American Journal of Medical and Biological Research, 2016, Vol. 4, No. 3, 53-65
Available online at http://pubs.sciepub.com/ajmbr/4/3/3

DOI:10.12691/ajmbr-4-3-3

Histomorphometrical Characterization of Skin of Native Cattle (*Bos indicus*) in Bangladesh

Md. Ershad Hossain[1], Mohi Uddin[2], S. Kumar Shil[2], M. H. B. kabir[3,*], M. Showkat Mahmud[4], Kh. Nurul Islam[2]

[1]Department of Quality Assurance, Incepta Vaccine Limited, Dhaka, Bangladesh
[2]Department of Anatomy and Histology, Chittagong Veterinary and Animal Sciences University, Chittagong, Bangladesh
[3]Department of Microbiology and Parasitology, Sher-e-Bangla Agricultural University, Dhaka
[4]Animal Health research Division, Bangladesh Livestock Research Institute, Savar, Dhaka-1341, Bangladesh
*Corresponding author: hazzazpara12sau@gmail.com

Abstract Fresh skin samples of the native cattle (*Bos indicus*) of 6 male and 6 female were collected from ten regions of the body immediately after slaughtering aimed to know the regional and sex variation of skin components. The skin samples were fixed, processed and stained according to the standard histological procedure. The samples of vertical sections were stained by both Hematoxylin & Eosin stain and Van Geison & Verhoff's stain. Transparent sheet and ocular micrometer was used for histomorphometric study. Histomorphometrical study of the skin revealed that the mean thicknesses of epidermis, papillary layer, reticular layer and total skin were 45.37 ± 0.59 µm, 0.55 ± 0.01 mm, 3.03 ± 0.09 mm and 3.57 ± 0.09 mm respectively. These thicknesses were significantly ($P<0.05$) varied among the body regions. The highest thicknesses for epidermis and papillary layer were found in back and ventral abdomen respectively and the lowest thicknesses in thigh and neck & shoulder respectively whereas the highest thicknesses for reticular layer and total skin were found in head and the lowest thicknesses in shoulder. The mean thicknesses of the epidermis, reticular layer and total skin were significantly ($P<0.05$)) higher in male than the female. The mean papillary layer thickness was insignificantly ($P<0.05$) higher in female than the male. The mean density of collagen fibre bundle, elastic fibre bundle, sebaceous gland, sweat gland and hair follicle per mm² were 302.93 ± 9.07, 4.96 ± 0.17, 4.22 ± 0.13, 4.57 ± 0.14 and 37.25 ± 1.77 respectively. The density of collagen and elastic fibre bundle were significantly ($P<0.05$) varied among the body regions. The highest density of collagen bundle was found in ventral abdomen and lowest density in thigh and the highest elastic bundle density in thigh and lowest in back & ventral abdomen. The density of collagen fibre, hair follicle and sebaceous gland were significantly higher ($P<0.05$) in male than the female. The density of sebaceous gland was significantly ($P<0.05$) highest in head and lowest in lateral abdomen. The density of sweat gland was insignificantly ($P>0.05$) highest in neck & shoulder and lowest in loin. The density of hair follicle was significantly ($P<0.05$) highest in back and lowest in ventral abdomen. In conclusion, male skin may be better than the female skin for the quality leather production. Collagen bundle is more compact in ventral abdomen that regions may be better for quality leather production, but the percentage of collagen did not revealed in this study.

Keywords: *Bangladeshi native cattle, skin, histology, histomorphometry*

Cite This Article: Md. Ershad Hossain, Mohi Uddin, S. Kumar Shil, M. H. B. kabir, M. Showkat Mahmud, and Kh. Nurul Islam, "Histomorphometrical Characterization of Skin of Native Cattle (*Bos indicus*) in Bangladesh." *American Journal of Medical and Biological Research*, vol. 4, no. 3 (2016): 53-65. doi: 10.12691/ajmbr-4-3-3.

1. Introduction

The quantitative study of the microscopic organization and structure of a tissue is termed as histomorphometry. Skin histomorphometry may includes thickness of different layers of skin, quantitative estimation of collagen and elastic fibre bundle and skin appendages such as sweat gland, sebaceous gland and hair follicle. The variation of the skin thickness between different sex groups and between different regions of the body is very important aspect. Skin thickness varies in different ages, sexes and in different regions of the body [1,2,3]. The skin appendages include the sebaceous gland, sweat gland and hair follicle which provide specialized physiological functions to individuals for environmental adaptation [4]. The skin quality depends mainly on structure and position of collagens and elastic fibers in dermis and their correlation with epidermis, fiber roots, sweat glands and sebaceous glands [5]. The skin of the native cattle is used as a basic raw material in leather industries in Bangladesh. Hence, on understanding it is very important to reveal the histomorphometry of skin of the Bangladeshi cattle.

2. Materials and Methods

Fresh skin samples were collected from six adult male and six adult female native cattle of Bangladesh. The skin

samples were collected immediately after slaughtering the animal from the ten regions of the body namely head, neck, shoulder, lateral thorax, ventral thorax, lateral abdomen, ventral abdomen, thigh, back and loin. The samples were fixed by 10% buffered formalin for 3 days. Then the samples were processed through ascending and descending grade of alcohol and xylene, embedding in paraffin and sectioning into 6 µm thickness by hand rotatory sliding microtome machine (LEICA SM2010RV1.2 English-09/2008 Sliding Microtome Machine, Germany). Both transverse and vertical section was taken from each body region. The glass slides with tissues were dried on electric warmer for 30 minutes and then air drying for 12 hours. The vertical sections were stained by both hematoxylin - eosin stain and Verhoeff's – Van Geison's stain according to the standard histological procedure whereas the transverse sections were only stained by hematoxylin - eosin stains. The micrometry of skin thickness was measured by using ocular micrometer. Skin thickness included thickness of epidermis, papillary and reticular layer of dermis and total skin thickness. Skin thickness was measured by taking three measurements of thickness for each sample and then the total measurement was divided by 3. Thickness of epidermis and papillary layer was measured by taking two measurements of thickness for each sample and then the total measurement was divided by 2. The values of thickness by ocular micrometer were multiplied by 9.9 (ocular micrometer index at 10× objective). The density of sweat gland, sebaceous gland and density of collagen, elastic fibre bundle were studied of vertical sections using transparent sheet on the slide (Photograph 4.3, 4.4) whose one square is 1 mm^2. The estimation of density of hair follicle was studied of transverse sections in same manner. For these structures, counting of 3 squares and then the total number was divided by 3. The density of these structures were done by counting in a manner like counting from top of the square ($1mm^2$) left to right, then right to left and so on up to bottom. The measurements were taken under light microscope (Olympus, CH2XX, Tokyo, Japan) atn10× objective.

2.1. Data Analysis

The data was reported as mean ± SE; all data were entered and stored into a spread sheet (Microsoft Excel-2007). Data were transferred to statistical software, STATA-13 (STATA Corp., Texas, USA) to perform statistical analysis. T-test was done to compare means of different variables between two groups. ANOVA was conducted to compare the means of different variables among different groups. A p-value of less than 0.05 was considered as significant for both tests (t-test and ANOVA).

3. Results

3.1. Skin Thickness

The mean of the total thickness, epidermal thickness, papillary layer thickness and reticular layer thickness were 3.57 ± 0.09 mm, 45.37 ± 0.59 µm, 0.55 ± 0.01 mm and 3.03 ± 0.09 mm respectively. These thicknesses were varied among the body regions significantly ($P<0.05$). The highest values for the total thickness, epidermal thickness, papillary layer thickness and reticular layer thickness were 4.32 ± 0.34 mm in head, 50.32 ± 2.22 µm in back, 0.61 ± 0.01 mm in ventral abdomen and 3.74 ± 0.35 mm in head respectively. The lowest values for the thicknesses were 3.02 ± 0.20 mm in shoulder, 40.83 ± 1.08 µm in thigh, 0.50 ± 0.02 mm in neck and shoulder and 2.51 ± 0.22 mm in shoulder respectively (Figure 1).

