MICROANATOMICAL STUDIES OF THE SKIN OF THE ONE-HUMPED CAMEL (*Camolus dromeiarius*), WITH PARTICULAR REFERENCE TO THE HAIR FOLLICLES AND SWEAT GLAND MEASUREMENTS

BY

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D E C L A R A T I O N

This is to certify that this thesis is not plagiarized, and that I carried out the work reported here in the Department of Veterinary Anatomy, Ahmadu Bello University under the supervision of Dr. M. N. Jamdar, Dr. S. A. Ojo and Professor C. O. Njoku.

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ABSTRACT

Skin samples were obtained from 10 camels (six males, four females) from eight body regions in the male and six in the female. Sections were cut for histological study and microscopic measurements were made on the skin sections which included the dimensions of (1) the hair follicles such as the depth, length, ~~diameter and hair follicles such as the depth, length~~, diameter and population density at the various body sites; and (2) sweat glands such as the depth, length, diameter, number and shape.

The hair follicle cluster at the knee was observed to be embedded in fibrocartilage unlike the usual reticular connective tissue in other regions. Because eccrine and apocrine sweat glands were found in the neck region of the camel, it is preferable to refer to camel's sweat gland as merocrine, which embraces both types of sweat glands.

There were low hair follicle depth, thick hair follicles and low (narrow) medullation ratio, all of which were relevant to the camel's adaptation to its hot environment and they apparently contribute to the animal's supposedly superior heat tolerance.

Low overall sweat gland and primary hair follicle density and a high secondary follicle density give more credence to the hair covering's insulation value as being more important to the camel's skin barrier against heat gain than the sweating.

The shape of the sweat gland of the camel is serpentine being highly coiled and having a length to diameter ratio (L/D) greater than 12.0. Average hair follicle depth (FD) was less than 1.5mm, thus making the camel skin classifiable into the type III category comparable to the superior leather making skin of the South American cattle.

Because of the intermediate angle of collagen weave in the dermis of the midside region, it has been suggested that the leather making quality of the skin of the camel might be good for sole leather, if carefully flayed to include this midside region.

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INTRODUCTION

Animals have envolved methods of easing the severity of, or raising their resistance to environmental stresses. The adaptations are anatomical, physiological and behavioural in nature.

Dromedary poses many problems of adaptation to environment for investigation and handling. Its bulky frame (McKnight, 1969), physiognomy, height, gaunt extremities, remarkable hump, type and distribution of hair (soft and fine) are pointers.

Camel, the ship of the desert has moved into semi-desert areas and it is finding its place in the northern parts of Nigeria, especially Sokoto, Kano, Maiduguri and parts of Kaduna State, where it is subserving the agro-industrial economy, including among others, the livestock, the farm transport and the leather industry.

The various Anatomical and Physiological aspects of the camel have received scant attention. The size of the animal, the financial implications and availability of the material have been constant constraints.

The limited studies that have been made on the histology of the camel involved only the general

histology of the skin, density of hair follicles and density and morphology of sweat glands from the midside region.

This study is intended to provide the following information:

1. The general histological structure of skin at different body parts.
2. The measurements of hair follicles involving length, diameter, depth and density at different body regions, in order to find the trend and relation if any, in adaptation to the environment.
3. The size, shape and density of sweat glands with the possible classification of camel skin as relating to the adaptation of the animal to its environment.
4. The collagen fibre weave in the dermis and the suitability of camel skin in leather manufacture.

REVIEW OF LITERATURE

The histological study of the skin of the camel by Lee and Schmidt-Nielsen (1962) revealed that the structure of the epidermis and dermis conforms to that of other mammals, but the structure and distribution of glands differ in some respects from those described for domestic mammals. The arrangement of hairs and their follicles also differs from that described for other mammals.

The most noticeable feature of the skin of the camel is the arrangement of the hair follicles embedded in reticular connective tissue in groups so that the hairs grow in tufts (Dowling and Nay, 1962). In the skin near the margin of the lip, external nares and lower eyelid, the hairs are spaced evenly and singly (Lee and Schmidt-Nielsen, 1962). In all other body areas they examined, the hair was grouped into distinct clusters. Each cluster was projecting from an irregular depressed area or groove and was separated from adjacent clusters by elevated ridges.

Dowling and Nay (1962), further noticed that the groups were roughly oval in shape, and varied in size. At the base of each group there was one large follicle equipped as a rule with one sweat gland and an arrector pili muscle. Flanking it there were two or

three follicles, usually of lesser size, and not always equipped with sweat glands and arrector pili muscles. They also observed that the remaining follicles in the group were smaller, the smallest lying at the edge of the group opposite the large follicles.

Normally only three follicles in the group were equipped with sweat glands, but four, five or even six may be present in large groups and two or one in small groups (Dowling et al., 1962). Lease (1927), Droandi (1936) and Curasson (1947) had observed the presence of sweat glands in the skin of the camel, though Leonard (1894), unfortunately had claimed that the skin of the camel had no sweat glands.

The sweat glands were simple, coiled tubular glands observed in all body areas except in the skin of the upper lip, external nares and perianal region (Lee et al., 1962). Their ducts were observed to open into the neck of the cover hair (primary hair) follicles above the level of the sebaceous gland ducts.

No sebaceous glands were found in the skin without hair follicles (Lee et al., 1962). But they observed that each cover hair follicle was surrounded by a ring of typical simple or branched saccular glands of the holocrine type. In the compound follicles of the wool hairs (secondary hairs) each branch had its

own indenpendent ring of such glands.

The poll tubular glands (tubular skin glands) which remain inactive during pubescence but become active during rutting season are present only in the male camel (Leese, 1927; Purohit and Singh, 1958). They were described as two large masses of cutaneous glands lying about two inches behind the apex of the head, one on each side of the midline.

Lee and Schmidt-Nielsen (1962) did a comprehensive histological study of the camel skin, sweat glands and hair follicles from 23 body areas. Dowling and Nay,(1962) pursued the study of camel's skin with measurements of the hair follicles and sweat glands as had been done for other domestic mammals (Burns, 1949, in Leicester and Romney breeds of lambs; Findlay and Yang, 1950, in Ayrshire cattle; Carter and Dowling, 1954, 1955, 1959a and b in Zebu (Bos indicus L) in Shorthorn (Bos taurus L) cattle; Nay and Hayman, 1956, 1963 in Zebu (Bos indicus L) and European (Bos taurus L) cattle; Carter and Clarke, 1957, in Australian Merino sheep; Hayman and Nay, 1958 in Zebu (Bos indicus) and European (Bos taurus) cattle; Lyne and Heideman, 1959, in prenatal cattle; Findlay and Jenkinson, 1960, 1964 in Ayrshire calf; Narayan, 1960, in Rajasthan sheep breeds; Taneja, 1960, in cattle;

Turner, Nay and French, 1962, in cattle; Pan, 1963, 1964 in Sahiwal Zebu and Jersey cattle; Jenkinson, 1968, 1972, 1973 in European, Asian, African and South American cattle; Jenkinson, 1972, in all domestic animals mainly sheep, goat and cattle; Amakiri, 1974a and b, 1975; Amakiri and Hill, 1975; Amakiri and Mordi, 1975 in some tropical and temperate breeds of cattle in Nigeria). Counting only from the midside region of camel skin, Dowling and Nay (1962) established that there were on the average 28 hair follicles in each group, and the number of follicle group per square centimeter was 63 to 65. There were approximately three sweat glands per group. They measured the average diameter of the sweat gland and found the tubes (myoepithelial cell base, across to the opposite myoepithelial cell base) to be 60 microns (u) to 70 microns (u) and the diameter of the lumen (from the apex of the epithelial cell, across to the apex of the opposite epithelial cell) about 30 u to 40 u. The average number of sweat glands per square centimeter of the skin at the midside region was approximately 200.

The reliability of a midside sample as an index of the whole has however, been questioned. Pan (1963) reported variation over the body in the number of hair characters, sweat gland density, length, width

and volume, skin thickness and skin shrinkage per unit area in Sahiwal and Jersey cattle. For some traits, the mean values at the commonly used midside sampling position were within 10% of the mean for all positions. That is why Pan (1963 and 1964), Amakiri (1974a and b, 1975), Amakiri and Hill (1975) made counts for samples chosen from different body regions of the cattle.

Some indices of adaptation to the environment are the sweat gland density, shape (length/diameter ratio), and size, while the hair follicle length, depth, diameter and density are important in mammalian temperature regulation. Measurements of the same parameters in cattle were undertaken by Jenkinson and Nay (1968, 1972 and 1973), and regional variations in the density and depth of the hair follicles of the cattle were studied by Amakiri and Hill (1975).

Pan (1963) in a study of the quantitative and morphological variation of sweat glands, skin thickness and skin shrinkage over various body regions of Sahiwal Zebu and Jersey cattle, found craniocaudal increase. Sweat gland length tended to increase caudally, significantly less along the dorsum than along the ventrum. Gland length to diameter ratio

(shape) was greater along the lateral midline than along the ventrum. Amakiri and Mordi (1975) established that mean sweat gland volume has no direct effect on sweating rate. Rather, evaporative loss could be related to a high sweat gland density. Nay, 1959, observed that the size of individual sweat glands in the same animal varies considerably and that the sweat glands in cattle varied greatly in shape (L/D). According to him three main types of gland could be distinquished:

1. The tubular, more or less coiled type, of varying length, with fairly constant low diameter (below or slightly over 100 um).

