains primary and secondary follicles, as well it contains hair follicles, sebaceous glands, and sweat glands (Figure 3, Figure 4). The thickness of the dermis varies according to the body region.

From our results, we found that the thickness of the dermis of female Sahraoui dromedary is homogeneous in the three regions studied: forehead, hump, and axillary part with ( $0.5358 \pm 0.1736$  cm), ( $0.543 \pm 0.1281$  cm) and ( $0.55 \pm 0.0833$  cm) respectively (Table 1).

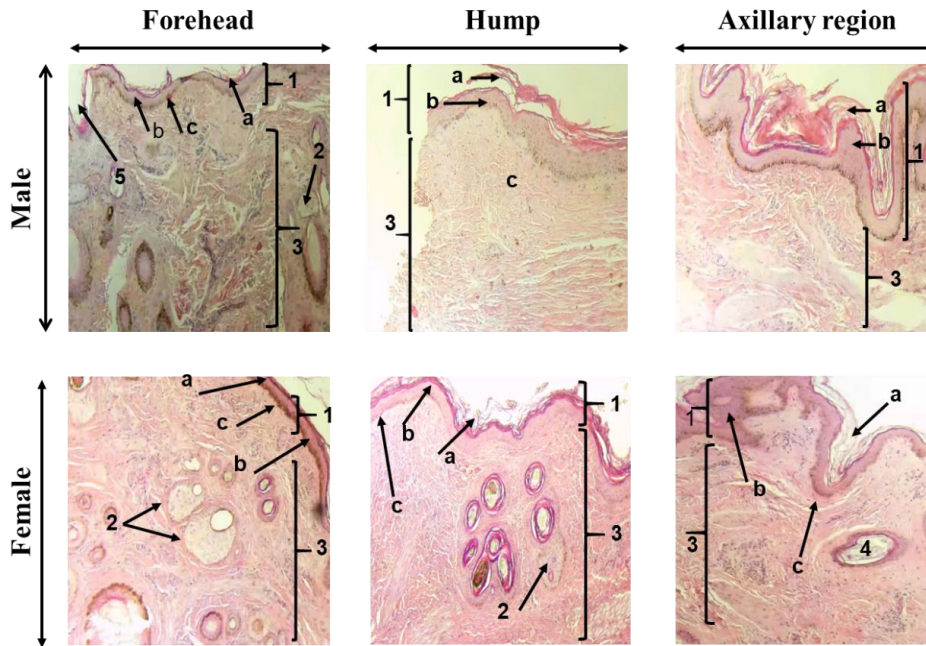
For the Targui dromedary, we notice that for the male as the female, the highest thickness of the dermis is obtained in the region of the hump with ( $0.05828 \pm 0.1404$  cm) for the male and ( $0.4597 \pm 0.0187$  cm) for the female (Table 2).