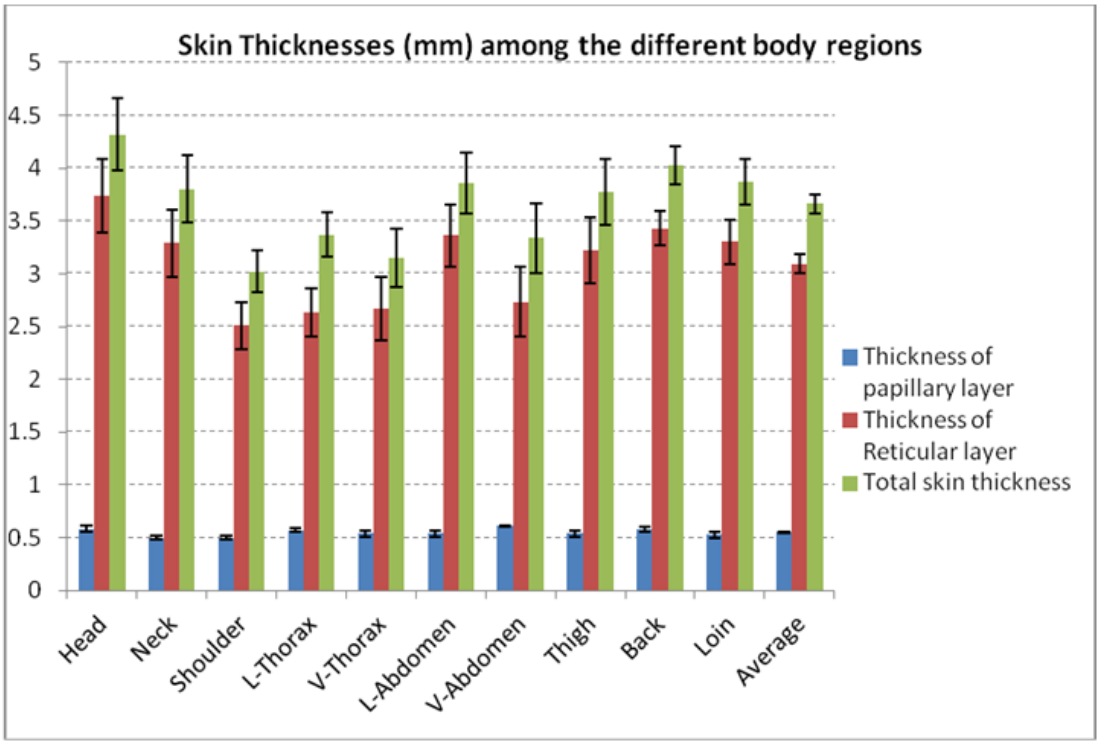

Figure 1. The bar diagram showing the comparative thicknesses (mm) of the papillary layer, reticular layer and total skin (n=12) among the different body regions (L = Lateral, V = Ventral) of the Bangladeshi native cattle. Each bar represents means ± SE

The present values of skin thickness revealed that the skin of dorsal parts of the body were thicker and gradually thinner in lateral to ventral portion of the body (Figure 2) Thick skin was found where either dermis or both dermis & epidermis is thicker. Among the studied body regions both layer was thicker in head and neck.

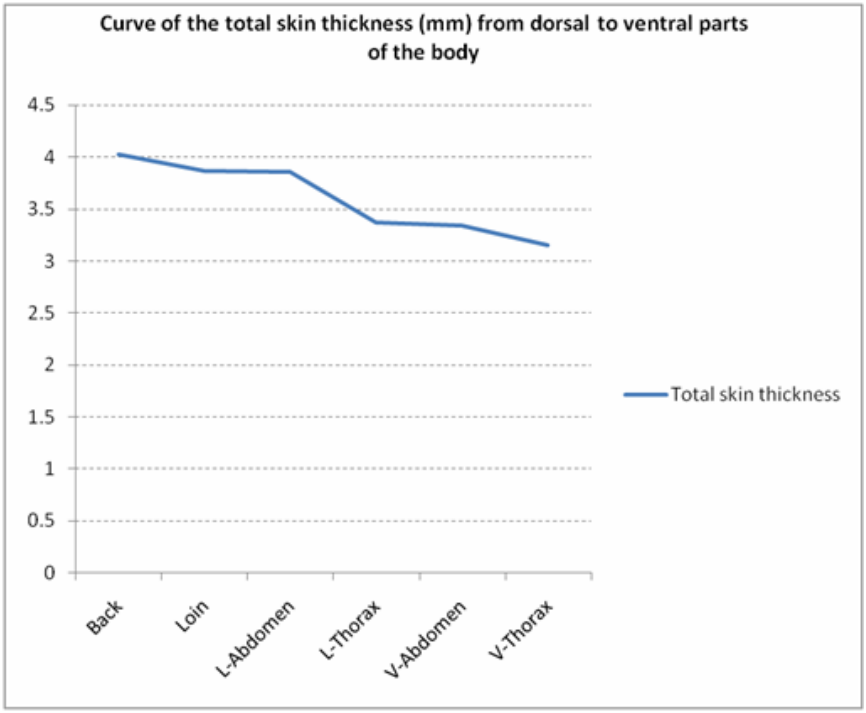

Figure 2. The figure showing the gradual declining of the total thickness from dorsal to lateral to ventral parts of the cattle body (L = Lateral, V = Ventral)

The mean of the total thickness, epidermal thickness and reticular layer thickness were significantly (*P<0.05)* higher in male (4.13 ± 0.13 mm, 46.61 ± 0.90 µm and 3.56 ± 0.14 mm respectively) than the female (3.18 ± 0.07 mm, 44.13 ± 0.75 µm and 2.62 ± 0.08 mm respectively). The mean papillary layer thickness was insignificantly higher in female (0.56 ± 0.01 mm) than the male (0.55 ± 0.01 mm) (Figure 3).

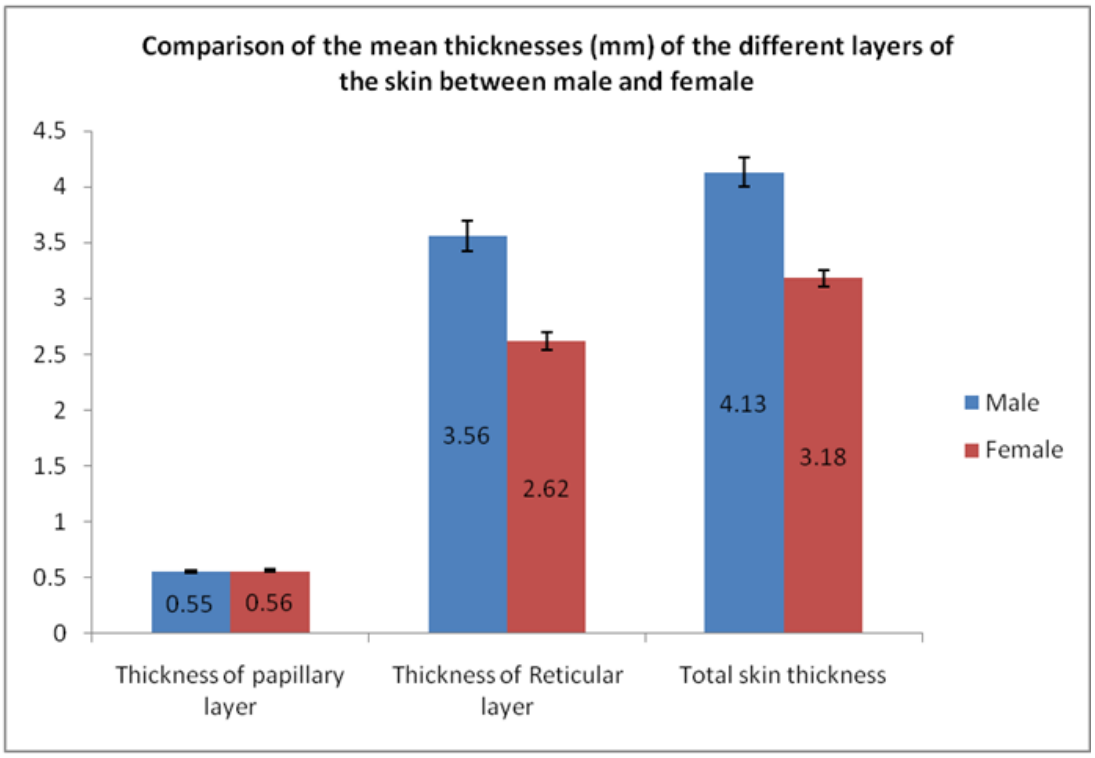

Figure 3. The bar diagram showing the comparative average thicknesses (mm) of the papillary layer, reticular layer and total skin between male and female cattle. Each bar represents means ± SE

The region wise sex variation of the thicknesses were significantly (*P<0.05*) only for head, neck, loin and thigh. In head, the total thickness and reticular thickness were higher in male (5.25 ± 0.31 mm and 4.70 ± 0.31 mm

respectively) than the female (3.40 ± 0.24 mm and 2.79 ± 0.27 mm respectively). In neck, the total thickness and epidermal thickness were also higher in male (4.42 ± 0.49 mm and 49.09 ± 1.34 µm respectively) than the female (3.18 ± 0.25 mm and 43.73 ± 1.52 µm respectively). In loin, the total thickness was higher in female (4.30 ± 0.32 mm) than the male (3.34 ± 0.17 mm) and the reticular layer was higher in male (3.85 ± 0.43 mm) than the female (2.60±0.27 mm) in thigh region (Table 1).