2. The baggy type, of varying length, shaped like a cucumber or sausage, often with an indentation at the upper end indicating a rudimentary coil, with wide diameter, up to 180 to 200 um.

3. The club-shaped, intermediate type with a wider baggy lower end and a narrower, more or less coiled upper end.

Nay (1959), concluded that the glands of any one animal were all of the same type, irrespective of the relative size.

There is no evidence to indicate that sweating in the camel has an important role in maintaining body temperature. In some species, for example, kangaroo, sheep and pig, sweating plays an insignificant role in heat adaptation in contrast to cattle and man (Jenkinson, 1972).

While noting that the sweat glands of cattle form the main avenue of heat dissipation in hot environments, thereby protecting the animal against extremes of temperature, it was affirmed that sweat gland shape (L/D) and hair follicle depth (FD) were also reliable indicators of skin types (Jenkinson and Nay, 1968, 1972 and 1973; Amakiri, 1974a).

Temperature regulation, just like water economy, is an important adaptational aspect of the camel. The thickness (density) of the fur corresponds to a high insulation value (Schmidt-Nielsen, 1964). Pan (1964) concluded that coat type in cattle is largely determined by hair density, length, diameter and medullation of the hairs. He also observed that hair length increased caudally: Along the caudal part of the body, hair length was greater in corresponding positions on the back. It was the same with hair diameter while the reverse was true for density gradient.

Dowling (1959b) observed considerable seasonal variation in the incidence and degree of medullation in the cattle. The more medullated hair fibres are known to facilitate air movement at the skin surface and thus aid vaporization of moisture. In addition, they are more effective infrared reflectors (Blackburn, 1965) and are therefore highly correlated with heat tolerance (Dowling, 1959a).

MATERIALS AND METHODS

Skin samples were obtained from a total of ten adult camels (six males, and four females) from Kano abattoir, immediately after slaughter.

They were taken from ten body sites. Some sites were common to both male and female. Others were exclusive to either male or female. The common sites were intended for a comparison between both sexes, while the sites exclusive to the male were meant for the study of those areas and could be assumed to be similar to those of the female. The sites exclusive to the female are those that female physiology may cause to show alterations in their structures.

Sites from which samples were taken

Common to Male and Female	Male only	Female only
1. Neck (dorsal)	1. Thigh	1. Ventral-abdomen
2. Hump	2. Breech	2. Udder
3. Back	3. Knee (dorsal)	
4. Midside	4. Upper lip	

Necropsy technique was adopted. Biopsy technique (Findlay and Jenkinson, 1960) or trephine (Carter and Dowling, 1954) could not be used due to inaccessibility to the instruments. Samples were spread out on corks and impaled in the manner described by Burns (1949) in order to retain as far as possible the original size and shape of the samples.

All samples were fixed in 10% formol saline, immediately after collection. They were divided into three groups. One third of the groups were fixed for 24 hours, dehydrated in 70% alcohol, wax impregnanted, and sectioned vertically at 25 microns (u) with a rotary microtome serially, taking every fourth section for uniformity, and then stained with 0.5% polychromic methylene blue. The length, diameter and depth of sweat glands were measured on such sections with a calibrated 10x micrometer eyepiece graticule in accordance with the methods of Jenkinson and Nay (1968) and Chowdhury and Sadhu (1963). The remaining two thirds of the groups stayed in formol saline for 72 hours, and were later transfered to a 4% aqueous solution of phenol for three days to soften, then dehydrated in various grades of alcohol, cleared in benzene, and wax impregnated using a Histokinnette[1]

1. Histokinnette type E 7326 British American Optical Company Limited. Instrument Group, 820 Veovil Road, Slough, Bucks, England.

tissue processor. The tissues were then embedded in paraffin. Vertical and horizontal sections were cut serially at eight µ with a rotary microtome. Sections from half of this group were stained using a simple triple stain (Mayer's haemalum, eosin and picric acid) as described by Carter and Clarke (1957). The sections from the remainder of the group were routinely stained with haematoxylin and eosin. The following parameters were studied.

Hair follicle length, diameter and depth were measured in vertical sections of skin, and hair follicle and sweat gland densities in horizontal sections, using calibrated 10x micrometer eyepiece (Amakiri and Hill, 1975).

Additional sections were processed and cut serially at eight microns (8 u). Special staining for specific structures were carried out. Masson's trichrome stain was used for staining dermal connective tissue fibres blue. Phosphotungstic acid haematoxylin (PTAH) stain was used, staining elastic fibres (purplish) and nerve fibres, and their cells (blue).

Medullation characteristics were studied histologically on hairs mounted grossly in a mixture of Canada balsam and xylol after they had been fixed

in a mixture of ether and 70% alcohol, according to the methods of Amakiri and Hill (1975) to make the hairs translucent.

The data on measurements were statistically analysed for mean measurements, standard errors, coefficient of variations (relative standard deviation), effective standard error of sites, and variation ratio which gave the 'F' values indicating the level of significance, all at 5% level (Ostle, 1954). Where the differences between both sexes at the common sites were required, 't' value was used to show at what significance level the differences existed, provided they were statistically significant (Ostle, 1954).

Photomicrographs of skin sections at different regions were taken. The final measurements in the different body areas have been presented in the tables as well as in the picture drawings of the animal for easy understanding as to how they differed in different regions cranio-caudally and dorsoventrally.

MEASUREMENTS

1. The Hair Follicle

(i) Depth (FD):- It is defined as the shortest distance between the base of an active hair follicle

and the skin surface (Jenkinson and Nay, 1968). In the camels of this study, the distance of the base of the deepest follicle within the group in the cluster was measured in ten random clusters. This measurement included either primary or secondary follicle. Hair follicle clusters seated deep in the reticular layer were ignored, because of their lack of connection with the skin surface.

(ii) Length (FL):- This is defined as the distance between the base of the bulb of an active hair follicle and the point where the follicle reaches the surface of the skin (Jenkinson and Nay, 1968). Measurement was from the base of the longest hair follicle within the group inside the cluster for ten random clusters. This also included either primary or secondary follicle. Deep seated clusters were again ignored for lack of contact with the skin surface.

(iii) Diameter (FDM):- The diameters of the same hair follicles were measured. Follicle diameter for the sake of uniformity was always measured at the level of the sebaceous glands.

2. The Sweat Gland

(i) Depth (SGD):- The distance of the secretory portions (fundus) of the gland, (from the surface of the skin to the deepest aspect of the secretory portion)

was measured. Five randomly selected glands were measured at each site.

(ii) Length:- The lengths (L) of the secretory portions (fundus) of the glands were obtained by measuring the stretch of the fundus from the point of contact with the duct to its base, and adding the measurement of coiled glands by Chowdhury and Sadhu (1963). The mean measurements on five glands at each site of the camel skin were calculated.

(iii) Diameter:- The diameter (D) of each of the same number of glands was measured in five places per gland. The mean of these readings was taken as the sweat gland diameter.

(iv) Ratio of the length of the sweat gland to its diameter (L/D) was calculated for skin typing and for determining the shape of the sweat glands (Jenkinson and Nay, 1968).

3. The Sweat Gland and Hair Follicle Density

The number of sweat glands and hair follicles per square centimeter of skin at the site from which samples were obtained was determined from sections cut horizontally (or parallel) to the skin surface. This measurement included all sweat glands and hair

follicles (primary and secondary) in the fields scanned. Six fields of one square millimeter each were measured, and the mean value was calculated, then converted to give the number per square centimeter of the skin at that site. Since each primary hair follicle has a sweat gland duct associated with it (Dowling and Nay, 1962), the primary follicles were therefore differentiated from the secondary follicles, by their association with sweat gland ducts.

4. Medullation Ratio

This is the ratio of the measurement of the length of the medulla of the hair to the length of the entire hair shaft after clipping the hairs uniformly from the skin surface. This was carried out for all the chosen sites of the camel skin, irrespective of the type of hair.

RESULTS

A. GENERAL HISTOLOGICAL OBSERVATIONS

I. Epidermis

The layers evident in all areas studied from the base to the surface were: stratum germinativum, stratum spinosum, stratum granulosum and stratum corneum. The layer of stratum lucidum was only seen in the area where hair follicles were very scarce or absent such as the smooth surface of the lip. In such areas, epidermal "peggings"were observed (plate Ia). The surface was characterized by very low ridges and grooves. The epidermal pegging which existed at the upper lip where there were only secondary hairs occurred at the adjacent portion to the point of the hair follicle. The epidermis was highly keratinized at the teat of udder (plate VIIa), male knee and upper lip.

The average thickness of the epidermis in each area obtained by measuring the thickest and thinnest zones in the sections was 0.20 mm for the male camel and 0.18 mm for the female (Table 21). In some regions, the epidermis was so thin, that all the zones were not always distinguishable. Plate Ib illustrates such epidermal thickness at sites like the male's back,

neck, and knee; the female's midside, back, ventral abdomen and neck. There was a general lack of epidermal peggings in such hairy areas. No significant differences existed in the average epidermal thickness between the male and female at common sites of the animal (Table 22).

II. Dermis

An overall average thickness of all the areas studied was 3.82 mm for the male camel and 3.16 mm for the female (Table 21). Striated muscle fibres were frequently observed at the udder region within the dermis of the female (Plate VIb).

