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MICROMORPHOLOGY OF THE SKIN (EPIDERMIS, DERMIS, SUBCUTIS) OF THE DOG

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ABSTRACT

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Grossly, the skin of the dog is characterized by varying thicknesses, density of the hair coat and the implantation angle of the hairs. Multiple folds varying in shape are formed by the epidermis and the papillary layer of the corium. The epidermis consists of a stratum profundum with a continuous layer of basal cells, a stratum spinosum consisting of 3–6 cell layers, a stratum superficiale with single granulosa and "lucidum" cells and a well-developed stratum corneum. The corium shows a narrow stratum papillare corii containing delicate fibres and a broad stratum reticulare corii with mainly coarse fibre bundles. The subcutis is divided into adipose and fibrous layers. The broad adipose layer displays breed and individual differences which vary with the region of the body. The fibrous layer corresponds to the connective tissue layer, formerly described as fascia trunci superficialis. The morphological and functional unity of the corium and subcutis is discussed.

Résumé

MICROMORPHOLOGIE DE LA PEAU DU CHIEN, INCLUANT L'ÉPIDERME, LE DERME ET LE TISSU SOUS-CUTANÉ

En gros, la peau du chien est caractérisée par des épaisseurs variables, par la densité de la fourrure et par l'angle d'implantation des poils. Des replis multiples de forme variable sont formés par l'épiderme et la couche papillaire du corium. L'épiderme est constitué par un stratum profundum avec une couche continue de cellules basales, un stratum spinosum consistant en 3 à 6 couches de cellules, un stratum superficiale avec des cellules granulosa et "lucidum" isolées, et un stratum corneum bien développé. Le corium montre un stratum papillare corii étroit et contenant des fibres fines, et un large stratum reticulare corii avec des faisceaux de fibres grossières pour la plupart. Le tissu sous-cutané se divise en couches adipeuse et fibreuse. La large couche adipeuse montre des différences qui tiennent à la race et, chez l'individu, à la région du corps. La couche fibreuse correspond à la couche de tissu conjonctif précèdemment décrite sous le nom de fascia trunci superficialis. On discute l'unité morphologique et fonctionnelle du corium et du tissu sous-cutané.

INTRODUCTION AND LITERATURE

Embryologically, the layers of the skin are derived from the ectoderm, which gives rise to the epidermis and its specific parts, and the mesoderm, which forms the corium and subcutis. This principle also applies to the dog, except that the dog has special features which are not present in other carnivores. The customary description of the common integument of domestic mammals, therefore, does not necessarily apply to the dog.

In the present study the specific structure of the skin layers and their demarcation are described. It requires no particular magnification to see that the thickness of the dog's skin varies with the breed, the individual and the region of the body. The skin of the head, neck and back, for example, is thicker than that of the abdominal, axillary and inguinal regions (Stoss, 1906; Siegel, 1907; Claushen, 1932; Webb & Calhoun, 1954; Creed, 1958; Adam, Calhoun, Smith & Stinson, 1970; Kristensen, 1976). The well-defined fold relief of the dog's skin was pointed out by Toldt (1908).

Reports on the number and thicknesses of the epidermal cell layers vary considerably and are sometimes contradictory (Hildebrand, 1952; Webb & Calhoun, 1954; Lovell & Getty, 1957; Baker, 1966; Kristensen, 1976). Because of the morphological and functional relationship between basal and spinous layers, Webb & Calhoun (1954) suggest that both layers should be regarded as the stratum profundum or germinativum. The layers belonging to the stratum superficiale, namely, the stratum granulosum and the stratum lucidum, are poorly developed, their extent being dependent on the degree of keratinization of the epidermis (Lovell & Getty, 1957).

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In the corium difficulty is experienced in demarcating the papillary and reticular layers. The criteria for differentiation could be the arrangement and fineness of the collagen fibres, differences in the elastic fibre content and the variable distribution of cells and capillary plexuses in both layers (Neurand & Schwarz, 1969).

