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A COMPARATIVE STUDY ON THE SKIN OF DIFFERENT BREEDS OF DOGS

K.B. Sumena[1], K.M. Lucy[1], N. Ashok[1], C. Leena[1], P.V.Tresamol[2], G.Radhika[3] and V.L. Gleeja[4]

[1]Department of Veterinary Anatomy, [2]Department of Veterinary Epidemiology and Preventive Medicine, [3] Department of Animal Genetics and Breeding, [4]Department of Statistics, College of Veterinary and Animal Sciences, Mannuthy, Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala.

Correspondence Email:sumena@kvasu.ac.in

ABSTRACT

A comparative study was conducted on the skin samples from different breeds of dogs, focusing on epidermal, dermal and total skin thickness, hair distribution pattern, subcutaneous fat and sebaceous as well as sweat gland characteristics. Notable variations were observed among breeds. Skin was thickest in Doberman Pinscher and thinnest in Beagle. The Labrador Retriever showed the highest epidermal contribution to total skin thickness (7.06%). Dachshund and Beagle exhibited the thickest (85.07±5.97 µm) and thinnest (29.30±2.98 µm) epidermis. Significant positive correlation was noticed between total skin thickness and dermal thickness. A significant negative correlation was observed between epidermal thickness and both dermal and total skin thickness. Hair distribution was compound in pattern in all breeds but varied in number and size across breeds. The primary hair and many secondary hairs emerged through a single opening. Among the eight breeds under study, maximum diameter for hair was noticed in Doberman Pinscher and minimum in the German Spitz. Maximum number of sweat glands was observed in the Dachshund and minimum in the Pug. The sweat glands in the ventral abdominal region in all breeds were of apocrine type. Simple branched alveolar type holocrine sebaceous glands associated with the hair follicles were present in dermis in all the breeds. These findings highlight breed-specific histological differences in canine skin that may influence their physiological and dermatological traits.

Keywords: Histomorphology of skin, epidermis, dermis, hair, dog breeds.

INTRODUCTION

Skin is the largest organ in the body and plays a vital role in protection, thermoregulation and sensory perception.

In dogs, the skin exhibits considerable variation in its structure and appendages, which can be influenced by breed, coat type and environmental adaptation. The basic organisation of skin includes an outer epidermis, a thicker dermis and the subcutaneous tissue, each contributing differently to its overall function. Associated structures such as hair follicles, sebaceous glands and sweat glands further enhance its physiological roles. Breed-related differences in skin morphology have practical significance, as they influence hair coat characteristics, sweat gland and sebaceous gland functions and susceptibility to dermatological disorders. Earlier studies in dogs and other domestic animals have reported variations in the relative thickness of skin layers, density of hair follicles, and distribution of adnexal glands. However, comparative data on these features across multiple breeds of dogs remain limited. Hence, the present study was undertaken to evaluate the histomorphological characteristics of the skin in eight different breeds of dogs, with special emphasis on the thickness of epidermis, dermis, and subcutaneous fat, along with the distribution of hair follicles, sebaceous glands and sweat glands. This comparative approach is expected to provide insights into breed-specific adaptations and contribute to a better understanding of canine dermatology.

MATERIALS AND METHODS

Morphological and histological studies were conducted on the skin of eight breeds of dogs, *viz.* German Shepherd, Labrador Retriever, Dachshund, Beagle, Doberman Pinscher, German Spitz Pug and indigenous dogs. For anatomical studies, the skin samples of adult dogs died of reasons other than any apparent cutaneous clinical ailments and also from skin tissues trimmed and removed during routine surgical wound closures in elective surgical procedures were collected. In total, 48 animals were used for the study (six animals from each breed). The skin samples of nearly 2 cm^2 area were collected from the ventral abdominal region. The tissue pieces were washed in normal saline and mopped with a blotting paper. Thickness of the skin and subcutaneous fat was measured using Vernier Callipers. The skin samples were cut into smaller pieces of 2 mm thickness and fixed in 10 per cent neutral buffered formalin. The tissue pieces were processed in high melting paraffin (melting point, 58-60^{o}C) employing the standard procedure. Paraffin sections of 4 to 5 µm thickness were taken for histological studies. The following histological staining techniques (Luna, 1968) were employed in paraffin sections.