Dermal papillae were prominent in the non-hairy portion of the upper lip, and were not present in hairy areas of the body. A thin superficial zone of delicate, closely woven fibres (stratum papillare) were clearly evident in all the regions studied (Plate IIa). At the junction of the two layers smooth arrector pili muscle was seen coursing diagonally, and getting attached to the primary follicle.

(i) Hair Follicles:- In all the body areas examined the follicles were grouped into distinct clusters. These clusters except at the knee were

embedded in reticular connective tissue in groups, so that the hair grew in tufts (Plates IIb and IIIa). The groups were roughly oval in shape and varied in size. At the knee the follicle group, rather than being covered by reticular connective tissue, was surrounded by fibrocartilage (Plate IIIb).

The study of sections revealed that the groups of small hairs emerged from a common hair follicle neck (Plate IVa), except at the upper lip where the hairs had emerged singly and evenly from the existing hair follicles (Plate IVb).

In the papillary layers of all body regions except at the upper lip, the hair follicles in clusters associated with sebaceous glands and sweat gland ducts were securely arranged. There seemed a patterned trio groups of primary and secondary hair follicles, each unit of the trio being covered and separated by invading septa from a larger defined covering of connective tissue capsule (Plate Va). However, in the skin of the upper lip, the follicles had singular existence (Plate Vb). At the deeper reticular layer the unit covering of connective tissue around the individual secondary follicles was gradually lost.

The trio group arrangement also seemed to have been lost, revealing an almost singular existence of the secondary follicles, even though still within the *common cluster* (Plate VIa).

The hair follicles were at different stages of development in the various regions of the animal's body (Plates VIIb and VIIIb). The clusters within the reticular layer revealed predominant regenerating hair follicles, usually of the secondary types at the ectal (upper) portion of the cluster. Detached secondary follicles were observed deep within the dermis of the upper lip (Plate VIIIb).

(ii) Sebaceous Glands:- The typical simple or branched saccular glands of the holocrine type surrounded each primary hair follicle, and each branch of the compound follicles of the secondary hairs had its own ring of such glands (Plate IXa). These glands were elaborately multilobed in association with detached hair follicles within the dermis of the skins of the udder (Plate IXb).

(iii) Sweat Glands:- Simple coiled tubular sweat glands were observed in sections from all body areas studied except in the skin of the upper lip. These tubular glands were seen in association with the larger primary (cover) hair follicles only, and

none was seen related to the follicles of small secondary hairs. Plate Xa illustrates a portion of the spiralled secretory portion and an oblique section of the associated duct; and Plate VIIb shows three ducts each associated with the follicle of a primary hair cluster.

(iv) The Blood Vascular System:- The dermis and the hypodermis were pervaded by continuous arteriovenous network with meshes of different sizes and with various spatial relationships. Arteriovenous anastomoses (AVA) or shunts, were seen between one hair follicle group and another, usually at the junction of the papillary layer and reticular layer (Plates XIIb and XIIIa). Plate XIIIb shows AVA situated in the reticular layer of the dermis. Even though discrete networks were seen around hair follicles and sweat glands, the general distribution was really one unit of vertically inter-connecting vessels of separate plexuses (from the deep reticular layer upwards to below the epidermis).

The AVA's were observed to be numerous in the skin at the midside, back, ventral, neck and knee regions of both male and female camels, but non was seen at the upper lip. Their sizes were smaller and scattered, and they were not in a particular regular

fashion (plexuses) in the skin of the udder (Plate XIVa).

(v) The Innervation:- Nerve trunks situated in the deeper layers of the stratum reticulare were observed in the female neck region and male midside (Plates XIVb and XVa).

(vi) Connective Tissue Fibres:- At all the sites of the camel skin studied, except the knee and hump where the dermis was markedly cornified, fine architectural distribution of elastic fibres was seen best in the papillaris dermis and around the cutaneous appendages and blood vessels. The strands ran parallel to the epidermis (Plate XVb).

The reticular layer of skin in all the regions, including the knee showed a dense network of irregularly arranged thick bundles of collagen fibres. They were most prominently cross-linked and sometimes wavy at the breech, midside, neck and ventral abdomen of both sexes. Very deeply within the dermis, they were found to agglomerate around blood vessels and sweat gland secretory portions (Plates XVIa and b, XVIIa and b).

B. MEASUREMENTS

I. The Hair Follicle

(i) Depth:- In all positions in the camel, hair follicle depth averaged 0.98 millimeters in male (Table 1) and 1.13 millimeters in the female (Table 2). In general, there was a dorsoventral decrease in both sexes. The hair follicles seemed to be deepest at the hump of the male camel and shallowest on the back; while the female had its deepest follicles at the midside and relatively shallower at the udder.

The statistical analysis in Tables 1 and 2 show that there were significant variations in follicle depth between the various body sites of both sexes at 5% level.

(ii) Length:- The hair follicle length average in all the positions of the male camel was 1.20 mm (Table 3) and 1.25 mm for the female (Table 4). There was a dorsoventral decrease in both sexes. The hair follicle of the male camel was longest at the hump and upper lip and shortest at the back and midside. The neck and breech areas were intermediate in the measurements obtained. The midside of the female had very long hair follicles (2.54 mm) with the back

and ventral abdomen having the same lengths (1.02 mm). At the hump it was intermediate. The neck had the shortest hair follicles.

Tables 3 and 4 show statistical analyses of the hair follicle lengths in both sexes. There were significant variations at 5% level in the lengths of the follicles between the body sites of both the male and female.

(iii) Diameter:- Measurements of the diameters of the same hair follicles at the sebaceous gland level are shown in Tables 5 and 6. In the male camel, hair follicle diameter averaged 115.31 micrometer (um), while the female averaged 87.4 um. The hump had the widest hair follicles in both sexes.

Variations between body sites of the hair follicle diameter were significant ($P<0.05$). It was only slightly significant in the female (Table 6).

II. Sweat Gland

(i) Depth:- The greatest depth was at the breech region of the male camel, and shallowest at the knee; while the hump and midside regions of the female had the highest values. The sweat glands were relatively shallow in the neck of the female. Average depths in the male and female camels were 2.58 mm (Table 7) and 1.81 (Table 8) respectively.

The variations between the body sites were significant ($P<0.05$) in the male and female animal (Tables 7 and 8).

(ii) Length:- Being a coiled gland, the length of the sweat gland, is the measurement of the fundus from where the duct begins to its base, including the dimensions of the individual loop.

In the male camel, the sweat gland was longest in the neck and shortest at the midside. There was a cranio-caudal decrease. In the female, it was longest at the udder and shortest on the back. Average length of the gland in the male was 1202.1 um (Table 9) and 1764.3 um in the female (Table 10).

There were no significant variations ($P>0.05$) in the sweat gland lengths between body sites of both sexes (Tables 9 and 10).

(iii) Diameter:- The average diameter in the male was 55.06 um (Table 11) and 62.66 um in the female (Table 12). In both, there was a cranio-caudal and also a dorso-ventral increase. The thigh of the male had the widest glands with the narrowest on the back. In the female, the glands were relatively narrow at the midside, very wide at the udder and next in order at the ventral abdomen.

Table 11 shows that the variations between the body sites were significant ($P<0.05$). But in the female, the variations were not significant ($P>0.05$) as shown in Table 12.

(iv) Shape:- The length to diameter (L/D) ratios of the sweat glands are shown in Tables 13 and 14. These ratios are the measure of the extent to which the gland are either saclike or serpentine (tubular).

In the male camel (Table 13), the sweat gland ratio was very high at the back and neck regions, thus having highly coiled glands, while the glands were moderately coiled at the remaining sites. The overall mean ratio was 22.21, which is a considerable measure of coil to make the gland serpentine.

The female (Table 14), had highly coiled glands at the udder, ventral abdomen and neck. They were moderately coiled at the midside and back. The overall ratio of 28.0 showed that the female camel's sweat gland is fairly more serpentine and more coiled than in the male.

III. The Sweat Gland and Hair Follicle Densities

Tables 15, 16, 17 and 18 show the densities in the various sampled sites of both the male and female camels. The number of sweat glands correspond to the

number of primary hair follicles present. In the male camel the back and thigh had the greatest number of sweat glands and corresponding primary hair follicles per square centimeter of skin, with the least number at the hump. Also in the female, the back, followed by the ventral abdomen had the greatest numbers and the udder had the least.

Table 15 shows an overall mean density of 294.3 for the primary hair follicle/number of sweat glands in the male. The secondary hair follicles had an overall mean density of 1483.1 per square centimeter. In the female, the primary hair follicles/sweat glands had an overall mean density of 308.2 per square centimeter. The mean density value for the secondary hair follicles was 1369.3.

Table 16 gives the number (density) of hair follicles and sweat glands of the male camel in six fields, each being one square millimeter. The primary follicles per sweat glands had the highest percentage variation of density in the hump and least in the thigh. The secondary follicle density also had the highest percentage variation at the hump but least at the midside.

In the female camel (Table 17), the percentage variation for primary hair follicles/sweat glands was greatest at the udder, followed by the hump area and least at the back. The secondary hair follicle density also showed the greatest percentage variation at the udder closely followed by the hump, and the least variation at the midside.

