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Pre- and Post-natal Development of Skin Characteristics in the One-humped Camel (*Camelus dromedarius*)

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Abstract: In a studied camel the epidermis began to appear as a single row of cells in 90 days, and both epidermis and dermis were fully developed in 147 days of foetal life when the epidermis was differentiated into its four strata (corneum, granulosum, spinosum and basale or germinativum). The dermis was differentiated into papillary and reticular sub-layers. The plugs which would form the hair follicle began to appear in 147 days, while the hair fibres began to appear in its follicles in 268 days of foetal life. The follicles were clearly differentiated into primary and secondary follicles at 286 days of foetal life. The hair follicles were arranged in groups and were clearly seen at 275 days of foetal life. Each group consisted of three primary follicles and several secondary follicles. The thickest secondary follicles (ear secondary follicles) were situated near the primaries, while the thinner secondaries (late secondary follicles) were found far from the primary follicles). The thickest secondary follicles (early secondary follicles) were situated near the primaries, while the thinner secondaries (late secondary follicles) were found far from the primaries. The primary follicle was associated with a sebaceous gland, a sweat gland and an arrector pili muscle, while each secondary follicle was associated only with a sebaceous gland. The sebaceous glands that were attached to the primary follicles had large lobules, while those attached to the secondaries were smaller. Several lobules of the sebaceous glands opened into a common short excretory duct. The sebaceous glands began to appear at 229 days of foetal life. The apocrine sweat gland was formed of a glandular tortuous part and its uppermost straight duct passed between or beside the sebaceous gland lobules, then enlarged in a sac before it opened near the follicle opening at the skin surface. The tortuous glandular distal part was situated either at or lower than the level of the hair follicle bulb and was formed of one layer of cuboidal epithelium. The sweat glands began to appear at 147 days of foetal life. The arrector pili muscle was formed of smooth muscle fibres. It ran from the lower part of the follicle to the area below the epidermis. The arrector pili muscles first appeared at 229 days of foetal life.

Key words: One-humped camel, pre- and post-natal development, skin histological structure, body regions.

The specific ability of the camel to regulate its body temperature under severe environmental conditions in the desert attracted the attention to study the development and histological structure of its skin. The objectives of the present investigation were to study pre- and post-natal development of histological structure of the one-humped camel (*Camelus dromedarius*) in its different body regions.

Table 1. Ages of camel foetei estimated according to El-Wishy et al. (1981)

No. of foetei	CVR (cm)	Estimated age from CVR(days)
4	6.50±1.33	90±4
4	11.75±1.25	106±4
4	25.50±1.75	147±5
4	34.25±1.75	174±5
4	44.75±1.31	204±4
4	53.00±1.31	229±3
4	66.25±1.37	268±4
4	74.75±1.65	293±5
4	85.25±1.25	325±4
4	102.25±4.26	375±12

Materials and Methods

The study was conducted in the Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. Forty unsexed camel foetei at different ages and from 4 animals at ages of one and two years, were used in the present study (Table 1). The camels foetei crown rump lengths passing on vertex (CVR) were measured to the nearest millimetre by means of a measuring tape. They were classified into 9 groups according to the CVR length. Their ages in days (x) were estimated (Table 1) according to the equation x = (CVR + 23.99) / 0.336, as suggested by EI-Wishy *et al.* (1981).

Fresh skin samples of camel were taken from 4 regions of the body. These regions were shoulder, hump, mid-side and flank. Skin samples were fixed in 10% formol saline for 24 h. Dehydration was accomplished by transferring the samples into 50, 60, 70 and 90% alcohol, followed by three changes of absolute alcohol. Clearing was achieved by two changes of methyl benzoate of 3 h each, followed by two changes of Benzol of 3 h each. Embedding in paraffin wax was carried out at 58°C. Horizontal and vertical sections were made by the use of a rotary microtome at a thickness of 5-7 microns. Some sections were stained by heamatoxylin and counter-stained by eosin and others were stained by Crossman's trichrome. Sections representing the different structures were photographed by a camera attached to a microscope.

Thickness of epidermis and dermis of skin were measured in vertical sections by an eyepiece micrometer. Follicle population counts were estimated using a normal microscope (Burns, 1949, 1953). The S/P ratio was determined by counting the number of primary and secondary follicles in the complete bundles per 10 fields. Follicle density per mm^2 of skin was counted (Clark, 1960). The diameter of follicles was measured by using eyepiece micrometer. All counts and measurements were estimated at the level of the sebaceous glands.

The data were statistically analysed. Analysis of variance was carried out according to Snedecor and Cochran (1980).

Duncan's new multiple range test (Duncan, 1955) was used for multiple comparisons.