1. Haematoxylin and eosin staining technique for routine histological studies

2. Masson's trichrome method for muscles and collagen fibres
3. Ayoub-Shklar method for keratin and prekeratin
4. Picrosirius red method
5. Fontana-Masson silver method for melanin pigments

For scanning electron microscopic (SEM) studies, small skin pieces of 1 mm^3 with stumps of hairs were fixed in 2.5 per cent glutaraldehyde in 0.1*M* phosphate buffer (pH 7.2) at 4°C and processed as per the standard procedures (Bozzola and Russell, 1998). The SEM studies were conducted using Tescan Vega -3LMU Scanning Electron Microscope.

RESULTS AND DISCUSSION

Structure and Thickness of Skin

The skin of dogs in ventral abdominal region was characterised by the presence of folds on the surface between the rows of hair follicles (Fig. 1). The width of these skin folds varied in different breeds and ranged from 0.5 to 2.0 mm. Well defined skin folds were noticed in Doberman Pinscher, German Shepherd and indigenous dogs. Skin of Beagle, Dachshund, Labrador Retriever and German Spitz showed less distinct folds while in the Pug, these were meagre.

Thickness of the skin varied considerably in all the eight breeds of dogs under study. Maximum thickness was noticed in Doberman Pinscher with an average value of 3.10±0.11mm (Tab. 1). Minimum thickness was noticed in Beagle that measured 0.97±0.05mm. The thickness of skin decreased in the order from Doberman Pinscher, Pug, indigenous dogs, Dachshund, German Shepherd, German Spitz, Labrador Retriever to Beagle. Post hoc tests for multiple comparisons revealed

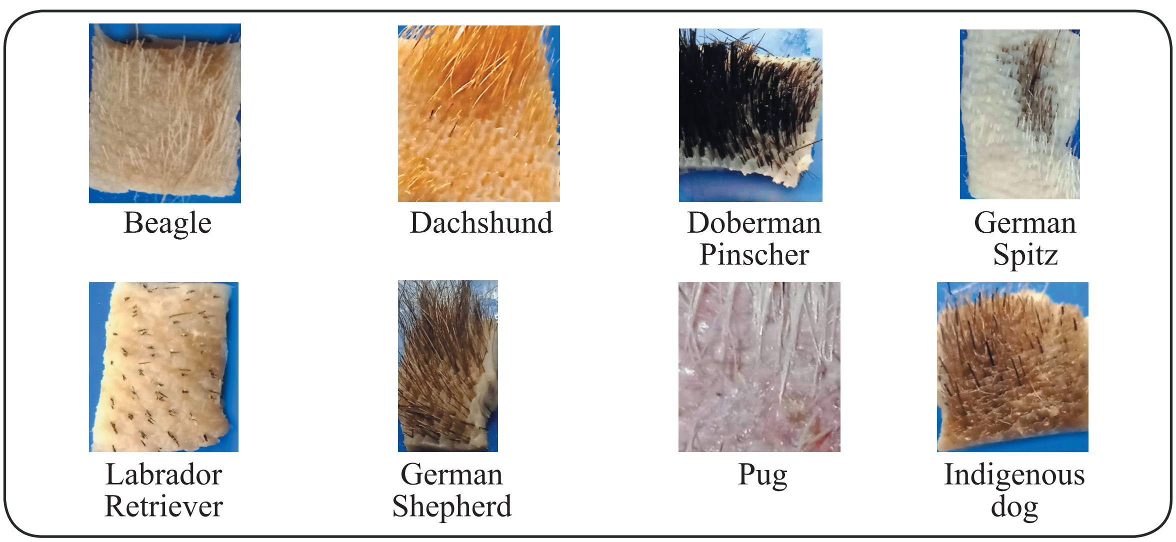

Fig.1. Skin samples from different breeds

significant differences in the skin thickness among different breeds of dogs.