Table 18 gives the comparison of the hair follicles (secondary and primary) and sweat gland densities at common sites between male and female camel. The female had more sweat gland density than the male. The former had a mean of 338 per square centimeter of skin, while the latter had 283. Secondary hair follicle mean density was also more in the female (1504) than in the male (1458). The midside had the same mean value of 317 in both sexes for the primary hair follicle cum sweat gland density. The neck showed a higher mean in the male (350) than in the female (283). In the back region it was higher in the female (550) than the male (433) and in the hump it was very much higher in the female (200) than male (33).

The secondary hair follicle mean density values were more in the female (2550) than in the male (2133) at the midside. The reverse was the case at the neck (female - 1233, male - 1400) and at the back

(female - 1633, male - 1717). The mean number at the hump of both sexes did not vary much (583 in male and 600 in female).

There were no significant differences between the male and female camel at common sites in their secondary hair follicles and primary follicles/sweat gland density. The 't' value of 0.34 (Table 18), for primary follicles/sweat glands was not significant and the 't' value of 0.062 for secondary follilces was also not significant.

The secondary to primary (S/P) follicle ratios for both sexes are shown in Table 19. The male had a very high ratio at the hump (18:1), but very low in the female (3:1), followed by at the breech (9:1) and least at the back (4:1). In the female the highest ratio was at the udder (15:1) followed by at midside (8:1).

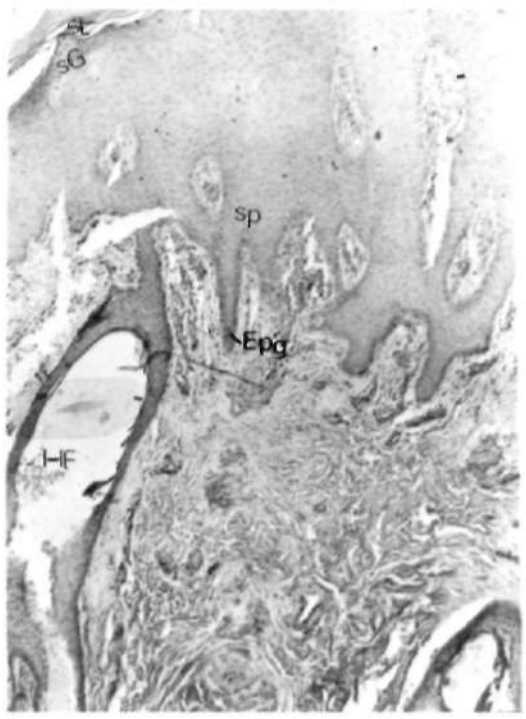
IV. Medullation Ratio

Medullation ratio is a relation of the length of hair medulla to the length of the hair shaft (medulla/shaft ratio), so that the wider the medullation ratio, the less the relative medullation.

The medullation ratio is shown in Table 20 for male and female camel. In the male, the follicles had the widest ratio at the midside (0.89:1) followed by at the neck (0.93:1). The overall ratio was 0.95:1. The widest ratio in the female was at the ventral abdomen (0.57:1) followed by at the neck (0.86:1).

PLATE I

a



b



PLATE I

a

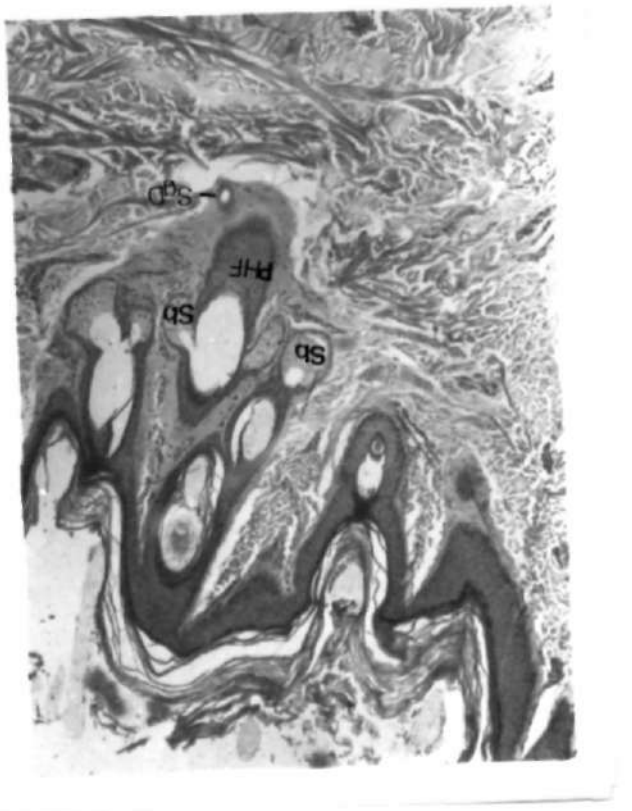
Camel skin, upper lip (vertical section), Male: From below to the surface, are the epidermal "peggings" (Epg) adjacent to the hair follicle (hF) The stratum spinosum (SP), stratum granulosum (SG) and stratum lucidum (SL).

Haemalum, picric acid and eosin x 120.

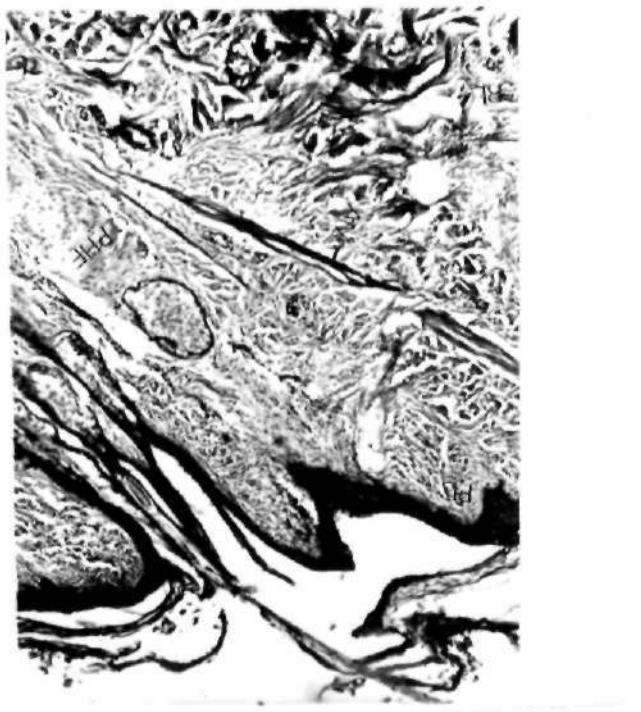
b

Camel skin, midside (oblique section), Female: The arrector pili muscle (AM) attaches to the primary hair follicle on the ental basal side of the follicle group. Sweat gland duct (SgD) opening at the neck of the primary hair follicle above the sebaceous gland (Sb) level.

Haemalum, picric acid and eosin x 120.



b



c

PLATE II

PLATE II

a

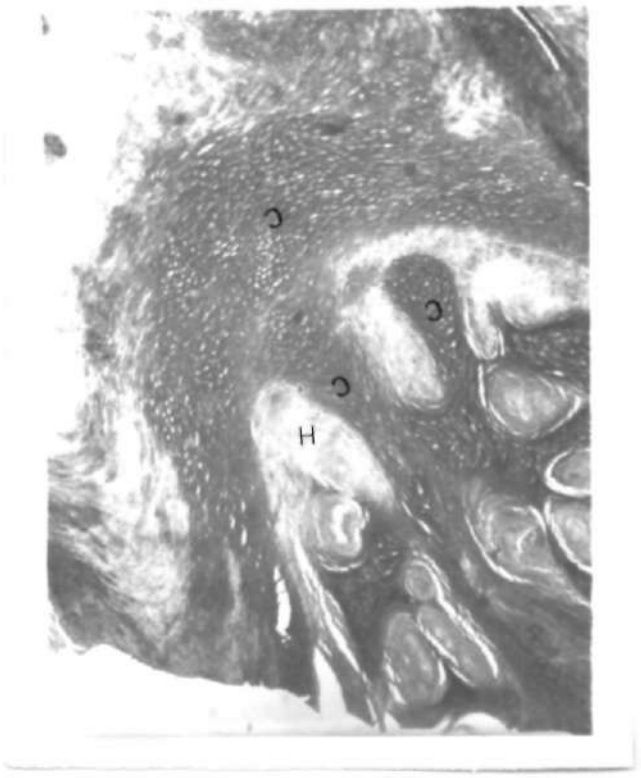
Camel skin, midside (oblique section), Female: Stratum papillare (PL) below the epidermis, and a thick deeper area of stratum reticulare (RL). At the junction of the two, the arrector pili muscle attaches to the primary hair follicle (PHF).

Masson's Trichrome x 120.

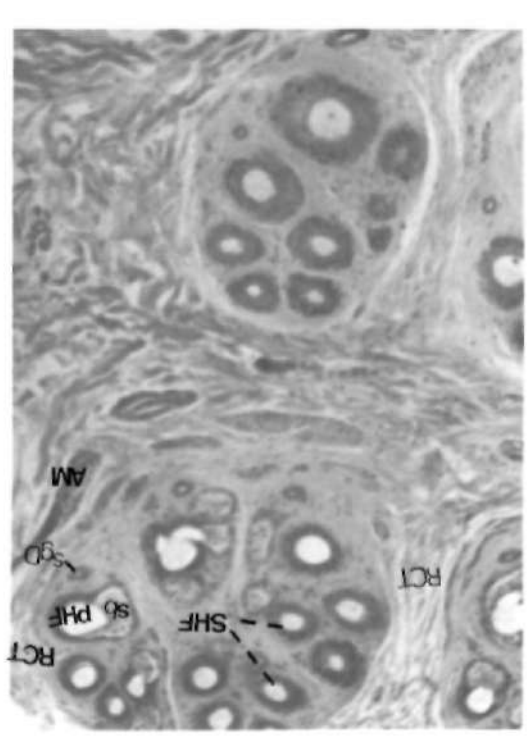
b.

