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Histological studies on the dermis of different breeds of dogs#

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

[1]Department of Veterinary Anatomy, [2]Department of Epidemiology and Preventive Medicine, [3]Department of Animal Genetics and Breeding, College of Veterinary and Animal Sciences, Mannuthy, Thrissur- 680 651, Kerala Veterinary and Animal Sciences University, Pookode, Wayanad, Kerala, India

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Abstract

The skin serves as the primary defense organ against environmental factors and pathogens, maintaining structural and functional stability despite of continuous changes. This study provides insight into the histological differences in the dermis of seven dog breeds (German Shepherd, Labrador Retriever, Dachshund, Beagle, Doberman Pinscher, German Spitz and Pug) and indigenous dogs, which could aid clinicians in tailoring breed-specific treatment protocols. Histological studies were performed on skin samples collected from the ventral abdominal region of 48 dogs (six from each breed) using standard procedures. The dermis was composed of a thin papillary layer and a thick reticular layer. The papillary layer lacked dermal papillae and was composed of closely arranged fine collagen fibres intermingled with a few elastic and reticular fibres. The reticular layer displayed coarser, loosely interwoven collagen bundles, with the presence of elastic fibres around adnexal structures. The dermis was highly vascularised, with numerous capillary loops and displayed abundant fibroblasts, macrophages, mast cells and nerve endings. Micrometrical analysis revealed significant breed-specific differences in dermal thickness. The Labrador Retriever exhibited the thickest papillary layer (308.49 ± 42.27 µm), while the Doberman Pinscher had the thinnest (80.43 ± 2.87 µm). In contrast, the reticular layer was thickest in the Doberman Pinscher (2985.06 ± 114.26 µm) and thinnest in the Labrador Retriever (688.66 ± 73.68 µm). A negative correlation existed between the thickness of epidermis and dermis. Variations in dermal structure were breed-dependent, affecting the mechanical properties, flexibility and susceptibility to dermatological conditions. Distinct differences in the histological structure of the dermis across breeds, emphasises the importance of breed-specific approaches in veterinary dermatology.

Key words: *Skin, canine, dermis.*

Skin acts as a complex and dynamic barrier that protects against environmental insults, pathogens and mechanical injury. Skin plays a critical role not only in protection but also in thermoregulation, sensory reception and immunological functions. Its structural integrity is maintained through the coordinated interaction of various components, including the epidermis, dermis, and associated adnexal structures like hair follicles and glands. The thickness of skin was mainly contributed by the thickness of dermis in canines and felines (Affolter and Moore, 1994). The dermis, composed primarily of collagen and elastic fibers, provides tensile strength and elasticity to the skin and forms the foundation

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**Corresponding author: sumena@kvasu.ac.in; Ph. 9447614778*

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

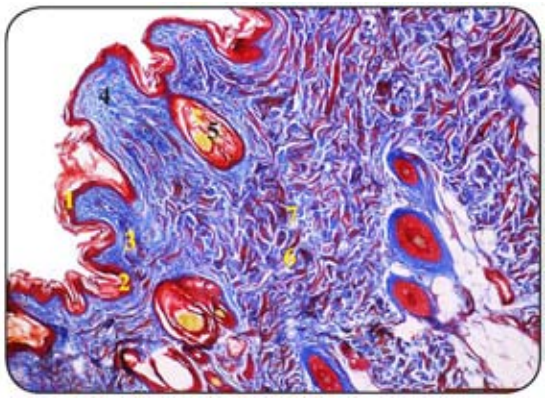


Fig. 1. Section of skin in the ventral abdomen region of Dachshund. Masson's trichrome method x 100

for cutaneous appendages and vascular networks. Understanding the detailed histological architecture of the skin, particularly the dermis, is essential for veterinarians and clinicians to develop tailored diagnostic and therapeutic strategies. This study aimed to investigate the histological differences in the dermis of different breeds of dogs, which will offer valuable insights into breed-specific treatment approaches for dermatological conditions, enhancing the clinical management of canines.