Table 1. Thickness of skin of different breeds of dogs, mm

Breed	Thickness of skin (Mean±SE)
Beagle	0.97 ^{e} ±0.05
Dachshund	1.32 ^{d} ±0.05
Doberman Pinscher	3.10 ^{a} ±0.11
German Spitz	1.12 ^{e} ±0.03
Labrador Retriever	1.07 ^{e} ±0.04
German Shepherd	1.29 ^{d} ±0.01
Pug	1.98 ^{b} ±0.04
Indigenous	1.69 ^{c} ±0.05
F value	12.633

P value<0.001. Means having same superscript are not significantly different at 0.05 level.

Skin was composed of upper epidermis and lower dermis. Contribution of the epidermis to the total thickness of skin was maximum in Labrador Retriever (7.06%). Epidermis was thickest in Dachshund (85.07±5.97 µm) followed by Labrador Retriever (75.69±14.83 µm) and thinnest in Beagle (29.30±2.98 µm) among the eight breeds (Tab. 2). Among Poodles, Golden Retrievers, Shih Tzus, Pugs and Labrador Retrievers, thickest epidermis was reported in the Labradors and thinnest in the Poodles (Theerawatanasirikul *et al*., 2012).

Table 2. Thickness of epidermis of different breeds of dogs, mm

Breed	Thickness of epidermis (Mean±SE)
Beagle	29.30 ^{b} ±2.98
Dachshund	85.07 ^{a} ±5.97
Doberman Pinscher	36.00 ^{b} ±2.22
German Spitz	65.98 ^{a} ±2.89
Labrador Retriever	75.69 ^{a,b} ±14.83
German Shepherd	60.08 ^{a} ±4.17
Pug	48.40 ^{a,b} ±8.71
Indigenous	31.95 ^{b} ±3.89
F value	12.633

P value<0.001. Means having same superscript are not significantly different at 0.05 level.

1. Stratum corneum
2. Stratum basalis
3. Papillary dermis
4. Thin collagen fibres
5. Hair follicle
6. Reticular dermis
7. Thick collagen Fibres

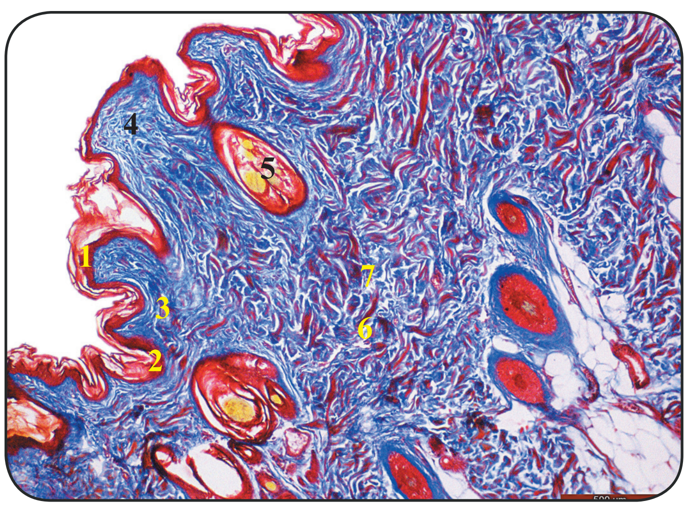

Fig. 2. Section of skin in the ventral abdomen region of Dachshund. Masson's trichrome method x 100

The dermis was composed of the superficial thin papillary layer and the deeper thicker reticular layer (Fig. 2). According to Maya *et al.* (2020), the papillary and reticular layers of dermis lacked a sharp boundary but were distinguishable by the arrangement of coarse and loosely interwoven collagen bundles in the reticular layer against the thin and more compactly arranged collagen fibres in the papillary layer.