Camel skin, midside (oblique section), Male: Hair follicle cluster. Large primary follicle (PHF) with its associated sweat gland duct (SgD) and bilobed sebaceous glands (sb).

Hematoxylin and Eosin x 300.



q



c

PLATE III

PLATE III

a

Camel skin, back (horizontal section), Female: Hair follicle cluster (RCT). Primary hair follicles (PHF) at the base with the associated sweat gland ducts (SgD). The secondary hair follicles (SHF) exist to the top.

H. & E. x 120.

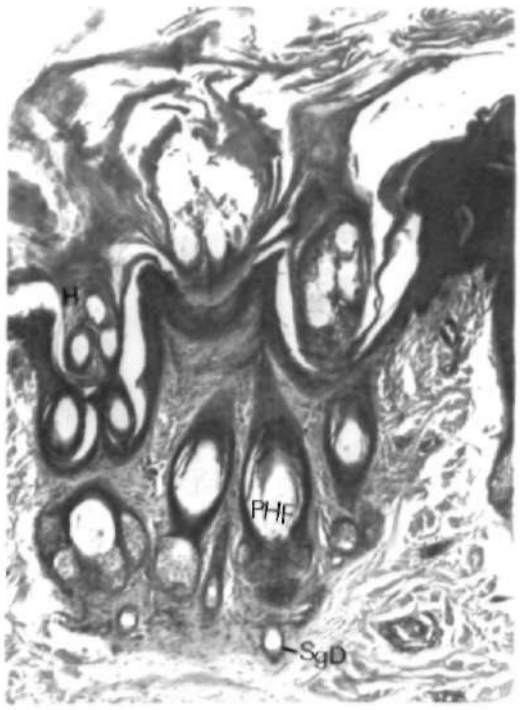
b

Camel skin, knee (oblique section), Male: Tuftlike hairs (H) within follicles, surrounded by fibrocartilage (C).

H. & E. x 300.

PLATE IV

a



b



PLATE IV

a

Camel skin, midside (vertical section), Male: Small hairs (H) emerging from a common hair follicle neck. Below, larger primary hair follicles (PHF) with associated sweat gland ducts (SgD).

H. & E. x 300.

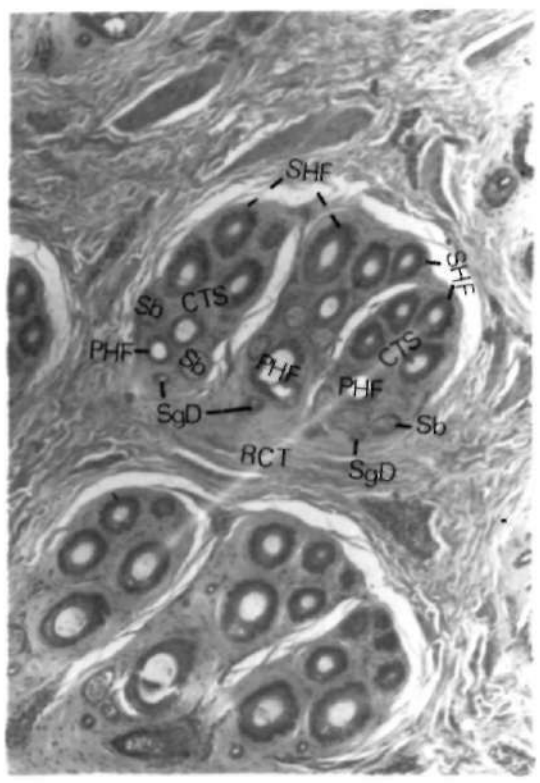
b

Camel skin, upper lip (vertical section), Male: Singly placed secondary hair follicles (SHF), Sebaceous glands (sb) with a ring formation at the base of the jutting follicles.

H. & E. x 300.

PLATE V

a



b

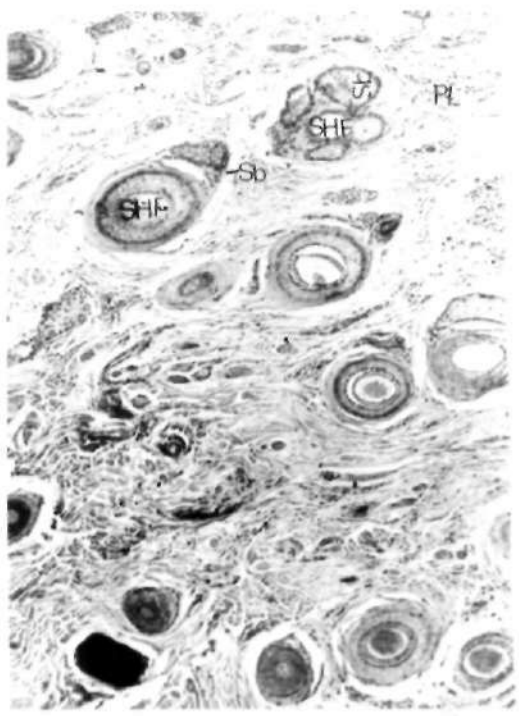


PLATE V

a

Camel skin, back (horizontal section), Male: The clustered group of primary hair follicles (PHF) with associated sweat gland duct (SgD) and secondary hair follicles (SHF) in trio groups. The follicles in each of the trio are surrounded by connective tissue septa (CTS).

Haemalum, Picric Acid and Eosin x 120.

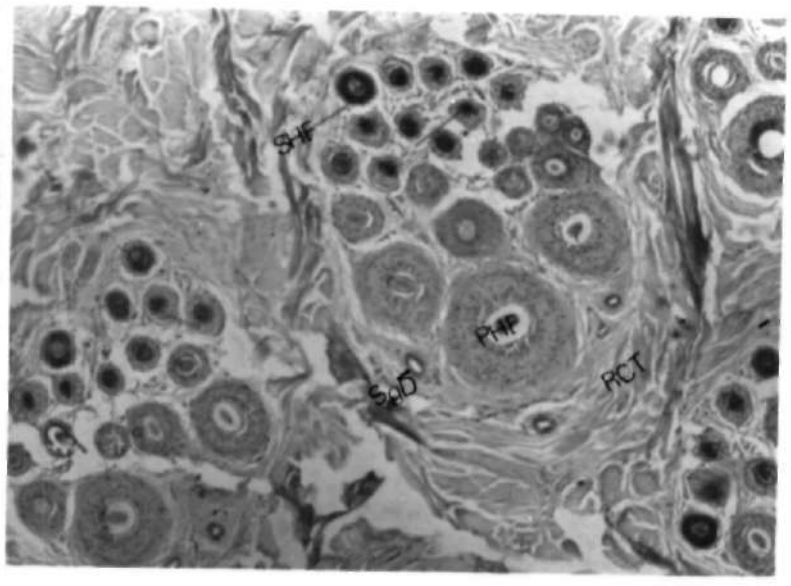
b

Camel skin, upper lip (horizontal section), Male: The singly arranged secondary hair follicles (SHF) with sebaceous glands (Sb) in the papillary layer (PL).

Haemalum, Picric Acid Eosin x 120.

PLATE VI

a



b

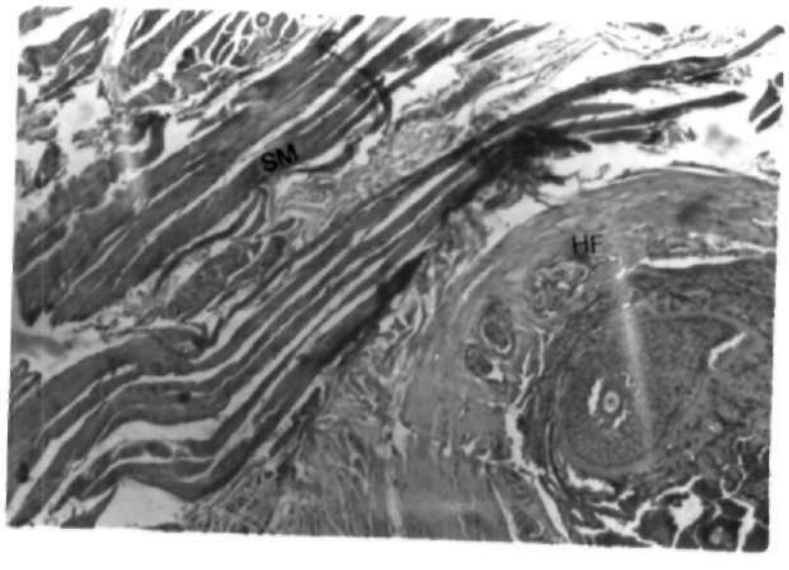


PLATE VI

a

Camel skin, midside (horizontal section), Female: Cluster of hair follicles in the reticular layer of dermis with secondary hair follicles (SHF) without distinct connective tissue septa. Primary hair follicles (PHF) with sweat gland ducts (SgD) having more distinct connective tissue envelopes.