Table 1. Thicknesses of the different skin layers of the Bangladeshi native cattle (n=6 for each sex) (M = Male, F = Female, L = Lateral, V = Ventral)

Body regions	Sex					Dermal thickness			
		Total thickness (mm) Mean ± SE	*'P'* for total thickness	Epidermal thickness (µm) Mean ± SE	*'P'* for epidermal thickness	Papillary thickness (mm) Mean ± SE	*'P'* for Papillary thickness	Reticular thickness (mm) Mean ± SE	*'P'* for Reticular thickness
Head	M	5.25 ± 0.31	*< 0.05*	53.63 ± 3.48	*> 0.05*	0.55 ± 0.03	*> 0.05*	4.70 ± 0.31	*< 0.05*
	F	3.40 ± 0.24		45.79 ± 3.93		0.61 ± 0.04		2.79 ± 0.27	
Neck	M	4.42 ± 0.49	*< 0.05*	49.09 ± 1.34	*< 0.05*	0.52 ± 0.03	*> 0.05*	3.89 ± 0.49	*0.05*
	F	3.18 ± 0.25		43.73 ± 1.52		0.48 ± 0.03		2.70 ± 0.24	
Shoulder	M	3.35 ± 0.35	*> 0.05*	44.14 ± 1.85	*> 0.05*	0.48 ± 0.04	*> 0.05*	2.87 ± 0.36	*> 0.05*
	F	2.70 ± 0.14		44.14 ± 1.62		0.54 ± 0.02		2.16 ± 0.16	
L-Thorax	M	3.58 ± 0.35	*> 0.05*	45.38 ± 1.38	*> 0.05*	0.55 ± 0.04	*> 0.05*	2.70 ± 0.44	*> 0.05*
	F	3.15 ± 0.25		46.61 ± 3.52		0.59 ± 0.04		2.57 ± 0.23	
V-Thorax	M	3.59 ± 0.42	*> 0.05*	39.60 ± 2.86	*> 0.05*	0.52 ± 0.06	*> 0.05*	3.19 ± 0.46	*> 0.05*
	F	2.71 ± 0.29		43.31 ± 1.24		0.57 ± 0.03		2.16 ± 0.29	
L-Abdomen	M	4.36 ± 0.49	*> 0.05*	48.26 ± 2.37	*> 0.05*	0.56 ± 0.04	*> 0.05*	3.80 ± 0.50	*> 0.05*
	F	3.37 ± 0.19		44.55 ± 2.79		0.53 ± 0.04		2.92 ± 0.19	
V-Abdomen	M	3.96 ± 0.56	*< 0.05*	47.03 ± 1.69	*> 0.05*	0.61 ± 0.03	*> 0.05*	3.35 ± 0.55	*< 0.05*
	F	2.73 ± 0.12		42.08 ± 2.12		0.62 ± 0.01		2.11 ± 0.11	
Thigh	M	4.39 ± 0.45	*< 0.05*	41.25 ± 1.04	*> 0.05*	0.55 ± 0.04	*> 0.05*	3.85 ± 0.43	*< 0.05*
	F	3.15 ± 0.27		40.43 ± 1.99		0.55 ± 0.04		2.60 ± 0.27	
Back	M	4.19 ± 0.27	*> 0.05*	53.21 ± 3.87	*> 0.05*	0.58 ± 0.02	*> 0.05*	3.55 ± 0.27	*> 0.05*
	F	3.94 ± 0.19		47.44 ± 1.85		0.59 ± 0.03		3.31 ± 0.19	
Loin	M	4.30 ± 0.32	*< 0.05*	44.55 ± 2.21	*> 0.05*	0.59 ± 0.04	*> 0.05*	3.68 ± 0.30	*0.05*
	F	3.34 ± 0.17		43.31 ± 2.19		0.47 ± 0.04		2.91 ± 0.18	
Average	M	4.13 ± 0.13	*< 0.05*	46.61 ± 0.90	*< 0.05*	0.55 ± 0.01	*> 0.05*	3.56 ± 0.14	*< 0.05*
	F	3.18 ± 0.07		44.13 ± 0.75		0.56 ± 0.01		2.62 ± 0.08	

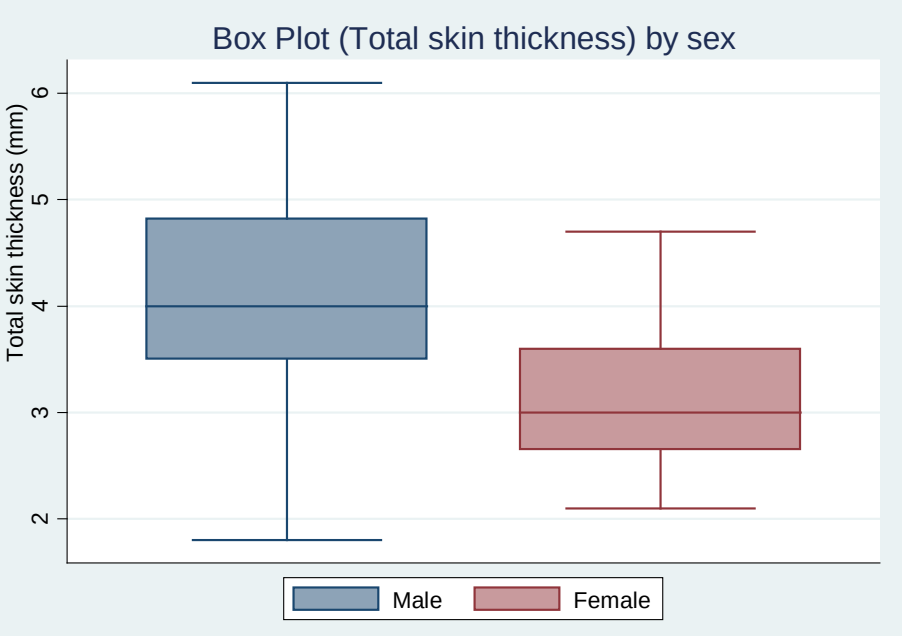

Figure 4. Box plot showing the patterns of quantitative data of total skin thickness in different regions of the body in male and female cattle. Middle bar in the box indicates median i.e. 50% of the data is greater than this value, lower bar of box indicates 25% of the data is less than this value and higher bar of box indicates 25% of the data is greater than this value. Higher and lower bar indicates maximum and minimum values of the data range

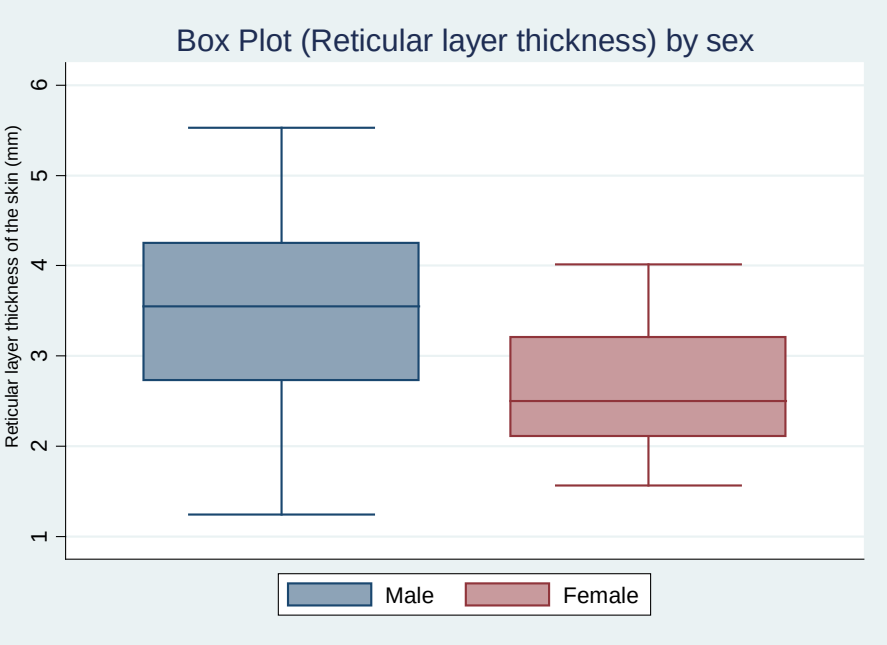

Figure 5. Box plot showing the patterns of quantitative data of reticular layer thickness of the skin in different regions of the body in male and female cattle. Middle bar in the box indicates median i.e. 50% of the data is greater than this value, lower bar of box indicates 25% of the data is less than this value and higher bar of box indicates 25% of the data is greater than this value. Higher and lower bar indicates maximum and minimum values of the data range

3.2. Density of Collagen and Elastic Fibre Bundle

The mean collagen and elastic fibre bundle were 302.93 ± 9.07/mm^2 and 4.96 ± 0.17/mm^2 respectively. The regional density of both collagen and elastic fibre bundle was varied significantly (*P<0.05*). Among the body regions the density of the collagen fibre bundle was highest in ventral abdomen (401.5 ± 44.29/mm^2) and lowest in thigh (237.25 ± 11.05 /mm^2) (Figure 6). The highest density of elastic fibre bundle was found in thigh (6.33 ± 0.49/mm^2) and lowest in back and ventral abdomen (4.08/mm^2) (Figure 7).