The subcutis is generally regarded as a continuous connective tissue layer below the skin but not directly belonging to the skin as such. Exact descriptions of its delimitation from the corium, however, are lacking. The adipose and fibrous layers of the subcutis in the cat were described for the first time by Neurand & Schwarz (1969), and a comparable subdivision will be attempted in the dog in this report.

MATERIALS AND METHODS

Skin specimens of the summer and winter coats of German shepherd, poodle and dachshund breeds of different ages were collected from the cranial, middle and caudal regions of the neck, the lateral body wall, the abdominal and scapulohumeral regions and the caudal part of the thigh. The specimens were collected immediately after the animals had been killed and were fixed in formalin or Bouin's solution and in gluteraldehyde and osmium tetroxide. After paraplast embedding, 5–7 μm thick sections were cut at various planes and stained with haemalum-eosin, according to Romeis (1968), Masson's trichrome stain, Weigert's resorcin fuchsin, PAS-reaction, Unna's polychrome methylene blue and Gomori's silver impregnation. Preview sections were cut from epon-embedded specimens and stained according to the method of Morgenstern (1969). For a general outline of the skin, fresh and fixed specimens unstained and treated with methylene blue were examined under a stereomicroscope. Microphotographs were taken with a photomicroscope fitted with differential interference contrast adjustment.

Results

In the regions examined, the skin was characterized grossly by the varying thickness and density of the hair coat and the implantation angle of the hair. The skin is relatively thicker over the neck and back and diminishes gradually along the sides of the neck and shoulder regions towards the lateral body wall and abdomen. The density of the hair coat depends on the number of hairs and satellite hairs in a hair bundle. The implantation of hair along the back is obtuse-angled and, along the lateral body wall, relatively acute-angled.

Skin folds relief

Numerous skin folds are observed on surface view (Fig. 1, 2, 3) and in sagittal and oblique sections (Fig. 4, 5, 6). These vary in shape but are not particularly high or large, and are covered with hair. They are coarse along the back (Fig. 1), delicate on the abdomen, with secondary folds which give them a wavy appearance (Fig. 3). Both types occur along the lateral body wall (Fig. 2) and in the shoulder region. The epidermis and the papillary layer of the corium participate in the formation of the folds (Fig. 4), while, depending on their height, the reticular layer of the corium is involved only to a very limited degree (Fig. 7, 8). Differences in breed and individual and regional variations make it impossible to determine with any consistency the number, size and shape of the skin folds. The multiplicity of the folding relief also influences the form of the epidermis so that in the description of the latter the features on the apex and base of the folds have to be considered.

FIG. 1 Dog. Skin of the back showing surface relief with coarse folds. Surface view. ×30
FIG. 2 Dog. Skin of the lateral body wall showing surface relief with skin folds. Surface view. ×30
FIG. 3 Dog. Skin of the abdomen showing surface relief with delicate folds and secondary folds. Surface view. ×30

FIG. 4 Dog. Skin of the back showing surface relief with folds. Sagittal section. a, epidermis; b, corium; c, hair canal with hair. ×130
FIG. 5 Dog. Skin of the lateral body wall showing surface relief with folds. Sagittal section. a, epidermis; b, corium; c, hair canal with hair. ×130
FIG. 6 Dog. Skin of the abdomen showing surface relief with folds. Sagittal section. a, epidermis; b, corium; c, hair canal with hair. ×130

Epidermis

The form and structure of the epithelial cells in the individual cell layers of the epidermis correspond only to a limited degree to the features of squamous stratified keratinized epithelium. Over the apices of the skin folds the single layers are comparatively clearly recognizable. Along the sides and especially at the base of the folds the epidermis is thin and the layers indistinct.

(a) *Stratum profundum (germinativum)*

The deep layer (Fig. 7, 8b & 9c) consists of a continuous layer of basal cells (str. basale) and 3–6 layers of spinous cells (str. spinosum). The basal cells are isoprismatic, pearshaped to triangular, or slightly flattened. The basal surface is provided with cytoplasmic processes, the free ends of which may be subdivided. They are usually absent in regions devoid of folds or between folds. Here the basal surfaces appear wavy. The opposing surfaces of the basal cells are either smooth or interdigitated, or they show intercellular bridges. Towards the spinous layer the cell surfaces are rendered coarse by small cytoplasmic processes which form intercellular bridges with corresponding processes of the spinous cells. The nucleus is round to oval in shape, clearly demarcated from the homogeneous acidophylic cytoplasm and poor in chromatin. Usually only 1 nucleus is present. In pigmented skin the pigment is concentrated mainly in the apical part of the cell.