H. & E. x 120.

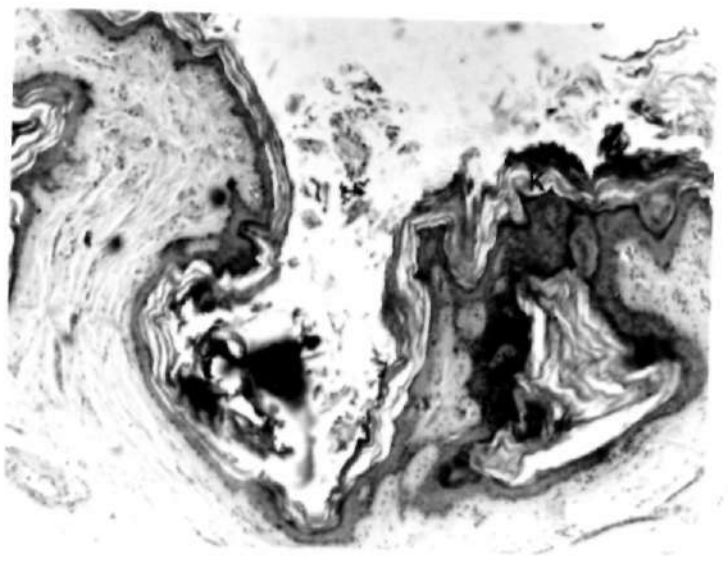
b

Camel skin, udder (horizontal section), Female: Striated muslce fibres (SM) in the dermis.

Haemalum, Picric Acid and Eosin x 300.

PLATE VII

a



b

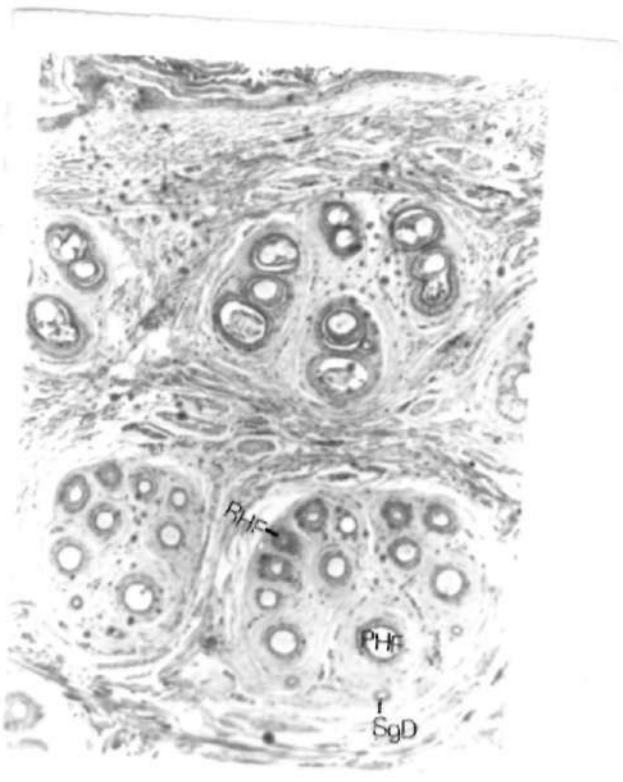


PLATE VII

a

Camel skin, teat of udder (oblique section), Female: Highly keratinized epidermis.

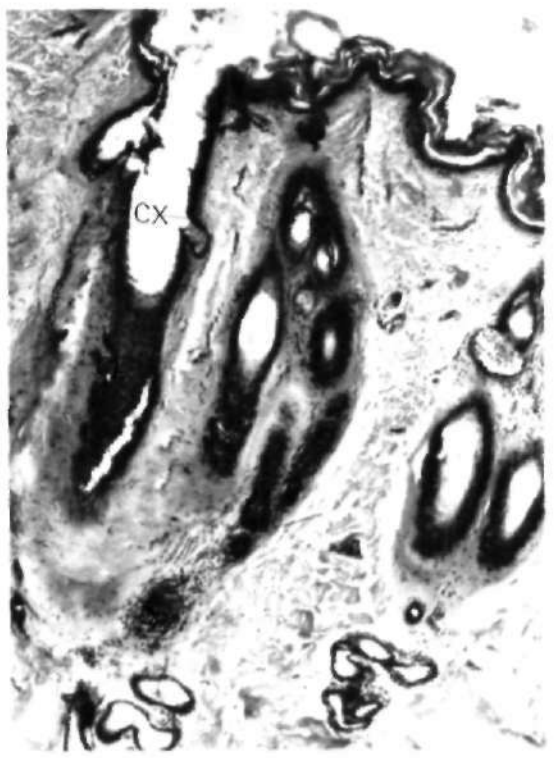
Masson's Trichrome x 300.

b

Camel skin, thigh (horizontal section), Male: Newly regenerating hair follicles (RHF) - mostly of secondary type. Three primary hair follicles (PHF) in an arc with sweat gland ducts (SgD).

H. & E. x 120.

a



b

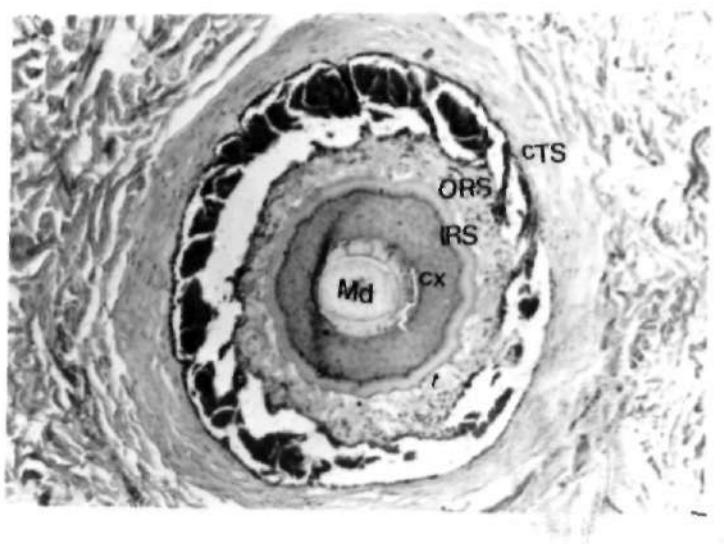


PLATE VIII

a

Camel skin, back (vertical section), Female: Hair follicles at telogen. Dermal papilla (DP) is outside the follicle, and the club (CL) within - below the cortex (CX).

H. & E. x 300.

b

Camel skin, upper lip (horizontal section), Male: A giant hair follicle in the dermis. The layers of the follicles from inside outwards are: 1. The hair medullar (Md), 2. The hair cortex (CX), 3. The Inner Root Sheath (IRS), 4. The Outer Root Sheath (ORS) and 5. The connective tissue sheath (CTS).

Haemalum, Picric Acid and Eosin x 600.

PLATE IX

a



b

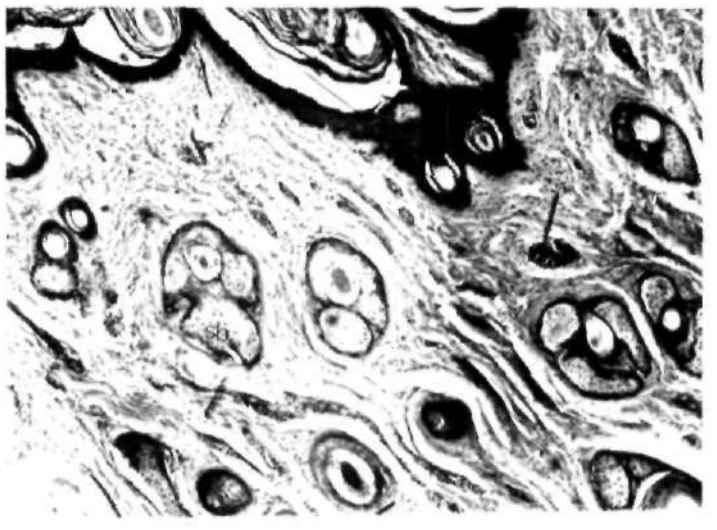


PLATE IX

a

Camel skin, midside (oblique section), Male: Simple branched saccular sebaceous glands (Sb) around both types of hair follicle (secondary and primary).

Haemalum, Picric Acid and Eoxin x 120.

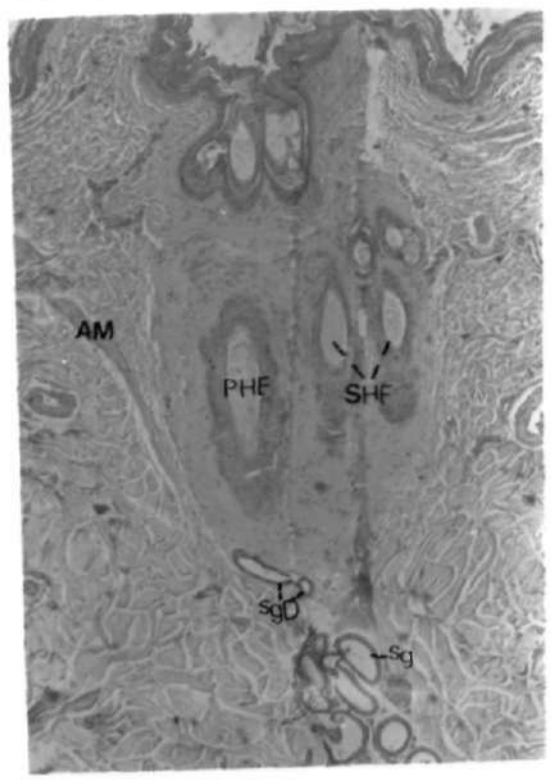
b

Camel skin, udder (oblique section), Female: The multilobular sebaceous glands (Sb) in association with detached secondary hair follicles at the nipple.