**Table 1** Layers skin thickness (cm) of young adult male and female Sahraoui dromedary's slices.

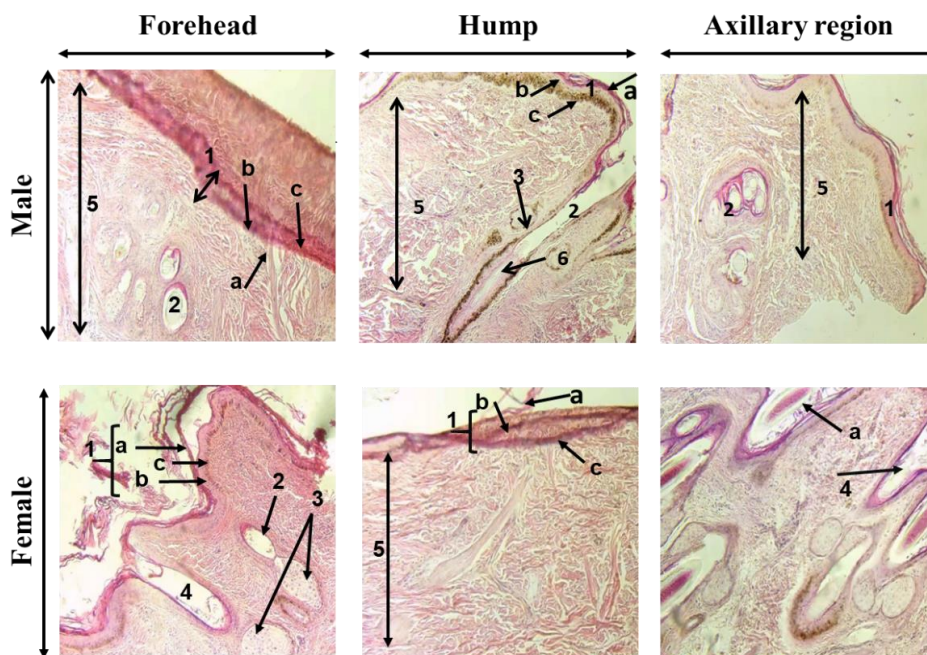
Sex	Male			Female		
	Forehead	Hump	Axillary region	Forehead	Hump	Axillary region
Epidermis	$0.0392 \pm 0.0131$	$0.0635 \pm 0.0222$	$0.0413 \pm 0.0222$	$0.0279 \pm 0.0159$	$0.0286 \pm 0.0095$	$0.0226 \pm 0.0074$
Dermis	$0.8477 \pm 0.4339$	$1.8429 \pm 0.5435$	$0.9789 \pm 0.1397$	$0.5358 \pm 0.1736$	$0.543 \pm 0.1281$	$0.55 \pm 0.0893$
Hypodermis	$0.7451 \pm 0.1503$	$1.42 \pm 0.2004$	$2.8119 \pm 0.4293$	$0.2766 \pm 0.1266$	$0.66 \pm 0.2593$	$0.36 \pm 0.08$