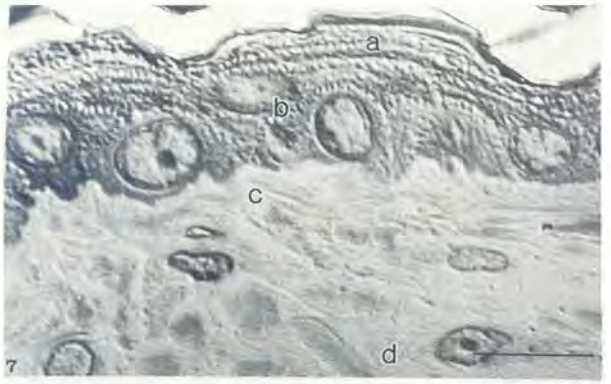

FIG. 7 Dog. Skin. Preview sagittal section. a, epidermis (str. superficiale); b, epidermis (str. profundum); c, corium (str. papillare); d, corium (str. reticulare). ×2 400

FIG. 8 Dog. Skin. Preview sagittal section. a, epidermis (str. superficiale); b, epidermis (str. profundum); c, corium (str. papillare). ×2 400

The cells belonging to the spinous layer are seen to be markedly flattened in sagittal and oblique sections. The long axis of these spindle-shaped cells is parallel to the surface of the epidermis. The largest diameter is in the region of the nucleus and tapers towards the periphery. Overlapping of the flattened peripheral parts of the cells renders identification of single cell layers difficult. The spinous cells are connected by delicate intercellular bridges. The intercellular spaces are narrow. The cytoplasm is less acidophylic than the basal cells. Pigment granules are present in regions of pigmented skin. The oval nucleus is poor in chromatin and has 1–2 nucleoli.

FIG. 9 Dog. Skin. Preview sagittal section. a, epidermis (str. corneum disjunctum); b, epidermis (str. superficiale) with str. corneum conjunctum (black); c, epidermis (str. profundum); d, corium (str. papillare); e, corium (str. reticulare). ×2 000

(b) *Stratum superficiale*

The cells following on the spinous layer may belong to different layers depending on the keratinization and thickness of the epidermis, since no closed continuous layers, apart from the cornified layer, exist any more. These cells are classified therefore as belonging to the superficial layer (Fig. 7, 8a; 9b).

A continuous stratum granulosum does not exist in the epidermis of the dog. The single granular cells present are even more flattened than the spinous cells and taper towards the ends. The cytoplasm is weakly acidophylic and is filled with fine granules staining darkly with HE. The nucleus is rod-shaped, with a well-defined nucleolus. The cells tend to be more rhomboid in shape at the base of the skin folds.

A stratum lucidum is not demonstrable. Single, flattened, apparently homogeneous cells, which can be differentiated by their refractiveness from neighbouring cells, can possibly be regarded as belonging to stratum lucidum cells.

The stratum corneum consists of several intimately connected cell layers—str. corneum conjunctum [Fig. 9b (black)]. The deeper layers have direct contact with granular and some lucid cells. Further layers of keratinized cells—str. corneum disjunctum (Fig. 9a)—are loosely attached to the integument of the dog, are connected to each other and to the firmly united cells of the corneum by means of very small, dot-like contact areas. These apparently desquamating cell layers are thicker than the combined remaining epidermal layers. Spaces of varying size, either empty or containing a weak acidophylic homogeneous

substance, are present between the desquamating layers. The essential cell characteristics are not easily recognizable and are even absent in the element of the corneum. The keratinized cells are evenly thread-like in nature, strongly refractive, and intensely acidophylic. Single pyknotic nuclear rests are present.

Corium

The connective tissue part of the integument is divided into the narrow stratum papillare corii and the much broader stratum reticulare corii. The former participates in the formation of the skin folds, the latter only to a slight degree.