Haemalum, Picric Acid and Eosin x 120.

PLATE X

a



b

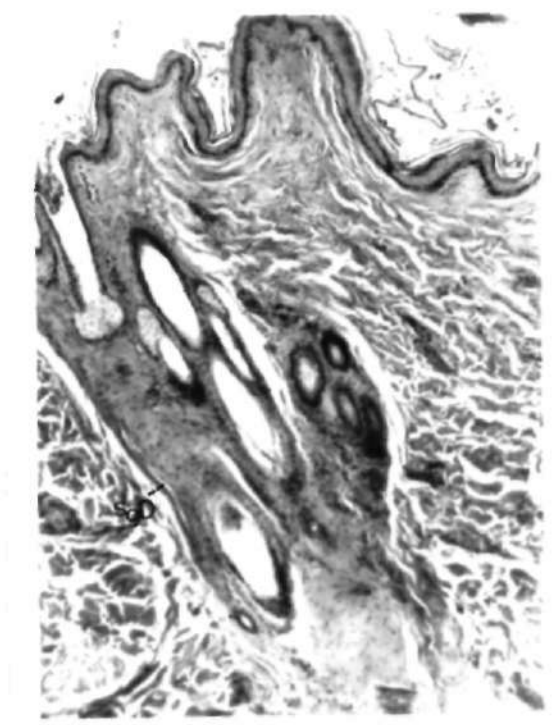


PLATE X

a

Camel skin, ventral abdomen (vertical section), Female: The sweat gland secretory portion (Sg) exists in relation to the primary hair follicle (PHF). Oblique section of the associated duct (SgD). The arrector pili muscle (AM) attaches to the ental side of the primary hair follicle (PHF). Secondary hair follicles are at the ectal side.

H. & E. x 120.

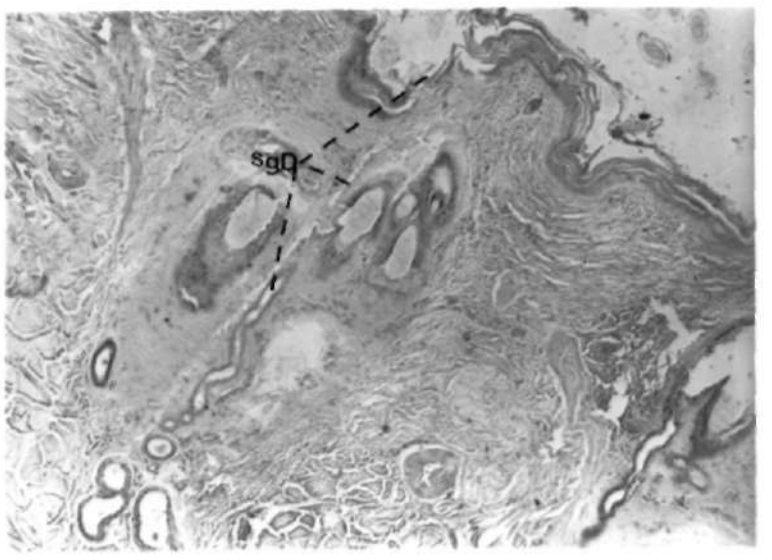
b.

Camel skin, neck (oblique section), Male: The narrow duct of the sweat gland (SgD) courses through and opens into the hair follicle neck at sebaceous gland level.

Haemalum, Picric Acid and Eosin x 120.

PLATE XI

a



b

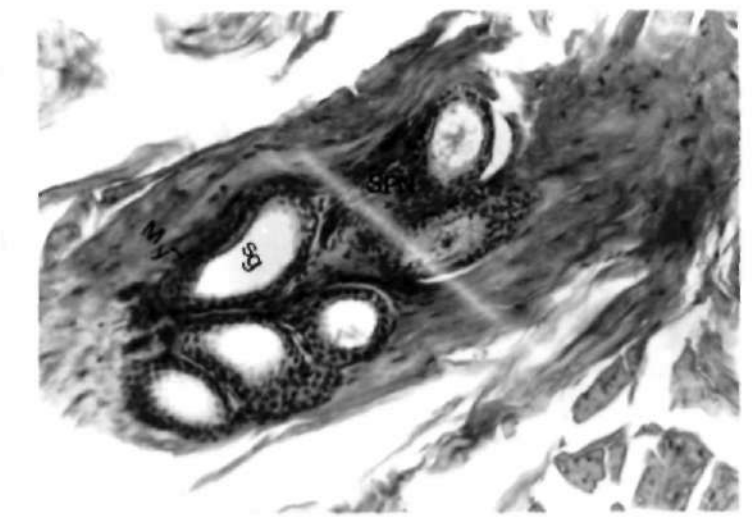


PLATE XI

a

Camel skin, neck (oblique section), Female: The spiral course of the sweat gland duct (SgD), opening directly onto the surface of the skin.

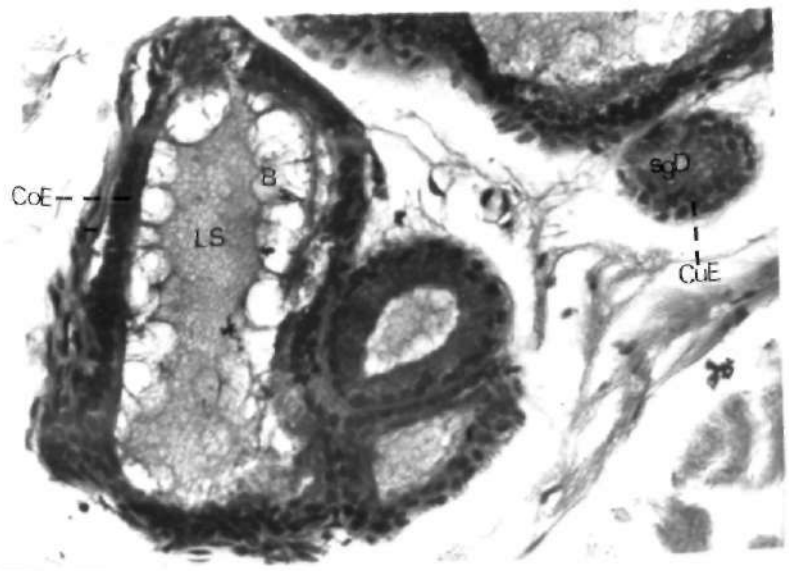
Haemalum, Picric Acid and Eosin x 120.

b

Camel skin, breech (transverse section), Male: The spiralled, expanded secretory portion of the sweat gland (Sg) finally ending in a loose serpentine net (SPN). The myoepithelial cells (MY), are at the base of the columnar epithelium.

H.

a



b

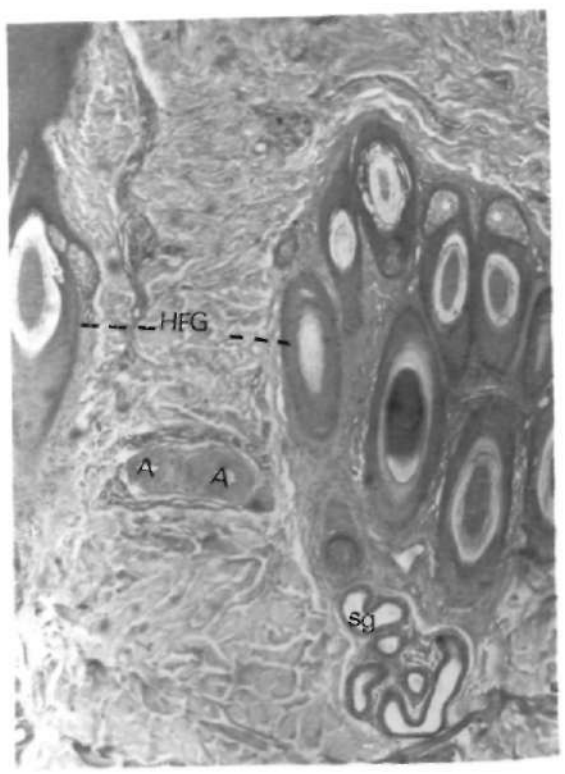


PLATE XII

a

Camel skin, udder (transverse section), Female: Bleblike protrusion (B) of the apical portions of the epithelium which retains the low columnar epithelial cells (CoE). The luminal secretions (LS). The two layered epithelial cells (CuE) of the sweat gland duct (SgD) are seen at tupper right.