**Table 2** Layers skin thickness (cm) of young adult male and female Targui dromedary's slices.

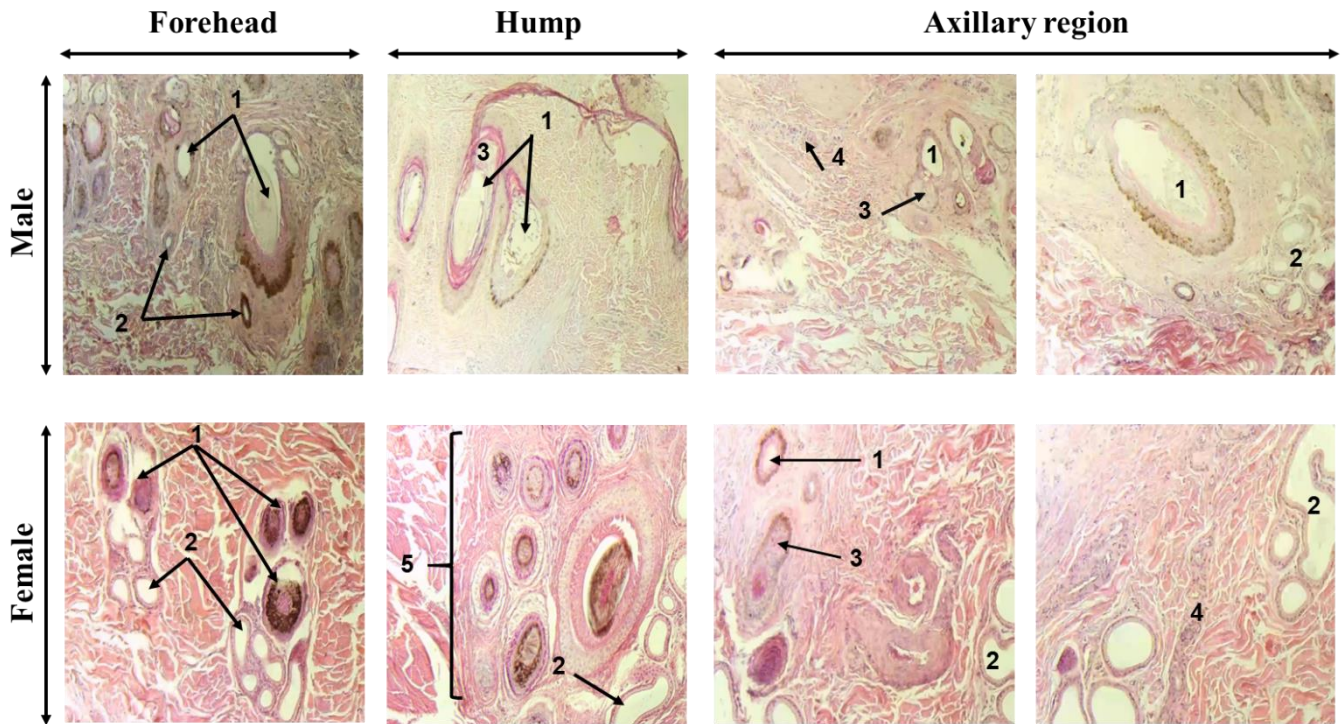
Sex	Male			Female		
	Forehead	Hump	Axillary region	Forehead	Hump	Axillary region
Epidermis	0.0494 ± 0.0095	0.0607 ± 0.009	0.0148 ± 0.0138	0.0275 ± 0.008	0.03322 ± 0.0046	0.0215 ± 0.0067
Dermis	0.2191 ± 0.0536	0.5828 ± 0.1404	0.2808 ± 0.0335	0.3267 ± 0.1772	0.4597 ± 0.0187	0.32 ± 0.0335
Hypodermis	0.3302 ± 0.0835	0.5207 ± 0.0535	0.8959 ± 0.1602	0.8212 ± 0.0861	1.0008 ± 0.0437	0.7435 ± 0.2037