(a) *Stratum papillare corii*

The papillae which characterize this layer of the corium are mostly absent in the dog. In some breeds, for example, in the German shepherd dog, papilliform structures can be recognized at the transition of corium and epidermis. But even in these cases a coherent papillary body is absent. The papillary layer of the corium (Fig. 7, 8c & 9d), which is usually not much broader than the epidermis, consists partly of reticular and elastic fibres, but mostly of delicate collagen fibres which are arranged in different planes. In the skin folds the connective tissue fibres are arranged more loosely. They appear wavy and are mainly perpendicular to the skin surface. The nuclei of the fibrocytes are round, oval or rod-like, depending on the plane of section. There are few wandering cells. Single histiocytes, lymphocytes, mast cells and plasma cells are present in the dense connective tissue which is poor in ground substance.

(b) *Stratum reticulare corii*

The reticular layer (Fig. 7d & 9e) joins the papillary layer without any clear demarcation. However, the 2 layers can be distinguished easily by the difference in size, arrangement and density of the fibres. The measurement of the collagen fibre bundles in the reticular layer exceeds the total width of the papillary layer in places. Towards the subcutis the density and size of the fibre bundles increase. Densely arranged fibre bundles form the connective tissue basis of the hair follicle walls. The intercellular spaces between the coarse collagen fibre bundles are filled with ground substance and some delicate collagen, reticular and elastic fibres. In addition, mast cells, lymphocytes and plasma cells are present in abundance. Blood vessels are concentrated in the upper part of the reticular layer while, a 2nd vascular layer is present in its lower 3rd or below the sebaceous glands. The lymph vessels contain many valves.

Subcutis

The subcutis of the dog, like that of the cat, consists of adipose and fibrous layers (Neurand & Schwarz, 1969). The junction between corium and subcutis runs in a wave-like fashion, the waves being high and narrow but not uniformly spaced. Along the lateral body wall they are arranged obliquely to the skin surface, but mainly perpendicularly along the back and abdomen. Hair follicles project into these areas.

(*a*) *Stratum adiposum subcutis*

The adipose layer lies directly against the reticular layer of the corium. In horizontal sections the adipose tissue is seen to be divided into polygonal compartments by connective tissue septae. They vary in size and contain mainly fat cells but also sections of hair follicles, tubular glands and collagen fibre bundles. The spaces between the wave-like projections of the adipose layer are filled with connective tissue of the reticular layer of the corium, the latter being directly continuous with the connective tissue septae of the adipose layer. These strong connecting fibre bundles carry blood vessels and nerves. In lean subjects the adipose layer is markedly reduced and the connective tissue appears more clearly as networks. The fat cells are polygonal in shape and are surrounded by delicate reticular fibres. Small capillaries are present between the fat cells. Towards the fibrous layer of the subcutis larger blood vessels and nerves are present.

(*b*) *Stratum fibrosum subcutis*

The fibrous layer of the subcutis is narrow and rich in closely arranged fibres, but poor in ground substance. The collagen fibre bundles run mainly parallel to the skin surface, but in various directions. Adipose tissue is absent in this layer, but single fat cells may occur in the vicinity of blood vessels. In the region of the head, neck and trunk, cutaneous muscle is connected to the fibre bundles. Relatively large blood vessels surrounded by loose connective tissue are present at the transition to the adipose layer as well as towards the fascia of the trunk.