Materials and methods

The study was conducted on the skin samples collected from 48 adult dogs that were brought for postmortem examinations and also from the dogs brought for elective surgical procedures (collected during routine surgical wound closures as trimmed and removed skin pieces). The dogs included six animals each from indigenous and seven breeds *viz.,* German Shepherd, Labrador Retriever, Dachshund, Beagle, Doberman Pinscher, German Spitz and Pug. Skin samples were collected from the ventral abdominal region of animals and processed as per standard procedures. Samples were fixed in 10 per cent neutral buffered formalin and 10 per cent formol alcohol, processed and 4-5 µm thick sections were cut for histological examination. The sections were stained using Hematoxylin and eosin, Gomori's aldehyde fuchsin method, Masson's trichrome method and Ayoub-Shklar method (Luna, 1968). Gridley's modification of silver impregnation method for reticular fibres (Sheehan and Hrapchak, 1980) and Toluidine blue method for mast cells (Singh and Sulochana, 1996) were also carried out.

The thickness of the dermal layers (papillary and reticular) was measured using a calibrated ocular micrometer. Data were analysed statistically using SPSS version 24.0.

Results and discussion

The histological examination of the dermis across the seven dog breeds and indigenous dogs revealed significant differences in dermal thickness, fibre composition and structural organisation. The dermis consisted of two primary layers, a superficial papillary layer composed of fine collagen fibres and a deeper reticular layer containing thicker, coarser collagen bundles (Fig. 1). Similar observations were reported by Mohammed *et al.* (2022) in dogs and other six domestic animal species. These layers varied in thickness and composition among the breeds, with notable breed-specific characteristics.

Thickness of dermis

The overall thickness of the dermis ranged from 947.00 ± 53.66 µm in the Beagle to 3070.48 ± 114.73 µm in the Doberman Pinscher. The indigenous dogs exhibited a dermal thickness of 1675.51 ± 54.17 µm, which was comparable to mongrel dogs reported by Rojko *et al.* (1978). A significant negative correlation was observed between the thickness of the epidermis and dermis across all breeds, suggesting that as epidermal thickness increased, dermal thickness decreased. This inverse relationship was in compliance with findings in human skin, where the dermis was reported to be 15-40 times thicker than the epidermis (Barbieri *et al.,* 2014).

Papillary layer

The papillary layer was composed of closely arranged fine collagen fibres with a few elastic and reticular fibres intermingled (Figs. 2 & 3). The papillary dermis lacked dermal papillae, which was consistent with earlier report in dogs (Schwarz *et al.,* 1979). Instead, this layer protruded into the epidermis, contributing to the formation of skin folds.

The micrometrical parameters of the papillary and reticular layers of the dermis are presented in table 1, which revealed significant differences in the thickness of the papillary and reticular layers among the different breeds. The Labrador Retriever exhibited the thickest papillary layer (308.49 ± 42.27 µm), whereas the Doberman Pinscher had the thinnest (80.43 ± 2.87 µm). These differences were statistically significant, as indicated by the P-values (<0.001), confirming breed-specific variations in dermal thickness.

1. Reticular dermis
2. Collagen fibres
3. L.S. of hair follicle
4. L.S. of sweat gland
5. Elastic fibres

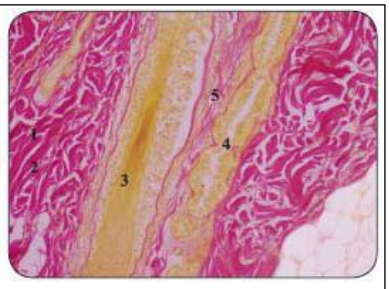


Fig. 2. Section of skin in the ventral abdomen region of Doberman Pinscher. Gomori's aldehyde fuchsin method x 200