Thickness of the dermis varied from 947.00±53.66 µm to 3070.48±114.73 µm in the skin of dogs under study (Tab. 3). The thickest dermis was noticed in the Doberman Pinscher and thinnest in the Beagle. Dermis was 85 times thicker than the epidermis in Doberman Pinscher. According to Barbieri *et al.* (2014), in human, the dermis was 15-40 times thicker than the epidermis. Rojko *et al.* (1978) reported that the thickness of the dermis in mongrel dogs ranged from 550 µm to 1250 µm, from ventral to dorsal aspect of the body. In the ventral trunk region, the dermis was 620µm thick.

There was a statistically significant negative correlation existed between the thickness of the epidermis and the total thickness of skin (Tab. 4). As the epidermal thickness increased, the total thickness of skin tended to decrease in all breeds under study. Similarly, significant negative

Table 3. Thickness of dermis of different breeds of dogs, mm

Breed	Thickness of dermis (Mean±SE)
Beagle	947.00^{e} ±53.66
Dachshund	1258.80^{d} ±49.14
Doberman Pinscher	3070.48^{a} ±114.73
German Spitz	1060.72^{d} ±32.53
Labrador Retriever	1003.33^{e} ±39.43
German Shepherd	1231.29^{e} ±15.22
Pug	1956.68^{b} ±34.58
Indigenous	1675.51^{c} ±54.17
F value	168.914

P value<0.001. Means having same superscript are not significantly different at 0.05 level

correlation existed between the thickness of the epidermis and the dermis. As the epidermal thickness increased, the dermal thickness tended to decrease. This showed the tendency to maintain the structural adaptation to maintain the functional integrity. A significant positive correlation was found between the total thickness of the skin and that of the dermis across all breeds of dogs under study. This can be related to high proportion of the dermis to the thickness of skin. Thus, variations in dermal thickness directly influence the overall thickness of skin across breeds, whereas epidermal thickness has only minor role in determining total thickness of skin. Theerawatanasirikul *et al*. (2012) in their study on the skin of dogs, opined that, the areas of skin with less hair were exposed to the external environment resulting in cell proliferation and increased thickness

Table 4. Correlation coefficients of different parameters on the thickness of skin in dogs

Parameters	**Pearson correlation coefficient**		**Spearman's rho-correlation coefficient**
	Thickness of epidermis	Thickness of skin	Number of hair follicles
Thickness of epidermis	1	-.332*	0.116
Thickness of dermis	-.357*	.999**	-.457**
Thickness of skin	-.332*	1	-.465**

Notes:
* Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

of the epidermis and thus, the morphology of skin, type of coat and breed were found as predisposing factors for pathological conditions affecting the skin.

Hair Distribution and Subcutaneous Fat

Hairs were made up of keratinised cells that were compactly cemented together and grew out of the hair follicles located in the dermis. All the eight breeds of dogs under study possessed compound hair pattern (Fig. 3 & 4), composed of a primary hair surrounded by secondary hair follicles. The hairs originating from different hair bulbs projected out to the skin surface through a single opening along with the openings of sebaceous and apocrine sweat glands as reported by Thomsett (1986) in dogs.

The number and size of hairs differed breed-wise. Labrador Retrievers, Dachshunds, Doberman Pinschers, Pugs, Beagles and indigenous dogs showed short and stumpy primary hairs. In contrast, German Spitz and German Shepherd possessed wavy and long primary hairs. The secondary hairs were shorter, thinner and slightly wavy than the primary hairs. Pugs possessed stiff primary as well as secondary hairs. The longest hairs were found in German Spitz and the shortest in Doberman Pinscher. Maximum diameter for the hair was noticed in the Doberman Pinscher and the minimum in the German Spitz. Housley and Venta (2006) found that in dogs, short hair was dominant to long hair. But long curly or wiry hair was dominant to both short and long. These two loci interacted to produce a distinct coat type. Even within each of these phenotypes, actual hair length varied because of the effect of modifier genes and environmental factors.