Results

Histological structure of the skin

Skin of the camel was formed of 2 main layers: epidermis and dermis, similar to that of the other farm animals such as sheep, cattle and buffaloes. The epidermis was further divided into 4 strata: stratum corneum, stratum granulosum, stratum spinosum and stratum basale (germinativum). The dermal layer, which is principally a connective tissue, was composed of the papillary and the reticular sub-layers. The hypodermis structure was clearly seen in the mid-side position than in the other regions of the body. Average thickness of the epidermis at 2 years of age was 0.73 mm. The skin thickness was 3.57 mm in camels at 2 years of age.

The hair follicles were arranged in groups. Each group consisted of 3 primary follicles (1 big central and 2 smaller laterals) and several secondary follicles on the ectal side of the primary follicles. The primary follicle was associated with a sebaceous gland, a sweat gland and an arrector pili muscle, while each secondary follicle was associated with a sebaceous gland only. The thickest secondary follicles (early secondaries) were situated near the primaries, while the more thin secondaries (late ones) were far from the primaries. The number of hair follicles per mm^2 found in the camel at 2 years of age was 34.7.

The sebaceous glands in the camel were simple or branched alveolar of holocrine type with several large lobules attached to the primary follicles and with more small ones attached to the secondaries. The lobules of each gland opened into a common short excretory duct connected to the follicle at the inner end of its external third. The sebaceous gland secretory part in camel was composed of cuboidal cells that filled the whole alveolus.

The sweat glands were of apocrine nature and were formed of a tortuous glandular part. The uppermost straight narrow ducts passed between or beside the sebaceous gland lobules, then each duct was enlarged in a sac before it opened near the follicle opening at the skin surface. The tortuous glandular distal part was situated either at or lower than the level of the hair follicle bulb and was formed of one layer of cuboidal epithelium, while the duct was lined by 2 layers of cuboidal epithelium.The camle's arrector pili muscle was formed of two or there fascicles of smooth muscle fibres.

The comparison between the regions of the body showed that the hump surpassed the other regions of the body in thickness of epidermis, dermis and skin density and external diameter of primary and secondary follicles and their averages, as well as the internal diameter of each of the secondary hair follicles and their averages. Shoulder region showed the highest S/P ratio and the flank showed the highest dp/ds and $\overline{dp}/\overline{ds}$ ratios. This was generally true in the pre- and post-natal stages.

The advancement of age resulted in highly significant ($P<0.01$) increase in each of the traits studied, except the density of primary hair follicles, number of total hair follicles and dp/ds and $\overline{dp}/\overline{ds}$ ratios which decreased significantly ($P<0.01$). The studied traits showed similar trends in pre- and post-natal stages. Statistically, age

effects were highly significant (P<0.0l) and body region effects were mostly significant (P<0.01 or 0.05) on the traits studied. The interactions between body region and age effects on most of the traits studied were significant (P<0.01 or 0.05), indicating differences in the trends.

Development of hair follicles

Regarding development of the skin structures, the first layer of skin, i.e., epidermis, began to appear in the camel foetus (foetal life is 375 days) as a single row of cuboidal cells. Then two rows of cells were developed at 90 days of foetal life. At 147 days of foetal life, the epidermis was fully developed and differentiated into its 4 strata, i.e., stratum corneum, stratum granulosum, stratum spinosum and stratum basale (germinativum).

The dermis appeared as a loose connective tissue with some blood vessels, and was formed of many angioblasts arranged in small batches. It was fully differentiated into its 2 sub-layers, i.e., papillary and reticular sub-layers at 147 days of foetal life. The plugs which would form the hair follicles began to appear at 147 days and the hair fibres began to appear in its follicles at 268 days of foetal life. The camel hair follicles were differentiated into primary and secondary hair follicles at 268 days of foetal life and were clearly seen at 375 days of foetal life. Each group consisted of 3 primary follicles (1 central and 2 laterals) and several secondary follicles on the ectal side of the primary follicles. The sebaceous and sweat glands began to appear in the camel at 229 days. The arrector pili muscle first appeared at 229 days of foetal life.

Discussion

The epidermis appeared as 3 rows of cells in the camel foetus at 90 days and fully developed at 147 days, similar to that reported by Doubhag and Berg (l983a). In sheep foetus (foetal age 150 days), the 2 events occurred (Abou-Fandoud, 1982) at nearly 30 and 75 days, respectively, of foetal life, i.e., both phases occurred at nearly similar ontogenetic stages of development in camel (90/375 and 147/375) and sheep (30/150 and 75/150, respectively). Almost similar trends were observed in full development of the dermis, first appearance of the plugs, first appearance of the fibres, differentiation into primary and secondary follicles, first appearance of the sebaceous and sweat glands and arrector pili muscle.