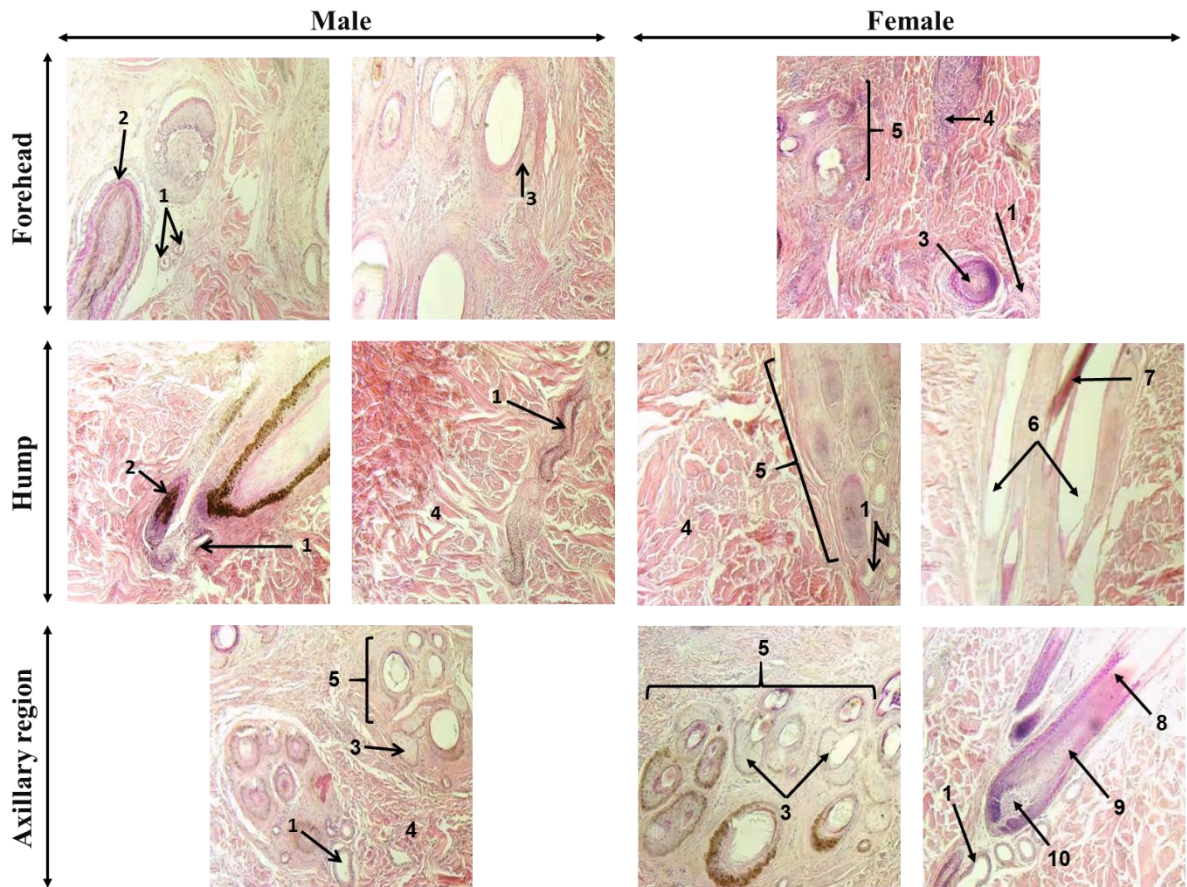
**Figure 1** Cross-section of the skin of the forehead, hump, and axillary region of the young adult Sahraoui dromedary showing (1) the epidermis composed from (a) the stratum corneum, (b) the stratum spinosum, and (c) the stratum basale, (2) sebaceous glands, (3) the dermis, (4) hair follicles, (5) the follicular lumen. (HE staining, X10).