Two types of hair follicles namely primary and secondary follicles were seen together surrounded by connective tissue layer and formed a compound hair follicle as reported by Affolter and Moore (1994) in dogs and cats. Primary follicles had a

1. Primary hair
2. Secondary hair
3. Corneocyte
4. Oily secretion
5. Squames

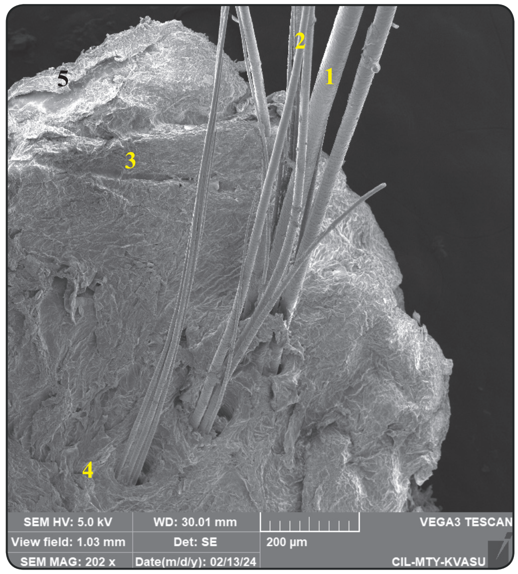

Fig. 3. SEM image of surface of skin of Doberman Pinscher showing the pattern of compound hairs. SEM x 202

1. Desquamating layer
2. Stratum corneum
3. Stratum spinosum
4. Stratum basalis
5. Clear cells
6. Paillary dermis
7. Blood vessels
8. Hair
9. Hair follicle

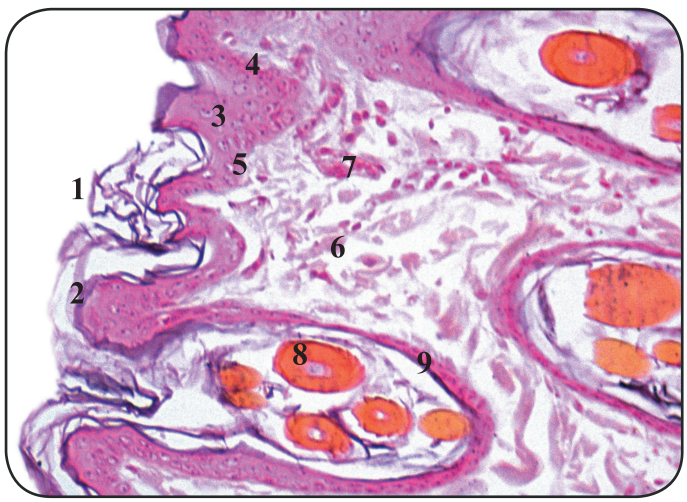

Fig.4. Section of skin in the ventral abdomen region showing the layers of the epidermis of German Spitz. Fontana Masson's methodx 400

larger diameter and were deeply rooted whereas, secondary follicles were smaller in diameter and were more superficially located in that follicle. Both these showed sebaceous glands associated with them. Affolter and Moore (1994) reported that the primary hair follicle was characterised by the presence of single hair, sebaceous glands, sweat glands and arrector pili muscles. Secondary hair follicles lacked sweat glands and arrector pili muscles.

The primary hair and many secondary hairs emerged through a single opening located in the grooves formed by the folds of the skin. These openings were located in a row on the surface of the skin with regular interfollicular distance. Affolter and Moore (1994) reported that the cats possessed more secondary hairs with maximum at the ventral aspect of the body. Among the eight breeds in the present study, German Spitz showed maximum average hair density per field followed by Dachshund, indigenous dogs, German Shepherd, Labrador Retriever, Doberman Pinscher, Beagle and Pug in the decreasing order of density. Thomsett (1986) reported that in dogs, density of the guard hairs was maintained throughout the year while the secondary down hairs were in telogen stage. The secondary down hairs revealed a seasonal variation *viz*., dense hair coat in winter and thinner hair coat during summer.