It is of interest to discuss the role of camel skin in withstanding the environmental stresses in the desert. The studies confirmed that the camel's histological skin structures are like that of the other animals in many aspects (Krolling and Grau, l960; Donald *et al.*, 1962). However, the potentiality of each structure in sustaining adaptation under severe desert conditions is still unclear, and needs further investigation. One remarkable feature obtained in this study was the camel's higher epidermal thickness (730 microns) than that in cattle (16-145 microns), horses (30-95 microns), sheep (27-42 microns) and goats (20-40 microns; Scott, 1988). Donald *et al.* (1962) reported that the average epidermis thickness was 760 microns in the camel. Thickness of skin was also higher in camel (3.57 mm) than that reported in Egyptian cattle (2.3-3.0 mm; Hafez *et al.*, 1955) and sheep (0.8-3.1 mm) (Badreldin

et al., 1961b and Marai and Abd-El-Salam, 1971). Such high thickness values in camel's epidermis and skin may increase insulation capabilities against the severe changes in climate and reduce or prevent water diffusion from the skin.

The camel's hair follicle group, consisting of 3 primary follicles and several secondaries found on the ectal side of the primaries, is similar to that in sheep (Marai, 1959, 1964) but different from that in camel (Dowling and Nay, 1962; Mahdi, 1979; Kamel *et al.*, 1986; Quasem *et al.*,1992) in which different numbers of primary follicles in each follicle group were recorded. The contradiction may be because of the differences in ages at which the mentioned studies were carried out. The present study was carried out on growing animals, while those of the others were carried out on mature animals. In mature animals, the large increase in the sizes of their groups may make each bundle (more than 1 group of follicles) seen as 1 group of follicles. However, such criteria were different from that in cattle (Carter and Dowling, 1954), buffaloes (El-Shafie, 1954) and rabbits (Ahmed, 1996), since all hair follicles in such species are primaries, i.e., each follicle is associated with a holocrine sebaceous gland, an apocrine sweat gland and an arrector pili muscle with no discernible follicle group. Further, in camels the thickest (early) secondary follicles are situated near the primaries and the thinner (late) secondaries, are situated near the early secondaries contrary to that in sheep (Marai, 1959,1964), i.e., the late secondaries are situated between the primaries and early secondaries. The sebaceous gland lobules that are attached to both primaries (large) and secondaries (small) with a common short excretory duct at the inner end of the external third in camel in this study, are similar to that reported by Mahdi (1979), Quasem *et al.* (1992) and Solouma (1992), but different from that in sheep (Marai, 1959; Badreldin *et al.*, 196la). In buffaloes, the sebaceous gland is a branched alveolar gland that is well developed in body regions with few hairs (Yamane and Ono, 1936) and of two pear-shaped lobes in cattle (Findlay and Yang, 1948), while El-Shafe (1954) found that it was a typical holocrine gland with a short duct opened into the hair follicle in both buffaloes and cattle. The camel's sweat apocrine gland sacs found before the ends of their ducts are not found in sheep (Badreldin *et al.*, 1961a) and cattle (Findlay and Yang, 1950). The attachment of the arrector pili muscle with the follicle is deeper in camels than that found in sheep (Marai, 1995; Badreldin *et al.*, 1961a). Similar results were reported by Mahdi (1979).

The higher number of hair follicles per mm^2 in the hump region than that in the other regions of body was similar to that reported by Kamel *et al.* (1986). The increase in the density of the hair follicles in the hump region may help protecting the animal's upper body parts from direct sun light during the dry hot climate with bright sun. The average number of hair follicles per mm^2 of skin in camel (34.7) was lower than that recorded (65) by Dowling and Nay (1962) in the same species, but higher than that recorded in cattle (26.3), buffaloes (3.4; EI-Shafei, 1954) and sheep (13.7-16) (Badreldin and Marai, 1966).

References

Abou-Fandoud, E. 1982. *Pre-natal Development of Follicles in the Skin of Sheep*. M.Sc. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Ahmed, B.A.K. 1996. *Some Studies on the Body Cover in Some Farm Animals*. Ph.D. Thesis, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

Badreldin, A.L., Kamar, G.A.R., Shafei, M.M. and Marai, I.F.M 1961a. Histological structure of wool follicle group in fat-tailed sheep. *Acta Anatomica* 44: 363-373.

Badreldin, A.L., Kamar, G.A.R. Shafei, M.M. and Marai, I.F.M. 1961b. Factors influencing wool follicle characteristics in fat-tailed sheep. *Journal of Animal Production* 1: 61-73.