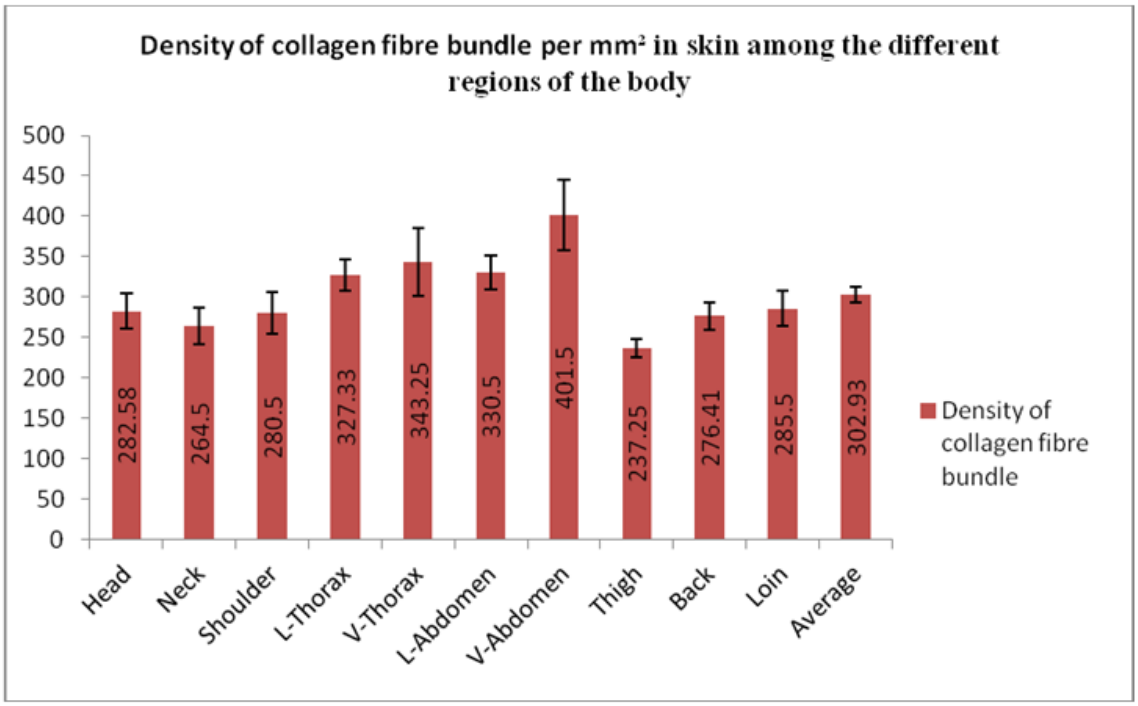

Figure 6. The bar diagram showing the density of the collagen fibre bundle per mm² in the cattle skin (n=6) among the different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

The mean density of collagen fibre bundle was significantly *(P<0.05)* higher in male (331.33 ± 15.10/mm^2) than the female (274.55 ± 8.73/mm^2) and the mean density of elastic fibre bundle was insignificantly (*P>0.05*) high in male (5.15 ± 0.25/mm^2) than the female (4.80 ± 0.24/mm^2). The significant (*P<0.05*) region wise sex variation of the collagen bundle density were found only in head and neck among the body regions. Both in

head and neck collagen fibre bundle was significantly higher in male (343.50 ± 18.71/mm^2 and 312.17 ± 35.30/mm^2, respectively) than female (221.67 ± 13.25/mm^2 and 217.00 ± 46.76/mm^2, respectively). The region wise sex variation of elastic bundle density was not found among the body regions. It was also found that in most of the body regions, the density of collagen and elastic fibre bundle were higher in male than the female (Figure 8 and Figure 9).

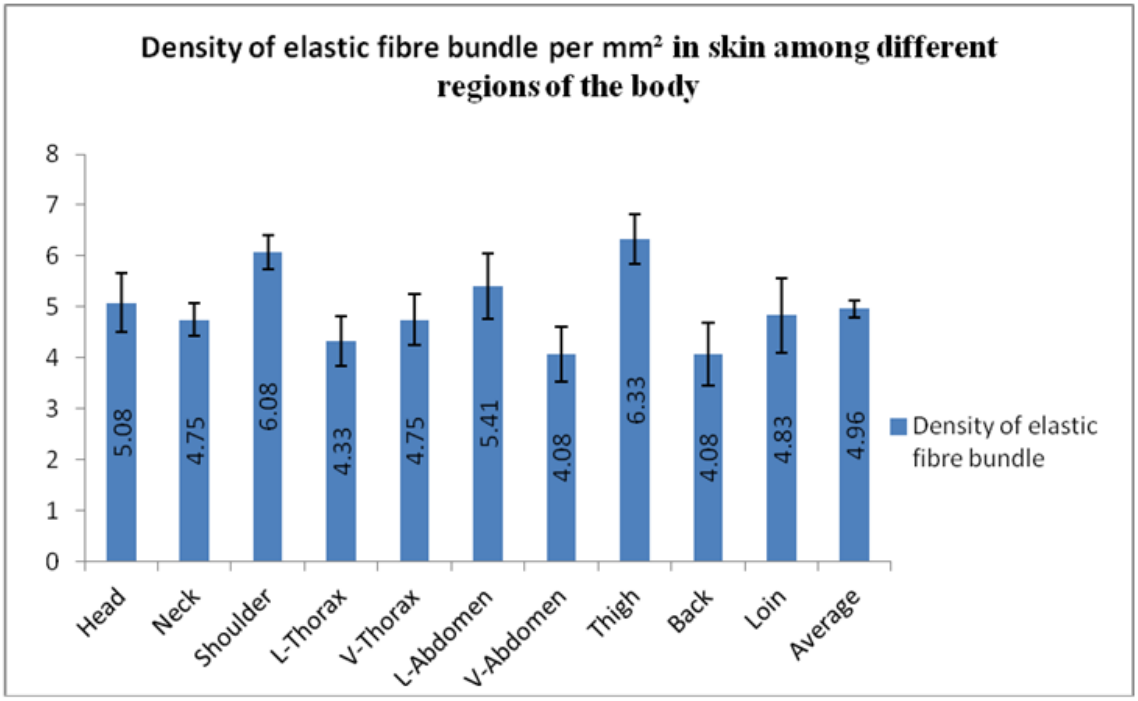

Figure 7. The bar diagram showing the density of the elastic fibre bundle per mm² in the cattle skin (n=12) among the different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

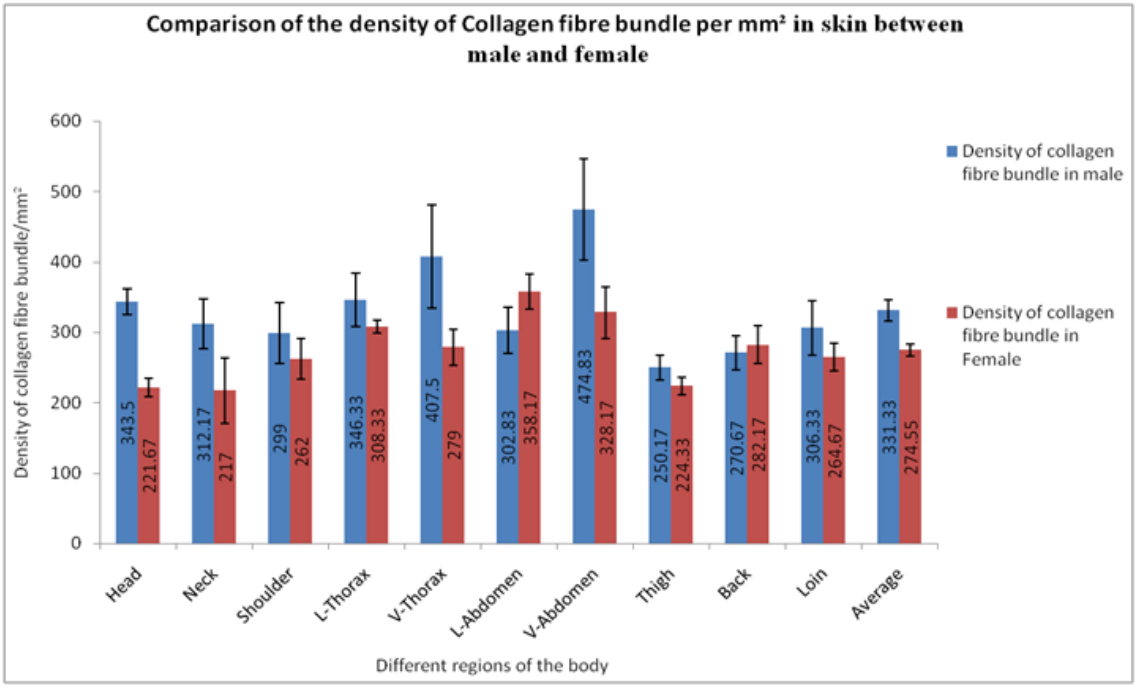

Figure 8. The bar diagram showing the comparative density of the collagen fibre bundle per mm² in the skin (n=6 for each sex) between male and female cattle in different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

3.3. Density of Sebaceous and Sweat Gland

The mean density of sebaceous gland and sweat gland were 4.22 ± 0.13/mm^2 and 4.57 ± 0.14/mm^2 respectively. The density of sebaceous gland was varied significantly *(P<0.05)* among the body regions. The highest density of sebaceous gland was found in head (5.16 ± 0.39/mm^2) and lowest in lateral abdomen (3.42 ± 0.36/mm^2). The density of sweat gland was not significantly differed among the body regions with the highest density in shoulder & neck (5.17/mm^2) and lowest in loin (3.58 ± 0.43/mm^2) (Figure 12).