The subcutaneous tissue consisted of a loose meshwork of collagen fibres, with small amounts of elastic and reticular fibres. A homogeneous adhesive ground substance held these fibres together. The roots of the hair follicles extended deep into the subcutaneous tissue and were surrounded by lobules of fat. Apocrine sweat glands were also embedded in the subcutaneous tissue. According to Mohammed *et al.* (2022), the hypodermis layer of the skin was very thick in sheep and goat compared to buffalo, cow, camel, dog and donkey.

The spaces within the fibrous network were filled with adipose tissue. Maximum thickness of adipose tissue was noticed in the Doberman Pinscher (7.50±0.27mm) and lowest in the Pug (0.40±0.03mm) as shown in table 5. Trautmann and Fiebiger (1957) suggested that the network of collagen and elastic fibres in the homogenous adhesive ground substance formed thin membranes. The spaces between these membranes were the area of subcutaneous oedema or emphysema in pathological conditions. The development of subcutis determined the degree of folding of the skin. In well-finished animals, panniculus adiposus extended to the deep surface of cutaneous muscles. Monteiro-Riviere (1998) noticed that the hypodermis anchored the dermis to

Table. 5. Thickness of subcutaneous fat of different breeds of dogs, mm

Breed	**Thickness of subcutaneous fat (Mean±SE)**
Beagle	$2.18^{c} \pm 0.22$
Dachshund	$3.91^{a,b} \pm 0.27$
Doberman Pinscher	$7.50^{a} \pm 0.75$
German Spitz	$3.29^{b,c} \pm 0.51$
Labrador Retriever	$3.83 \pm 0.38^{a,b,c}$
German Shepherd	$5.58^{a,b} \pm 0.58$
Pug	$0.40^{d} \pm 0.03$
Indigenous	$4.23^{a,b,c} \pm 0.53$
F value	168.914

P value<0.001. Means having same superscript are not significantly different at 0.05 level.

1. Reticular dermis
2. Compound hair follicle
3. Sebaceous gland
4. Sweat glands
5. Blood vessels

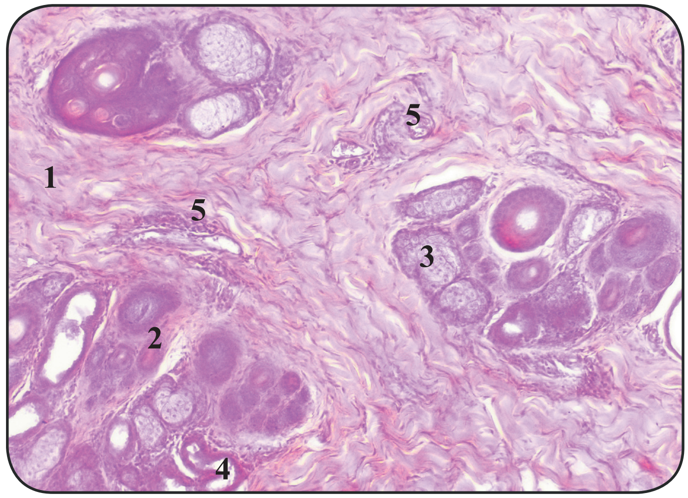

Fig.5. Section of the dermis of the ventral abdomen region of Dachshund showing the sweat glands. H&E. x 200

the underlying muscles or to the bone. The loose arrangement of collagen and elastic fibres allowed the skin flexibility and free movement over the underlying structures.

SWEAT GLANDS

Sweat glands were consistently observed adjacent to hair follicles, often positioned parallel or lateral to them. These glands were also located on the ventral and deeper part of the hair root. Histologically, sweat glands appeared both in the deep dermis and the superficial subcutaneous tissue (Fig. 5).