**Figure 2** Cross-section of the skin of the forehead, hump, and axillary region of the young adult Targui dromedary showing (1) the epidermis composed from (a) the stratum corneum, (b) the stratum spinosum, and (c) the stratum basale, (2) hair follicles, (3) sebaceous glands, (4) the follicular lumen, (5) the dermis, (6) hair. (HE staining, X10).



**Figure 3** Cross-section of the skin of the forehead, hump, and axillary region of the young adult Sahraoui dromedary showing dermis composed of (1) hair follicles, (2) sweat glands, (3) sebaceous glands, (4), collagen, (5) group of primary and secondary follicles. (HE staining, X10).

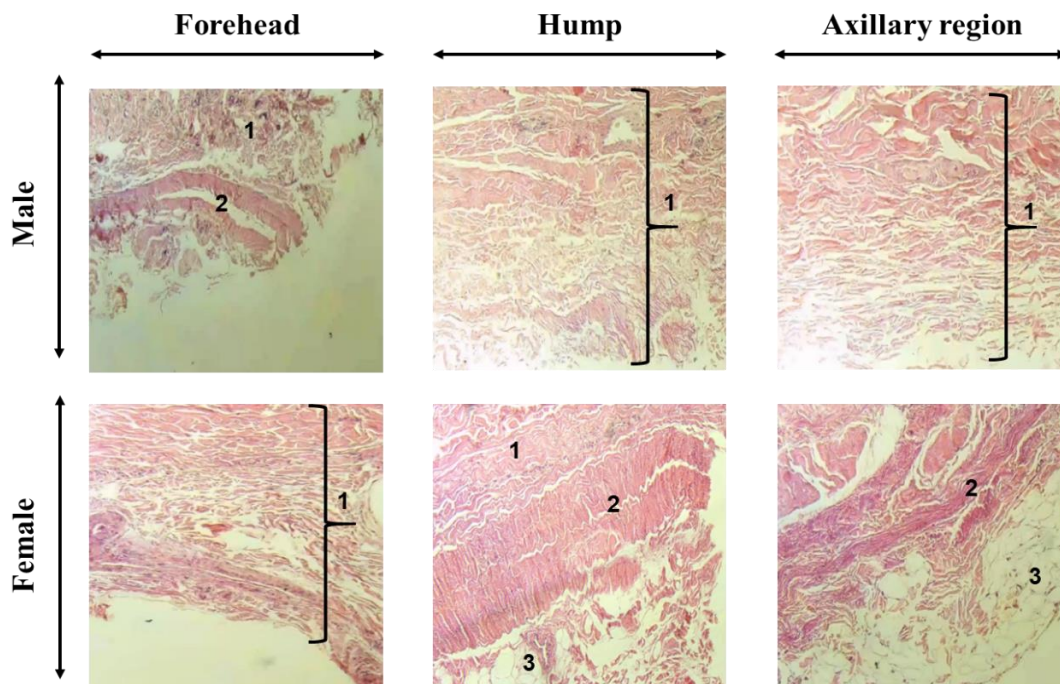


**Figure 4** Cross-section of the forehead, hump, and axillary skin of the young adult Targui dromedary showing the dermis composed of (1) sweat glands, (2) hair follicles, (3) sebaceous glands, (4) collagen, (5) group of primary and secondary follicles, (6) the follicular lumen, (7) hair, (8) keratinized hair cortex, (9) keratinogenic zone, (10) conjunctive papilas. (HE staining, X10).

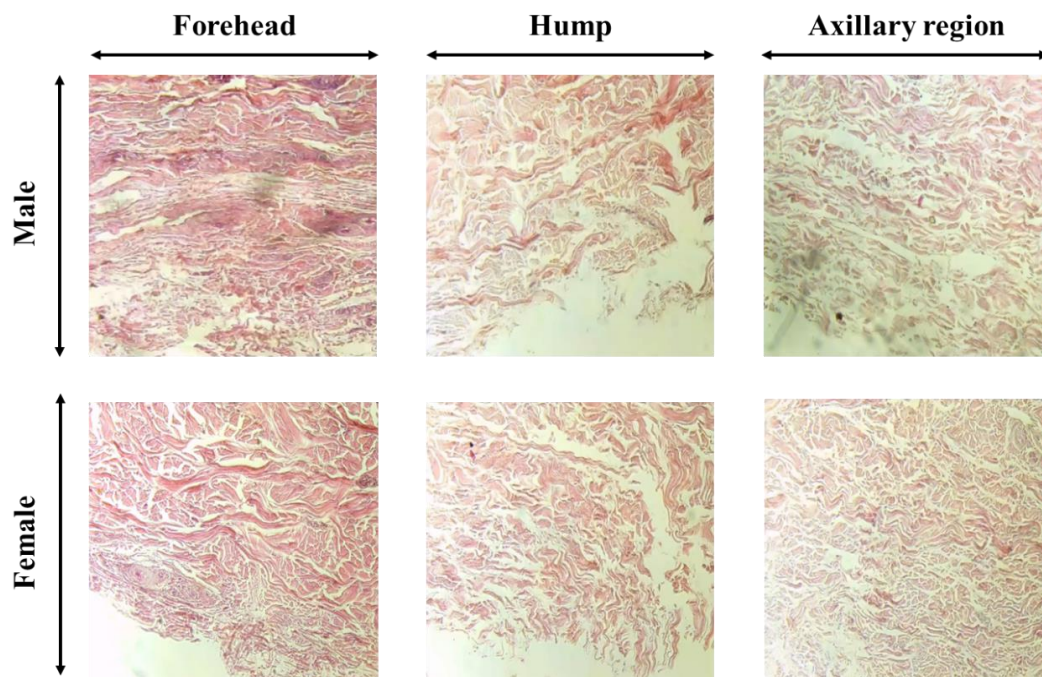
### 3.3. Hypodermis

It is located under the dermis and consists of connective tissue, collagen fiber, and fatty tissue (Figure 5, Figure 6). The thickness of the total skin varied between the two populations. Comparing the thickness of hypodermis between the two populations, we found the thicker ones in the Targuis' dromedary.

For the Targui dromedary, we notice that the thickest hypodermis is obtained in the region of the female hump ( $1.0008 \pm 0.0437$  cm) followed by the male and female axillary part ( $0.8959 \pm 0.1602$  cm) and ( $0.7435 \pm 0.2037$  cm) respectively then we found the hypodermis of the male forehead ( $0.3302 \pm 0.0835$ ) (Table 2).



**Figure 5** Cross-section of the skin on the forehead, hump, and axillary region of the young adult Sahraoui dromedary showing the hypodermis composed of (1) collagen, (2) dense connective tissue, (3) adipose tissue. (HE staining, X10).