Discussion

The thickness of the skin depends upon the breed, the individual and the region of the body. The degree of fat deposition may have a considerable influence on the thickness of the skin. Since functional and structural changes of the skin depend on the growth cycle of the hair, the cyclic phases of hair growth may have an influence on the thickness of the skin (Westendorf, 1974). The deposition and resorption of fat in the subcutis are other factors which play a role in temperature regulation. The reciprocal influence of both factors on temperature regulation remains an open question. The relief of the skin folds renders accurate measurement of the skin thickness most difficult. Hiertel (1916) describes the surface pattern of the integument in the dog as resembling rows of roof tiles overlapping each other. Hildebrand (1952) considers the folding relief as having a typical pattern for all Canidae. The thickness of the epidermis can be correlated with the cell layers which form it (Horstmann, 1957). However, the present study proved that the diminishing of the epidermal thickness is not always at the expense of cell layers. The cells are markedly flattened, elongated and overlapping. Consequently, the stratification of the narrow canine epidermis is difficult to determine and contradictory reports have been published. Baker (1966), for example, described a 2–4 layered epidermis and Lovell & Getty (1957) observed 3–6 layers. The granular and lucid layers are not taken into account because of their incompleteness or absence as continuous layers (Hildebrand, 1952). The granular layer, which is present in man as a continuous layer (Horstmann, 1957), is formed incompletely in domestic mammals (Gouldsberry & Calhoun, 1959; Neurand & Schwarz, 1969). The findings of Lovell & Getty (1957), that the granular and lucid layers are present in areas of delayed keratinization, could not be confirmed. The corneum is striking for its pars disjuncta containing wide intercellular spaces.

The division of the canine epidermis into deep and superficial layers, as described by Webb & Calhoun (1954), is undoubtedly consistent with the morphological and functional situation. The form of the basal cells in the profundum conforms to the adaptation of the epidermis in different body regions. The

thicker the epidermis, the better the unfolding of the layers of the profundum, and the more prismatic the tendency of the basal cells. They are seldom high prismatic. The impression that basal cells are high prismatic is caused by the presence of the long basal cytoplasmic processes. The thickness of the epidermis also determines the shape of the spinous cells and the cells of the superficial layer, especially the degree of flattening. In the comparatively thin epidermis of the dog, the spinous cells have mostly lost their polygonal shape and tend to be flattened and arranged with the long axis parallel to the skin surface.

It is possible to distinguish morphologically between the connective tissue of the papillary and reticular layers of the corium. Differentiation is also possible on the measurement of the collagen fibre bundles, the cellular content and the distribution of blood vessels. Owing to the nature and consistency of the tissue in the border area between the papillary and reticular layers, this area is subjected to artefacts during histological preparation. The thin epidermis does not place special demands on the subepidermal connective tissue in regard to mechanical junction and transport of metabolites. Accordingly, the papillary body of the corium is reduced to the minimum or is absent, and vascularization is poor. The entire corium participates in the formation of the surface relief of the skin. Creed (1958) reports that there are more elastic fibres in the subepidermal layer than in the reticular layer. The dense, network-like arrangement of the fibres in the papillary layer corresponds in the main to that found in organ capsules. This also holds good for the reticular layer with its well-developed fibre bundles. Horstmann (1957) ascribes mainly mechanical properties to the reticular layer. This broad layer of the corium contributes very little indeed to the surface relief, but does contribute indirectly as a sliding layer to the formation of skin folds. The superficial part of the reticular layer contains an extensive capillary network which extends into the papillary layer. The vascularization of the skin is discussed by Hackländer (1972).

The subcutis of the dog, like that of the cat (Neurand & Schwarz, 1969), can also be divided into adipose and fibrous layers. The development of this layer and the degree of fat deposition depend on the breed, the individual, the region of the body and the nutritional condition of the animal. The adipose layer is continued as the fibrous layer which is devoid of fat cells and which corresponds to what was formerly known as the superficial fascia of the trunk. The arrangement of the fibres and the distribution of the blood vessels in this relatively thin connective tissue layer are consistent with a sliding layer (Cunningham, 1909; Lang, 1960, 1962; Zuckerman, 1961; Frewein, 1967). The fibrous layer of the subcutis represents the direct connection with the fascia of the trunk.

The wave-like area demarcating corium and subcutis represents an interdigitation between these 2 layers. Stratification of the different connective tissue types—closely knitted connective tissue and adipose tissue—facilitates the determination of the transition between corium and subcutis. Strong connective tissue bundles belonging to both corium and subcutis firmly connect these 2 layers. Form and function are manifested in the unity of corium and subcutis. Hair follicles projecting into the subcutis as well as the presence of cutaneous glands (Neurand, 1974) and cutaneous muscle contradict the usual view that the subcutis is an independent layer below the skin.

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