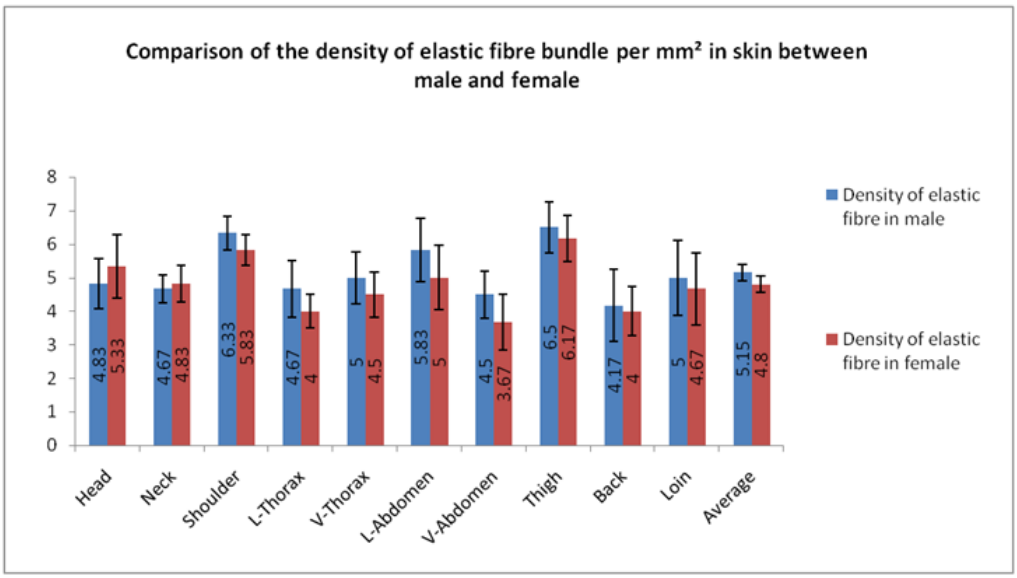

Figure 9. The bar diagram showing the comparative density of the elastic fibre bundle per mm² in the skin (n=6 for each sex) between male and female cattle in different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

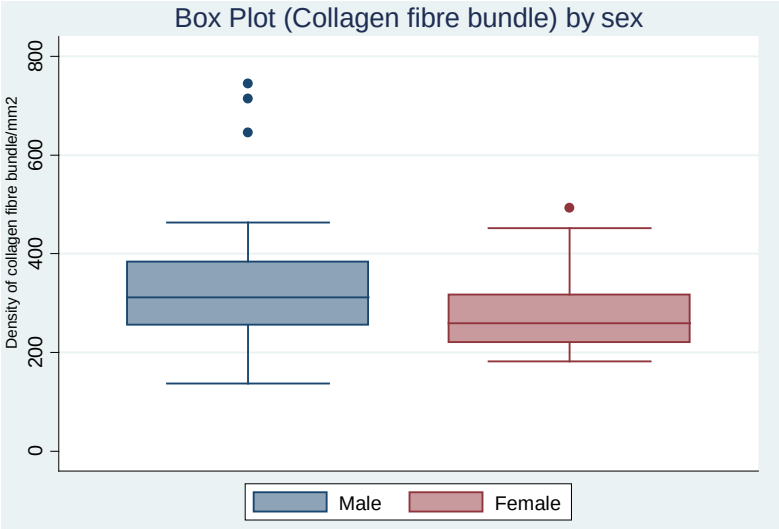

Figure 10. Box plot showing the patterns of quantitative data of collagen fibre density in skin of different regions of the body in male and female cattle. Middle bar in the box indicates median i.e. 50% of the data is greater than this value, lower bar of box indicates 25% of the data is less than this value and higher bar of box indicates 25% of the data is greater than this value. Higher and lower bar indicates maximum and minimum values of the data range. The upper dot indicates higher extreme value and lower dot indicates lower extreme value

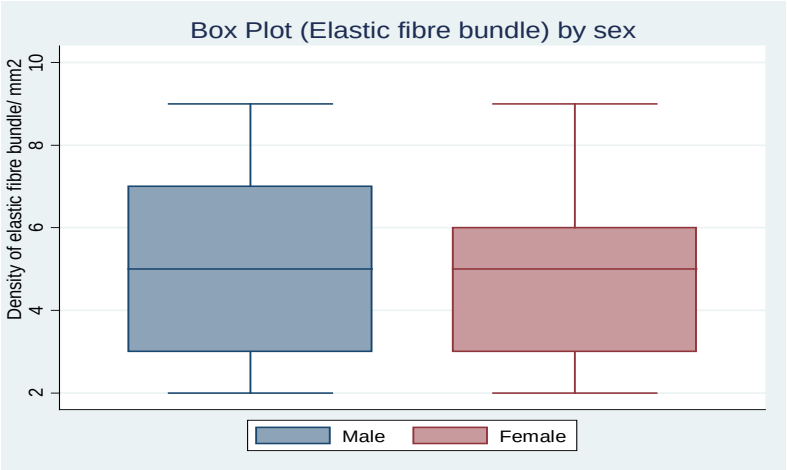

Figure 11. Box plot showing the patterns of quantitative data of elastic fibre density in skin of different regions of the body in male and female cattle. Middle bar in the box indicates median i.e. 50% of the data is greater than this value, lower bar of box indicates 25% of the data is less than this value and higher bar of box indicates 25% of the data is greater than this value. Higher and lower bar indicates maximum and minimum values of the data range

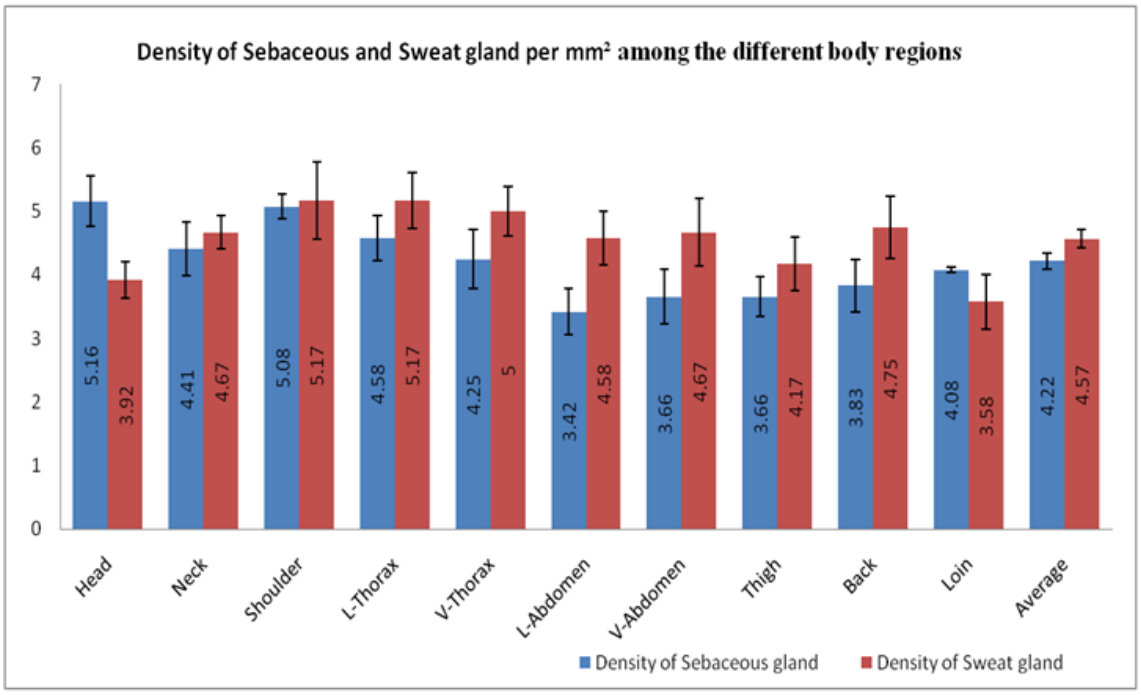

Figure 12. The bar diagram showing the comparative density of the sebaceous and sweat gland per mm² in the cattle skin (n=12) among the different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

Table 2. The density of the sebaceous and sweat gland in the cattle skin (n = 6 for each sex) (M = Male, F = Female, L = Lateral, V = Ventral)

Body regions	Sex	Sebaceous gland /mm^2 Mean ± SE	'*P*' for sebaceous gland	Sweat gland /mm^2 Mean ± SE	'*P*' for sweat gland
Head	M	4.67 ± 0.67	> *0.05*	3.50 ± 0.34	> *0.05*
	F	5.67 ± 0.33		4.33 ± 0.42	
Neck	M	4.17 ± 0.31	> *0.05*	4.50 ± 0.43	> *0.05*
	F	4.67 ± 0.80		4.83 ± 0.31	
Shoulder	M	4.83 ± 0.31	> *0.05*	4.50 ± 0.56	> *0.05*
	F	5.33 ± 0.21		5.83 ±1.08	
L-Thorax	M	4.67 ± 0.49	> *0.05*	5.00 ± 0.73	> *0.05*
	F	4.50 ± 0.56		5.33 ± 0.56	
V-Thorax	M	5.67 ± 0.54	< *0.05*	4.50 ± 0.43	> *0.05*
	F	3.33 ± 0.56		5.50 ± 0.62	
L-Abdomen	M	3.50 ± 0.56	> *0.05*	3.83 ± 0.48	> *0.05*
	F	3.33 ± 0.49		5.33 ± 0.56	
V-Abdomen	M	4.33 ± 0.76	> *0.05*	4.83 ± 0.70	> *0.05*
	F	3.00 ± 0.26		4.50 ± 0.85	
Thigh	M	3.83 ± 0.48	> *0.05*	4.00 ± 0.63	> *0.05*
	F	3.50 ± 0.43		4.33 ± 0.61	
Back	M	4.00 ± 0.58	> *0.05*	5.00 ± 0.86	> *0.05*
	F	3.67 ± 0.61		4.50 ± 0.56	
Loin	M	3.67 ± 0.56	> *0.05*	3.33 ± 0.76	> *0.05*
	F	4.50 ± 0.56		3.83 ± 0.48	
Average	M	4.28 ± 0.17	> *0.05*	4.30 ± 0.19	*0.05*
	F	4.15 ± 0.18		4.83 ± 0.20	

The Table 2 showing there were no significant sex differences of the density of sebaceous gland and sweat gland among the body regions with the exception in ventral thorax. In ventral thorax the density of sebaceous gland was significantly (*P<0.05*) higher in male (5.67 ± 0.54/mm^2) than the female (3.33 ± 0.56/mm^2). The mean density of sebaceous gland was insignificantly higher in male (4.28 ± 0.17/mm^2) than the female (4.15 ± 0.18 /mm^2) but the sweat gland was insignificantly (*P>0.05)* higher in female (4.83 ± 0.20/mm^2) than the male (4.30 ± 0.19/mm^2) (Figure 13).