1. Dermis
2. Reticular fibres
3. Hair follicle

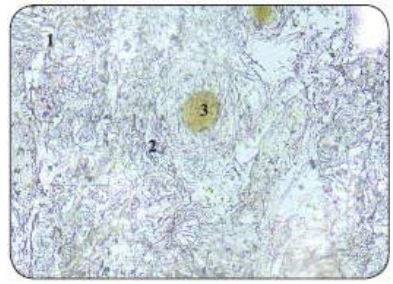


Fig. 3. Section of dermis in the ventral abdomen region of Doberman Pinscher. Gridley's modification of silver impregnation method for reticular fibres

Table 1. Micrometrical parameters of the layers of dermis in different breeds of dogs, µm

Breed	Papillary layer (Mean ±SE)	Reticular layer (Mean ±SE)
Beagle	167.12 ^{a,b} ±22.62	770.54 ^{e} ±61.21
Dachshund	276.84 ^{a,b} ±49.88	961.47 ^{d,e} ±68.25
Doberman Pinscher	80.43 ^{b} ±2.87	2985.06 ^{a} ±114.26
German Spitz	113.03 ^{a} ±6.42	939.35 ^{d,e} ±37.25
Labrador Retriever	308.49 ^{a} ±42.27	688.66 ^{e} ±73.68
German Shepherd	152.85 ^{a} ±11.33	1074.77 ^{e} ±13.54
Pug	254.01 ^{a,b} ±48.36	1677.01 ^{b} ±56.36
Indigenous	191.37±17.67^{a}	1464.57±62.56^{c}
F value	6.825	127.363
P value	<0.001	<0.001

Means having same superscript are not significantly different at 0.05 level.

Fibroblasts and macrophages were the predominant cell types in the papillary layer (Fig. 4), as reported in other mammals (Barbieri *et al.,* 2014). The presence of mast cells was confirmed through toluidine blue staining (Fig. 5), with an average of 4 to 12 mast cells per high-power field, in line with findings by Affolter and Moore (1994). Additionally, rich capillary networks were observed, particularly in the papillary dermis, contributing to the vascularity and immune response of skin.

Reticular layer

The reticular layer exhibited significant breed-specific differences, both in thickness and fibre arrangement (Table. 1). The Doberman Pinscher had the thickest reticular dermis (2985.06 ± 114.26 µm), while the Labrador Retriever had the thinnest (688.66 ± 73.68 µm). The ratio of reticular to papillary layer thickness was highest in the Doberman Pinscher (37.12 times) and lowest in the Beagle and Dachshund (2.25 to 4 times), indicating a more robust reticular dermis in certain breeds.

The reticular layer consisted of loosely interwoven bundles of coarse collagen fibres. These fibres were primarily arranged parallel to the skin surface but became thinner and oriented perpendicularly towards the deeper layers, extending into the subcutis. The arrangement of collagen fibres provided mechanical strength and flexibility, particularly around structures like hair follicles, sweat glands and sebaceous glands. Elastic fibres were intermingled with the collagen bundles, forming a thick network around these adnexal structures, supporting the skin's ability to stretch and return to its original shape. Reticular fibres were also seen surrounding the sweat and sebaceous glands.

As the dermis merged into the subcutaneous tissue, collagen bundles became smaller and less distinct, with lymphatic vessels draining towards the subcutaneous layer. Blood vessels, nerves and lymphatics traversed the reticular layer, with medium-sized arteries predominating in this region (Fig. 6). Numerous glomi were observed, particularly in the deeper regions, contributing to blood flow regulation and thermoregulation.

1. Desquamating layer
2. Stratum corneum
3. Stratum granulosum
4. Stratum basalis
5. Clear cells
6. Paillary dermis
7. Blood vessels
8. Lymphocytes
9. Fibroblasts

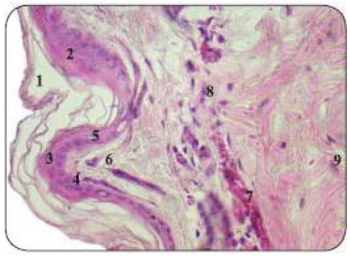


Fig. 4. Section of skin in the ventral abdomen region showing the layers of skin of German Spitz. H&E. x 200