Among the breeds of dogs under study, maximum number of sweat glands was observed in the Dachshund and minimum in the Pug. Bell and Montagna (1972) reported that sweat glands were numerous in the digital pads of dogs and were surrounded by nerves. All the sweat glands observed in the ventral abdominal region in the eight breeds under study were of apocrine type. The duct of the apocrine sweat gland coursed parallel to the wall of the hair follicle, toward the epidermis and opened into the upper portion of the hair follicle above the opening of the sebaceous gland.

In the present study, the holocrine sebaceous glands were present in the dermis as large, lobulated, sac-like structures that were associated with the hair follicles (Fig. 6). Baker (1966) reported that the sebaceous and apocrine glands were of the simple type and were active at birth in dogs. In the present study, the sebaceous glands were most abundant in the skin of the Dachshund, while the Pug had the fewest. The Labrador Retriever had the largest sebaceous gland diameter, measuring 156.22±32.69 µm. The mean area of the

1. Dermis
2. Sweat gland
3. Sebaceous gland
4. Duct of sebaceous gland
5. Primary hair hair follicle
6. Secondary hair follicles

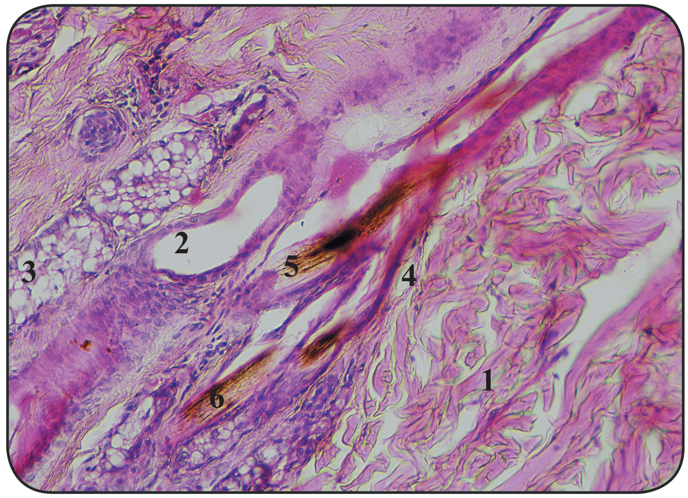

Fig. 6. Section of skin in the ventral abdomen region of Doberman Pinscher. H&E. x 200

sebaceous glands per hair follicle in dogs was reported to be 9600 µm^2 with a range of 800 µm^2 to 64000 µm^2 (Rojko *et al.,* 1978).

SUMMARY

The skin of ventral abdominal region of dogs showed breed-specific variations. Skin folds were prominent in Doberman Pinscher, German Shepherd, and indigenous dogs, while they were less evident in Beagle, Dachshund, Labrador Retriever and German Spitz, and nearly absent in Pugs. Skin thickness varied markedly across breeds, ranging from 0.97 mm in Beagle to 3.10 mm in Doberman Pinscher, with significant statistical differences. The epidermis was thickest in Dachshund and thinnest in Beagle. Dermal thickness was greatest in Doberman Pinscher and lowest in Beagle. A strong positive correlation was observed between dermal thickness and total skin thickness, while the epidermis showed a negative correlation with both dermis and total skin. All breeds displayed compound hair follicles. Hair type and density varied, with German Spitz showing the highest follicular density and Pugs, the lowest. Primary hairs were long and wavy in German Spitz and German Shepherd, but short and coarse in Doberman Pinscher, Pug and Beagle. The subcutaneous thickness was highest in Doberman Pinscher and lowest in Pug. This layer influenced skin flexibility and folding. Sweat glands were apocrine predominantly, with the Dachshund having the most and Pug the fewest numbers per microscopic feild. Sebaceous glands, associated with hair follicles, were abundant in Dachshund and least numerous in Pug, while Labrador Retriever showed the largest gland diameter.

Overall, the study highlighted significant inter-breed differences in skin architecture, thickness, adnexal structures, and subcutaneous tissue, suggesting that breed-specific morphological traits can influence its susceptibility to disorders and appropriate breed specific treatment regimens can be formulated.

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