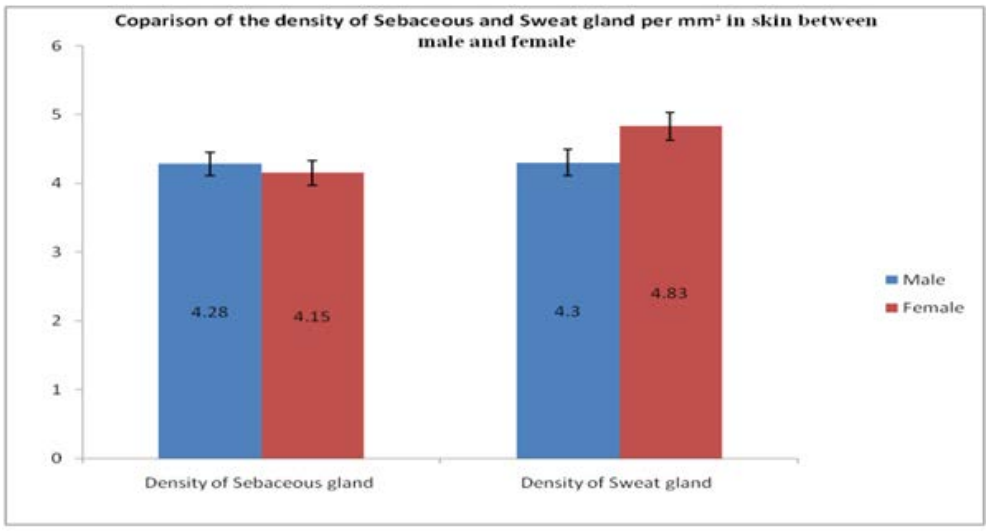

Figure 13. The bar diagram showing the comparative mean density of the sebaceous and sweat gland per mm² in the skin (n=6 for each sex) between male and female. Each bar represents means ± SE

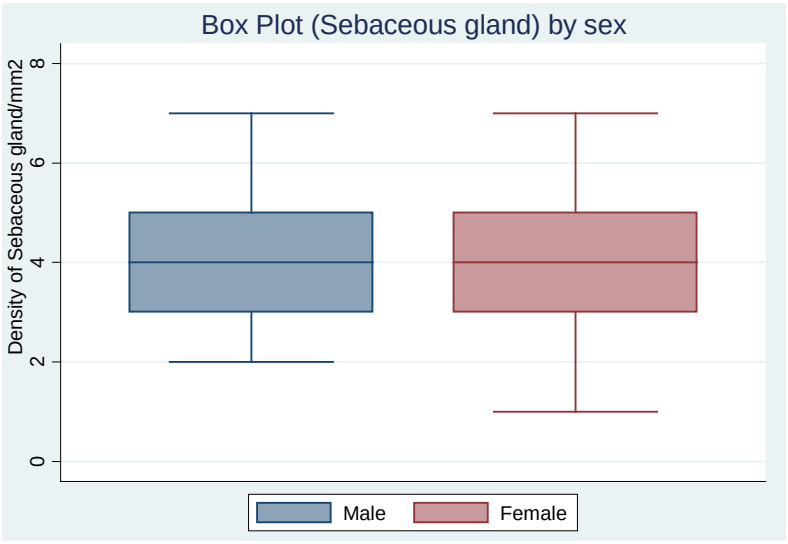

Figure 14. Box plot showing the patterns of quantitative data of sebaceous gland density in skin of different regions of the body in male and female cattle. Middle bar in the box indicates median i.e. 50% of the data is greater than this value, lower bar of box indicates 25% of the data is less than this value and higher bar of box indicates 25% of the data is greater than this value. Higher and lower bar indicates maximum and minimum values of the data range

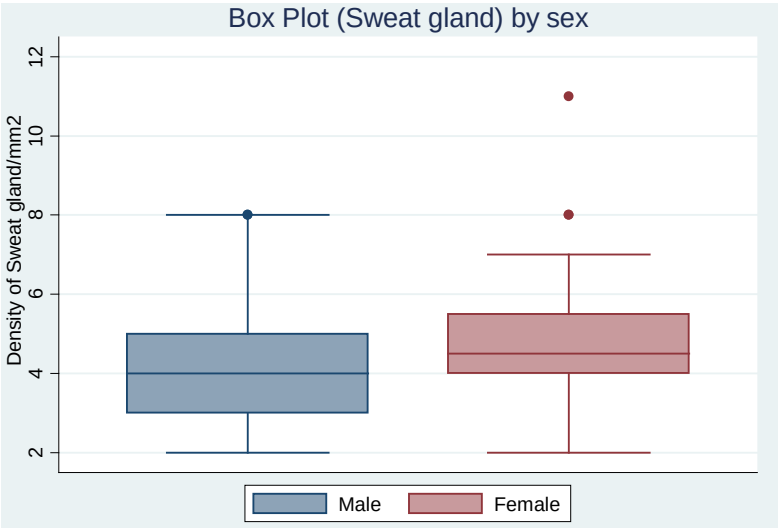

Figure 15. Box plot showing the patterns of quantitative data of sweat gland density in skin of different regions of the body in male and female cattle. Middle bar in the box indicates median i.e. 50% of the data is greater than this value, lower bar of box indicates 25% of the data is less than this value and higher bar of box indicates 25% of the data is greater than this value. Higher and lower bar indicates maximum and minimum values of the data range.The upper dot indicates higher extreme value and lower dot indicates lower extreme value

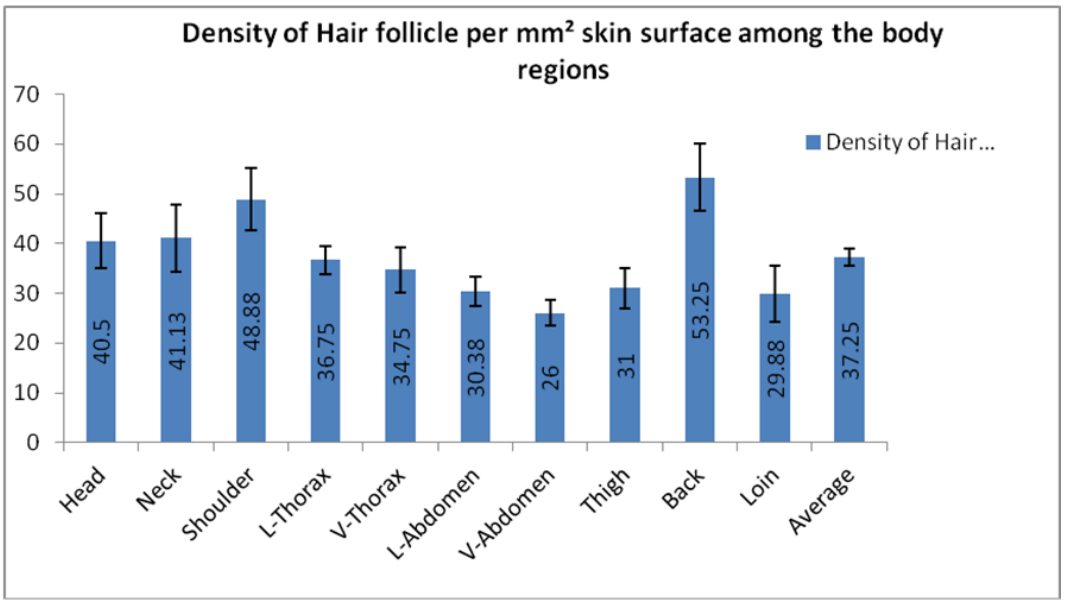

Figure 16. The bar diagram showing the density of the hair follicle bundle per mm² of the cattle skin (n=8) among the different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

3.4. Density of Hair Follicle

The study found that the mean of the hair follicle was 37.25 ± 1.77/mm^2 in the skin surface. The density of hair follicle was significantly (*P<0.05*) varied among the body regions. The highest density of hair follicle was found in back region (53.25 ± 6.74/mm^2) and lowest in ventral abdomen (26.00 ± 2.60/mm^2) (Figure 16).

The mean density of hair follicle was significantly (*P<0.05*) higher in male (43.93 ± 2.69/mm^2) than the female (30.575 ± 1.76/mm^2). Among the body regions, the significant (*P<0.05)* sex variation of hair follicle was found only in neck and loin. In both regions the hair follicle was higher in male than the female. In neck the hair follicle was 54.25 ± 7.98/mm^2 (male) & 28.00 ± 5.61/mm^2 (female) and in loin 40.50 ± 7.89/mm^2 (male) &19.25 ± 2.39/mm^2 (female) (Figure 17).