1. Mast cell
2. Fibroblast
3. Lymphocyte
4. Reticular fibres

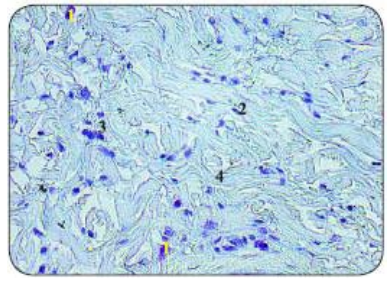
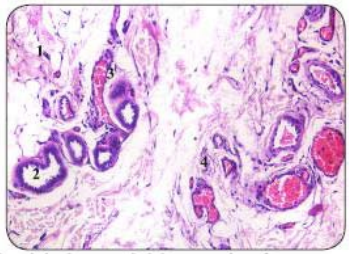


Fig. 5. Section of dermis in the ventral abdomen region of Indigenous dog showing the mast cell. Toludine blue method. x 400



1. Reticular dermis
2. Sweat glands
3. Blood vessels
4. Nerve bundle

Fig. 6. Section of dermis in the ventral abdomen region of Indigenous dog. H&E. x 200

Cellular density in the reticular layer was lower compared to the papillary layer. Fibroblasts, macrophages, mast cells and extravasated leukocytes were frequently present (Fig. 4), playing a role in immune responses and maintaining tissue integrity. Additionally, cutaneous muscle bundles and nerve fibers were detected in the deeper regions, indicating a complex interaction between the skin and its underlying structures. Sweat glands were abundant throughout the reticular layer, with the highest concentration in the deeper dermis. Sebaceous glands, located near the hair follicles in the upper reticular dermis, contributed to the maintenance of skin hydration and barrier function. PAS-positive areas were detected around dermal appendages and blood vessels, suggesting the presence of glycosaminoglycans and other carbohydrates that contribute to the hydration and resilience of skin.

Breed-specific variations were evident in the thickness of the dermal layers. For example, in the German Spitz and Pug, the reticular layer was 6 to 7.5 times thicker than the papillary layer, while in breeds like the Beagle and Labrador Retriever, the reticular layer was only two to four times thicker. These differences may be related to the functional demands placed on the skin by breed-specific activities, body conformation and environmental adaptation.

The presence of arteriovenous anastomoses, known as glomus bodies, was also observed in the deeper reticular dermis. These specialised structures contributed to blood flow regulation and temperature control, which contributed to the thermoregulatory efficiency between breeds (Pavletic, 1991).

The significant breed-specific differences in dermal structure highlight the need for tailored dermatological treatment protocols. Thicker reticular layers, as seen in the Doberman Pinscher, may provide greater resistance to mechanical trauma, while thinner dermal layers, as in the Beagle, may make these breeds more susceptible to skin injuries and infections. Additionally, the variations in collagen and elastic fibre arrangement may influence the progression of skin disorders, such as atopic dermatitis, across different breeds. The study underscores the importance of understanding dermal histology in breed-specific clinical diagnosis and treatment, offering a foundation for more personalised veterinary care.

Conclusion

The present study investigated the histological structure of the dermis in seven dog breeds and indigenous dogs. Skin samples from 48 dogs were examined (six in each breed), revealing the presence of a thin papillary layer and a thick reticular layer in the dermis. The thickness of the dermis varied across breeds, with the Doberman Pinscher having the thickest and the Beagle the thinnest dermis. Histologically, the papillary layer was characterised by closely arranged fine collagen fibers, elastic and reticular fibers, with the absence of dermal papillae. The reticular layer consisted of coarser collagen bundles, especially around hair follicles and glands. The dermis was highly vascularized, with abundant fibroblasts, macrophages and nerve endings present in both layers. These variations in skin structure and composition across breeds may contribute to differences in skin function and susceptibility to dermatological disorders. These findings provide a foundation for developing breed-specific treatment protocols for dermatological conditions.

Acknowledgement

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Conflict of interest

The authors declare that they have no conflict of interest.

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