**Figure 6** Cross-section of the skin of the forehead, hump, and axillary region of young adult Targui dromedary showing the hypodermis. (HE staining, X10).

For Sahraoui dromedary, we noticed that the hypodermis of the male axillary region is the thicker ( $2.8119 \pm 0.4293$ ) followed by the male hump ( $1.42 \pm 0.2004$ ) and male forehead ( $0.7451 \pm 0.1503$ ). Finally, we note the less thick part in the female dromedary with ( $0.66 \pm 0.2593$ ) on the hump, ( $0.36 \pm 0.08$ ) in the axillary region, and ( $0.2766 \pm 0.1266$ ) on the forehead region (Table 1).

**Table 3** Mean thickness skin's forehead score difference between Sahraoui and Targui dromedary's slices.

Variable	Mean difference	t (df)	p-value	95% C.I
Test result	0,32465	1,002182	0,726515	12,7062

**Table 4** Mean thickness skin's hump score difference between Sahraoui and Targui dromedary's slices.

Variable	Mean difference	t (df)	p-value	95% C.I
Test result	0,95004	1,714253	0,576802	12,7062

**Table 5** Mean thickness skin's axillary region score difference between Sahraoui and Targui dromedary's slices.

Variable	Mean difference	t (df)	P-value	95% C.I
Test result	1,2441	1,3965	0,536701	12,7062

#### 4. Discussion

The forehead, the hump, and the axillary parts of the dromedary are composed of three layers: the epidermis, the dermis, and the hypodermis. The epidermis is composed of keratinized stratified squamous epithelium consisting of four layers; corneal, granulosum, spinosum, and basal layer. It consists of four cell types: keratinocytes, melanocytes, Langerhans cells, and Merkel cells (Prost-Squarcioni 2006; Umeri and Mamoori 2016; Packham et al 2022).

Dermis and hypodermis are connective tissues of mesoblastic origin. They contain vessels, receptors, and nerves for sensitivity, nerve endings for vessels and appendages, and smooth muscle tissue or skeletal striate (Prost-Squarcioni 2006; Packham et al 2022).

The present study showed the anatomical composition of the three layers of the skin of Targui and Sahraoui dromedaries as well as their thickness.

Our results show that the thickness of the epidermis varies from ( $0.0215 \pm 0.0067$ ) cm in the axillary part of Sahraoui dromedary to ( $0.635 \pm 0.222$ ) cm in the hump of Targui male dromedary.

The thickness of the dermis varies from ( $1.8429 \pm 0.5435$ ) cm in the hump of the male Sahraoui dromedary to ( $0.2191 \pm 0.0536$ ) cm in the male Targui dromedary. These results agree with the results of the work of Hekal, 2014 works' where they measured the thickness of the skin in two types of Arabian dromedaries (Maghrabi and Sudani). This variation in thickness concluded that the thick dermis produced strong skin with high tensile strength (Abdalla et al 2018; Hekal et al 2017).

The thickness of the dermis of the dromedary can contribute to its resistance to thermal variations, characteristics of desert environments (Lee and Schmidt-Nielsen 1962; Faye and Ratovonahary 1995).

The results of paired t-test show that there are non-significant differences in the thickness of skins parts between the two populations studied (Sahraoui and Targui) with a *P-value* = 0,726515 in the forehead (Table 3), *P-value* = 0,576802 in the hump (Table 4) and *P-value* = 0,536701 in the axillary region (Table 5).

Our results demonstrate that the thickness's skin of the hump and the axillary part is higher than the forehead's skin. These results suggest that the hump and axillary part may function as a thermal window (Abdoun et al 2012; Samara 2019).

#### 4. Conclusions

Our results show that the axillary part of the male Sahraoui dromedary is the thickest and the forehead of the male Targui dromedary is thinnest. These observations and variations of thickness between skins of different parts and sex of the two populations dromedaries studied suggest an effect on the adaptation of the dromedaries to climatic variation. This hypothesis will be discussed in later works.

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#### Conflict of Interest

The authors declare no conflict of interest.

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