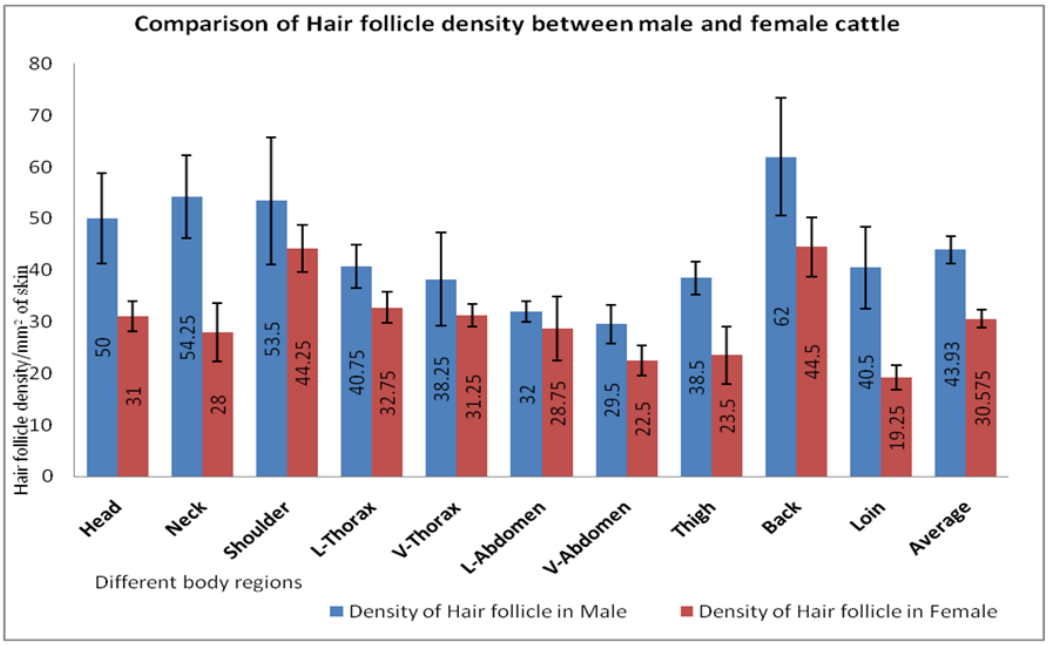

Figure 17. The bar diagram showing the comparative density of the hair follicle per mm² in the skin (n= 4 for each sex) between male and female cattle in different body regions (L = Lateral, V = Ventral). Each bar represents means ± SE

4. Discussion

4.1. Skin Thickness

In the present study, the mean of the total skin thickness in Bangladeshi native cattle was 3.57 ± 0.09 mm. The less average total skin thickness than the present study was reported 2.4 mm in cattle [6], 3.45 mm in local cattle [7], 1-2 mm in domestic animal [8], 2.99 mm in ewe [5], 1.71-2.93 mm (young adult) & 1.59-2.72 mm (old adult)) in lori Bakhtiari sheep [1] and 2.90 mm to 3.51 mm in Merino sheep [9]. The average total skin thickness more than the present result, was reported in the Jersey breed,

jersey & Sindhi crossbreed, buffalo [10] and in horse 10.7 mm [6].

In present study, the thickest skin was found on head and thinnest skin on shoulder, but [6,8] reported that the skin is thickest over the dorsal surface of the body and thinnest on the ventral side of the body. In the present study, if consider the trunk portion and hind quarter of the body, then it is similar findings with [6,8]. In the present study revealed skin thickness of dorsal part of the body was thicker and gradually thinner in lateral to ventral portion of the body. Similar skin thickness pattern was observed by [11,12]. Thick skin was found where either dermis or both dermis and epidermis are thicker. Similar observation was found by [8]. Among the studied body regions both layer was thicker in head and neck. [8] also found the thicker dermis in back region. The mean of the skin thicknesses were significantly ($P<0.05$) higher in male than the female. [13] reported the similar findings in Hereford and Angus cattle.

In the present study, the mean epidermal thickness was 45.37 ± 0.59 µm. [14] reported lower epidermal thickness than the present in different sheep breed such as German black head (15-25 µm), Hampshire Down (18-25 µm), Lincoln longwool (15-25 µm), white Karaman (22-44 µm), Awassi (20-38 µm) and Konya Merino (18-24 µm). The higher epidermal thickness was found in buffalo (50 µm) [15]. In present study, the epidermis was thickest on back (50.32 ± 2.22 µm) and thinnest on thigh (40.83 ± 1.08 µm) but the epidermal thickness in lactating cow in dorsal, lateral and ventral aspect of body region was 41.6 ±1.02, 43.36 ± 1.29 and 49.46 ±1.90 µm respectively and in non-lactating cow 42.25 ±1.03, 46.11±1.30 and 55.61 ±1.89 µm respectively [16]. In present study, the epidermal thickness was significantly higher in male than the female. Similar observation was reported in black goat [17].

In the present study, the average papillary layer thickness and reticular layer thickness were 0.55 ± 0.01mm and 3.03 ± 0.09 mm respectively. The both papillary layer and reticular layer thickness was higher than the present findings in the Jersey cattle (1.22 ± 0.02 mm and 4.01±0.02mm respectively), in Murrah buffaloes (1.18 ± 0.06 mm and 4.91 ± 0.06 mm respectively) and in Graded Murrah buffaloes (1.15 ± 0.03 mm, 3.74 ± 0.06 mm respectively). The higher papillary thickness (0.62 ± 0.04 mm) and lower reticular thickness (2.63 ± 0.02 mm) were found in Sindhi cattle. The lower papillary thickness (0.53±O.02 mm) and higher reticular thickness (3.84 ± 0.02mm) were found in jersey and Sindhi crossbreed [10].

These thicknesses were varied among the body regions significantly *(P<0.05)*. The highest values for papillary layer thickness and reticular layer thickness were 0.61 ± 0.01 mm in ventral abdomen and 3.74 ± 0.35 mm in head respectively. The lowest values for the thicknesses were 0.50 ± 0.02 mm in neck & shoulder and 2.51 ± 0.22 mm in shoulder respectively, but [18] reported in cow, the thickness of dermis of neck, abdominal and caudal regions of the skin was 11.0 ± 0.6 mm (highest), 4.8 ± 0.7mm (lowest) and 5.4 ± 0.8 mm respectively. The both layers were thicker in male than the female [13] also found higher thickness in male than the female. Androgen (testosterone) stimulation causes an increase in skin thickness, that's why male skin is thicker than the female skin. The reticular layer which is the main source of collagen and elastic fibre, so male skin may contain higher collagen and elastin protein than the female skin.

4.2. Density of Collagen and Elastic Fibre Bundle

The mean collagen and elastic fibre bundle were 302.93 ± 9.07/mm^2 and 4.96 ± 0.17/mm^2 respectively. The regional density of both collagen and elastic fibre bundle was varied significantly ($P<0.05$). Among the body regions the density of the collagen fibre bundle was highest in ventral abdomen (401.5 ± 44.29/mm^2) and lowest in thigh (237.25 ± 11.05 /mm^2). The highest density of elastic fibre bundle was found in thigh (6.33 ± 0.49/mm^2) and lowest in back & ventral abdomen (4.08/mm^2). [19] also reported that the volume density of connective tissue of skin in sheep is significantly affected by different body regions. The overall volume density of connective tissue per one mm^{2}of skin is highest in belly, 20.60 ± 2.22 and lowest in forearm, 17.36 ± 2.74 [19]. In the present study, the mean density of collagen fibre bundle was significantly ($P<0.05$) higher in male than the female and elastic fibre bundle was insignificantly higher in male than the female. Similar findings were reported by [20], but [19] found that there was no sex difference regarding the density of connective tissue (collagen & elastic bundle) in the skin. So, it may be stated that the male skin of the cattle is better for leather production than the female as collagen content decides the strength of the skin as well as its compactness and it is so importance to the tanner as the lather forming protein substance of skin [21].

4.3. Density of Sebaceous and Sweat Gland

In the present study, the mean density of sebaceous gland was 4.22 ± 0.13/mm^2. The lower density than the present study was found indifferent body regions of Iranian native sheep such as belly (1.16 ± 0.57/mm^2), neck (0.70 ± 0.76/mm^2), leg (2.08 ± 0.76/mm^2), rump (1.62 ± 1.05/mm^2), flank (1.62 ± 1.05/mm^2), forearm (1.39 ± 1.24/mm^2), shoulder (0.46 ± 0.72/mm^2) and hip (0.93 ± 0.72/mm^2) [19]; in Merino ewes was 2.91 ± 0.15 per mm [22]. The density of sebaceous gland was varied significantly ($P<0.05$) among the body regions and found highest density in head (5.16±0.39/mm^2), but [19] reported maximum density in leg. In the present study, the mean density of sebaceous gland was insignificantly higher in male than the female, but [23] found that the density of the sebaceous gland was higher in male than the females.

In the present study, the mean density of sweat gland was 4.57 ± 0.14/mm^2 in the cattle skin. The higher density of sweat gland than the present density was reported in Egypt cattle 26.33/mm^2 [15], in Jersey 11.30/mm^2 and in Sahiwals 12/mm^2 [24].The lower density was found in buffalo (2.93/mm^2) [15].In the present study, the density of sweat gland was not significantly differed among the body regions with the highest density in shoulder & neck (5.17mm/^{2}) and lowest in loin (3.58 ± 0.43/mm^2). [19] also found the sweat gland density was not significantly differed among the various body regions, but found the maximum volume densities of the glands in leg and belly skin and minimum in rump. There were no significant region wise sex differences of the density of sweat gland.