Badreldin, A.L. and Marai, I.F.M. 1966. Wool follicle development in relation to fleece type in Barki, Merino, Ossimi and Texel sheep. *Journal of Animal Production* 6: 105-16.

Burns, M. 1949. Studies on follicle population in relation to fleece changes in lambs of the English Leicester and Romney breeds. *Journal of Agricultural Science* 39: 64-79.

Burns, M. 1953. Observations on the follicle population of Blackface sheep. *Journal of Agricultural Science* 43: 422-431.

Carter, H.B. and Dowling, D.F. 1954. The hair follicle and apocrine gland population of cattle skin. *Australian Journal of Agricultural Research* 5: 745-754.

Clark, W.H. 1960. *A Histological Technique for the Study of the Skin Follicle Population in Sheep*. C.S.I.R.O. Technical Paper No. 3.

Donald, G., Lee, G.D. and Schmidt-Nielsen, K. 1962. The skin sweat glands and hair follicles of camel (*Camelus dromedarius*). *Anatomy Research* 143: 71-77.

Doubhag, A. and Berg, R. 1983a. The pre-natal development of the skin in one-humped camel (*Camelus dromedarius*). *Zeitschrift fur mikroskopisch-anatomische Forschung* 97: 589-596.

Doubhag, A. and Berg, R. 1983b. The development of the sweat glands and sebaceous glands in the skin of the one-humped camel (*Camelus dromedarius*). *Zeitschrift fur mikroskopisch - anatomische Forschung* 97: 894-902.

Dowling, D.F. and Nay, T. 1962. The hair follicles and sweat glands of the camel. *Nature* 195: 578-580

Duncan, B.D. 1955. Multiple range and multiple F test. *Biometrics* 11: 1-42.

El-Shafie, M.M. 1954. *Skin Histology of Egyptian Buffaloes and Cattle*. M.Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt.

EL-Wishy, A.B., Hemeida, N.A., Omar, M.A., Mobarak, A.M. and El-Sayed, M.A.I. 1981. Functional changes in the pregnant camel with reference to foetal growth. *British Veterinary Journal* 37: 527-37.

Findlay, J.D. and Yang, S.H. 1948. Capillary distribution in cow skin. *Nature* 161: 1012.

Findlay, J.D. and Yang, S.H. 1950. The sweat gland of Ayrshire cattle. *Journal of Agricultural Science* 40: 102.

Hafez, E.S.E., Badreldin, A.L. and Shafie. M.M. 1955. The hair coat in bovine. *Empire Journal of Experimental Agriculture* 23: 89.

Kamel, G., Schwarz, R. and Ali, A.M.A. 1986. Studies on hair follicles and apocrine tubular glands in the skin of one-humped camel. *Assiut Veterinary Medicine Journal* 17: 55-60.

Krolling, O. and Grau, H.1960. *Lehrbuch der Histologie und Vergleichenden Mikroskopischen Anatomie der Haustiere*. Paul Parey, Berlin.

Mahdi, A.H. 1979. *Morphological and Histochemical Studies on the Skin of the Camel (Camelus dromedarius)*. M.Sc. Thesis, College of Veterinary Medicine, Bagdad University, Iraq.

Marai, I.F.M. 1959. *Histological Study of Wool Follicles of Native Sheep*. M.Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt.

Marai, I.F.M. 1964. *Wool Follicle Characteristics in Some Imported and Indigenous Sheep and their Crosses*. Ph.D. Thesis, Faculty of Agriculture, Cairo University, Egypt.

Marai, I.F.M. and Abd-El-Salam, M.E, 1971. Technology and Wool Production (in Arabic language). The General Society for Books and Instruments, Cairo University, Egypt.

Quasem, M.A., Mahdi, A.H., Khan, M.Z.I. and Ahmed, M.U. 1992. Histomorphological studies on the skin of camel (*Camelus dromedarius*). *Bangladesh Journal of Animal Science* 21: 71-75.

Scott, D.W. 1988. *Large Animal Dermatology*. W.D. Saunders Company. Harcourt Brace Jovanovich, Inc.

Snedecor, C.W. and Cochran, W.G. 1980. *Statistical Methods*. The Iowa State College Press, Ames, Iowa.

Solouma, G.M.A. 1992. *Some Histological Studies on Fiber Producing Follicles in the Camel*. M.Sc. Thesis. Faculty of Agriculture, AI-Azhar University, Cairo, Egypt.

Yamane, J. and Ono, Y. 1936. Rassenanatomische untersuchungen der Hautstrukture Vom Buffel, Zabu, Formosarind und Friesisch-Hollander in Hinblick auf dais problem der tropenanpassung. *Mem Fac. Sci. Agr. Taihoku* 19: 87.