The sweat gland was insignificantly higher in female than male, but [19] found that the sweat gland density of the hip region was higher in male sheep, whereas the ewes had a higher value in rump skin.

4.4. Density of Hair Follicle

The present study revealed that the mean density of the hair follicle was 37.25 ± 1.77/mm^2 in the skin surface. The lower density of hair follicle than the present result was reported in cattle (26.33/mm^2) [15], in Egypt bulls (36.00/mm^2) [25], in Egypt buffalo (3.94/mm^2) [15], in buffaloes (3.4/mm^2) [26], in cashmere goats (36.19/mm^2) [27], in dromedarius camels (30.1/mm^2), in bactrianus camels (32.8/mm^2) [28], in Bakhtiari sheep (6.25–9.03/mm^2) [19], in Lori sheep (6.06/mm^2) [29], in Merino sheep (21.7/mm^2) [30], in Swedish Pelt sheep (14–19/mm^2) [31], in Hampshire Down sheep (24-25/mm^2), in White Karaman sheep (15-36/mm^2) and in Awassi sheep (13-16/mm^2) [14];but higher density in Konya Merino sheep (44-72/mm^2) [14], in Tuj sheep (38.71/mm^2 [34]. In the present study, the density of hair follicle was significantly ($P<0.05$) varied among the body regions. The highest density of hair follicle was found in back region (53.25 ± 6.74/mm^2) and lowest in ventral abdomen (26.00±2.60/mm^2), but [15] recorded the highest hair follicle density in the forearm region (9.03 ± 4.19/mm^2) and lowest in the shoulder region (6.25 ± 1.91/mm^2). In the present result, the mean density of hair follicle was significantly ($P<0.05$) higher in male than the female. Similar observations were found by [32] in calves, [33] in sheep and [15] in bakhtiari sheep; but [33] and [29] found higher hair follicle density in female than the male. The hair follicle density in the skin surface may be varied from animal to animal, species to species, body region to region.

5. Conclusions

The present data concerning total skin thickness, epidermal thickness, papillary layer thickness, reticular layer thickness, number of collagen fibre bundle, elastic fibre bundle, sebaceous gland, sweat gland and hair follicle vary significantly or insignificantly according to the body regions and sex. On an average, it can be suggested that the male skin is better for quality leather production than the female skin based on distribution of the skin components. According to regions, ventral abdomen has more compact collagen whereas the thickness is higher in dorsal part of the body, so the assessment of the best body region for quality leather production will depend on purposes of finished leather products. The present results could provide significant consideration for the sorting of raw skin to produce quality leather.

References

[1] Mobini B, Faradonbeh KS (2012) A morphometric study on differentregions of the skin in lori-Bakhtiari sheep at different ages. International journal of plant, animal and environmental science. 2(4): 180-185.

[2] Salehi M, Lavvaf A, Farahvash T (2013a) Skin Quality and Physical Properties of Leather Based on Sex, Age and Body Parts of Goats Reared on Sub - Humid Hill Country. Iranian Journal of Applied Animal Science. 3(4): 853-857.

[3] Adel R, Elboushi Y (1994) Poultry Feed from Waste. Hide and Tanning by Products. 154-156.

[4] Widelitz RB, Tin-Xin J, Noveena A, Sheree A, Tin-Berreth EY, Hang-Sung J, Cheng-Ming C (1997) Molecular Histology in Skin Appendage Morphogenesis. Microscopy Research and Technique. 38: 452-465.

[5] Genkovski D, Gerchev G (2007) Study of the skin histological structure in ewes from staroplaninska and thorough bred Tsigai. Biotechnology in Animal Husbandry. 23(5-6): 191–197.

[6] Dellmann HD, Brown EM (1987) Text book of Veterinary Histology; 3rd editionn. Lea and Febiger. Philadelphia. 382-415.

[7] Mannan AM (1973) Micro-anatomical and histochemical investigation of the normal and pathological skin of the hump of cattle. M. Sc (Vet. Science) thesis. Bangladesh Agricultural University, Mymensingh.

[8] Copenhaver WM, Kelly DE, Wood RL (1978) Bailye's Textbook of Histology. 17th Edition. Asian Edition. 423-445.

[9] Ozfiliz N, Balikcier M, Erdost H, Zik B (2002) Histological and morphometric features of the skin of native and hybrid (f2) sheep. Turkish Journal of Veterinary and Animal Sciences. 26: 429-438.

[10] Muralidharan MR, Ramesh V (2005). Histological and biochemical studies of the skin of cattle and buffalo. Indian Journal of Animal Research. 39: 41-44.

[11] Razvi R, Suri S, Sarma K, Sharma R (2014) Histomorphological and histochemical studies on the different layers of skin of Bakerwali goat. Journal of Applied Animal Research. 1-6.

[12] Sharma DN, Bharadwaj RL (1993) Regional variations in the thickness of the skin of adult yak. The Indian Veterinary Journal. 70: 437-438.

[13] GoJdsbery S, Calhoun ML (1959). The comparative histology of the skin of Hereford and Aberdeen Angus cattle. American Journal of veterinary Research. 20: 61-68.

[14] Kurtdede N, Asti RN (1999) The investigation on the skin structure of German Black Head, HampshireDown, Lincoln Longwool, White Karaman, Awassi and Konya Merino. Veterinary Journal of Ankara University. 46: 219-230.

[15] Hafez ESE, Badreldin AL, Shafei MM (1955b) Skin structure of Egyptian buffaloes and cattle with particular reference to sweat glands. The Journal of Agricultural Science. 46(1): 19-30.

[16] Hole MB, Bhosle NS Kapadnis PJ (2008) Histological Study of Skin Epidermis in Red Kandhari Cows. Indian Journal Animal Research. 42(1): 69-70.

[17] Sultan GA (2012) Comparative histological and topographical study for the skin of head of male and female native black goat. AL-Qadisiya Journal of Veterinary Medicine Science. 11: 21-33.

[18] Kobayashi A, Takehana K, Eerdunchaolu, Iwasa K, Abe M, Yamaguchi M (1999) Morphometric analysis of collagen; a comparative study in cow and pig skins. Anatomia, histologia, embryologia. 28: 235-238.

[19] Mobini B (2013a) A quantitative evaluation of different regions of skin in adult Iranian native sheep. Veterinarni Medicina. 58(5): 260-263.

[20] Bilgen G, Oktay G, Tokgoz Z, Guner G, Yalcin S (1999) Collagen content and electrophoretic analysis of type I collagen in breast skin of heterozygous naked neck and normally feathered commercial broilers. Turkish Journal of Veterinary and Animal Sciences. 23(5): 483-488.

[21] Mitra SK (1963) Indian Hides and Skins-Histological Characteristics. Part - I.

[22] Warren GH, James PJ, Neville AM (1983) A morphometric analysis of the changes with age in the skinsurface wax and the sebaceous gland area of Merino sheep. Australian Veterinary Journal. 60: 238-240.

[23] Mobini B (2013g) Studies on the density of various dermal structures in adult rams and ewes. Bulgarian Journal of Veterinary Medicine. 16(1): 1-6.

[24] PanYS (1963) Quantitative and morphological variation of sweat glands, skin thickness, and skin shrinkage over various body regions of Sahiwal Zebu and Jersey cattle. Australian Journal of Agricultural Research. 14(3): 424-437.

[25] Hafez ESE, Badreldin AL, Shafei MM (1955a) The Hair Coat in Bovinae. Empire Journal of Experimental Agriculture. 23: 34-39.

[26] Shafie MM (1954) Skin histology of Egyptian buffaloes and cattle. M. Sc. Thesis, Faculty of Agriculture. Cairo University. U.A.R.

[27] Renani, HRA, Salehi M, Ebadi Z, Moradi S, Baghershah HR, Renani MYA, Ameli SH (2011b) Determination of hair follicle characteristics, density and activity of Iranian cashmere goat breeds. Small Ruminant Research. 95: 128-132.

[28] Renani HRA, Salehi M, Ebadi Z, Moradi S (2010) Identification of hair follicle characteristics and activity of one and two humped camels. Small Ruminant Research. 90: 64-70.

[29] Abbasi M, Gharzi A, Karimi H, Khosravinia H (2008) Effects of sex on histological characteristics of various areas of skin in an Iranian native breed of sheep. Journal of Animal and Veterinary Advances. 7: 1503-1505.

[30] Andrews RN, Beattie AE, Dodds KG, Wuliji T, Montgomery GW (1998) Wool follicle traits of 1/2 Merino ½ Romney F1, and backcross 3/4 Merino 1/4 Romney gene mapping flocks. In: Proceedings of the New Zealand Society of Animal Production, New Zealand. 262-265.

[31] Butler LG, Orazio RD, Ahlen K (1993) Some objective skin and fleece traits relating to pelt quality of Swedishpelt sheep. Small Ruminant Research. 12: 69-78.

[32] Turner HG (1962) Effect of clipping the coat on performance of calves in the field.Australian Journal of Agricultural Research. 13: 180-192.

[33] Renani HRA, Moradi S, Baghershah HR, Ebadi Z, Salehi M, Momen SMS, Renani MYA (2011a) Determination of wool follicle characteristics of Iranian sheep breeds. Asian-Australian Journal of Animal Sciences. 24: 1173-1177.

[34] Kocamis H, Aslan S (2004) Histological and histometrical study on the structure of Tuj breed sheep skin. Kafkas Universitesi Veteriner Fakultesi Dergisi. 10(1): 91-98.