H. & E. x 600.

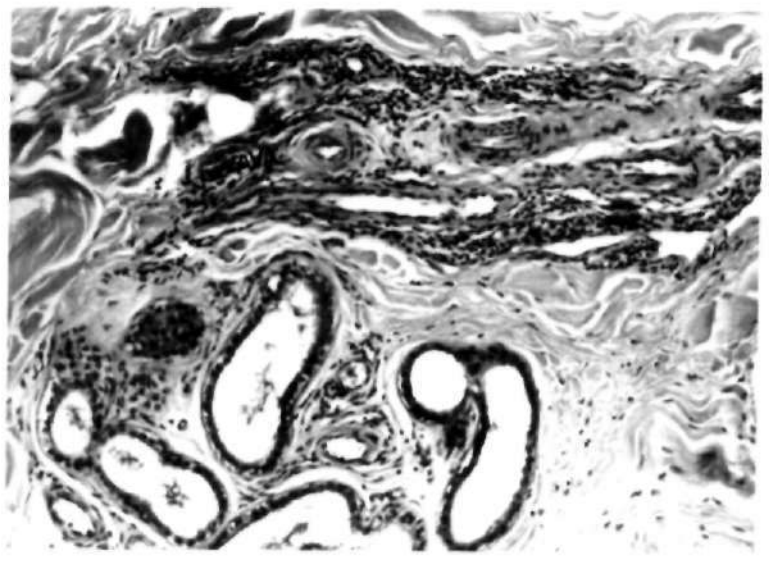
b

Camel skin, midside (vertical section), Male: Two spirally cut arteries (AA) and an arteriole (At) in the arteriovenous anastomoses (AVA) unit between two adjacent hair follicle group (HFG). Sweat gland (Sg) secretory portion below the hair follicle.

H. & E. x 300.

PLATE XIII

a



b

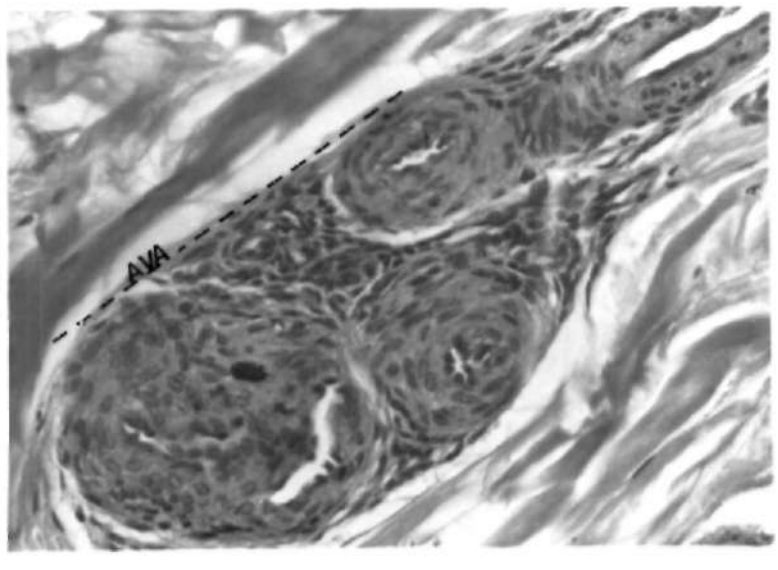


PLATE XIII

a

Camel skin, thigh (transverse section), Male: Arteriovenous anastomoses (AVA) in close association with the secretory portion of the sweat glands.

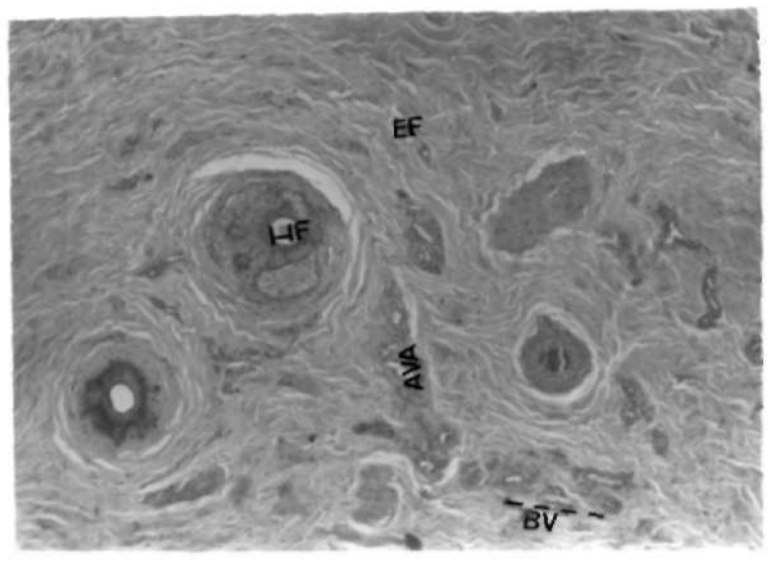
H. & E. x 120

b

Camel skin, midside (transverse section), Female: Arteriovenous anastomoses (AVA) within the reticular layer of dermis.

H. & E. x 600.

a



b

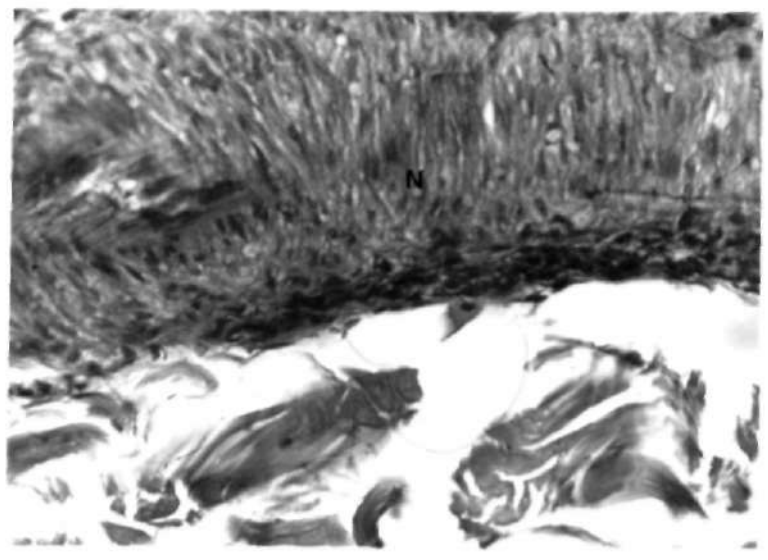


PLATE XIV

a

Camel skin, udder (horizontal section), Female: Scattered arteriovenous anastomoses (AVA's) and blood vessels (BV) between the elastic fibres (EF) of the dermis.

Masson's Trichrome x 120.

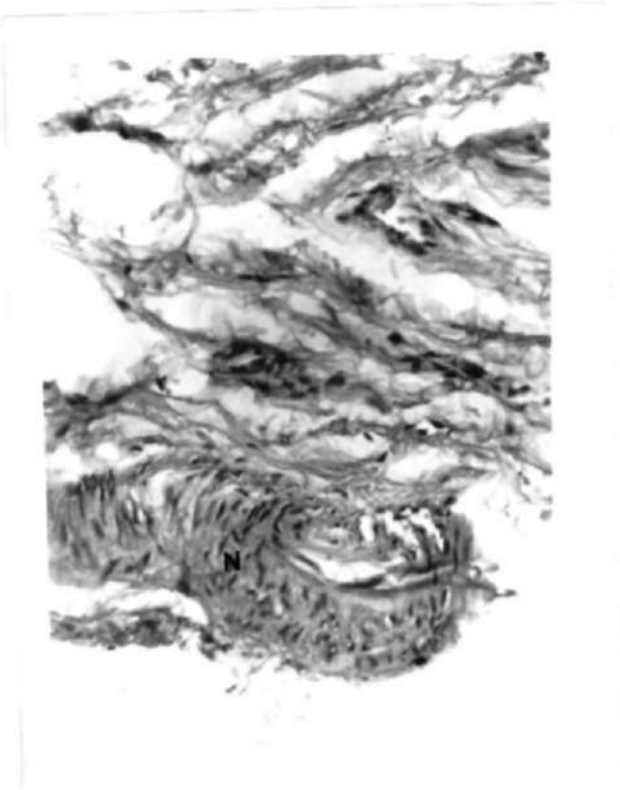
b

Camel skin, neck (oblique section), Female: Nerve trunk situated deep in the stratum reticulare.

P T A H x 600.

PLATE XV

a



b

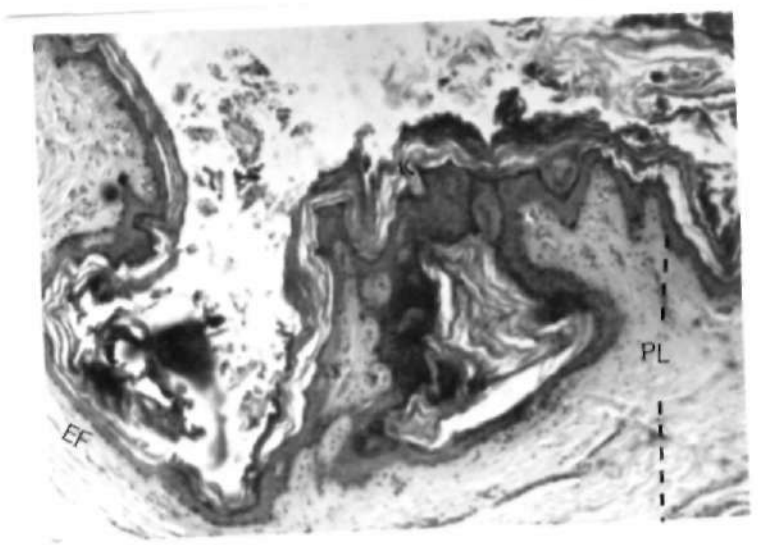


PLATE XV

a

Camel skin, neck (vertical section), Male: Elaborately pigmented nerve endings (N) very deep within the dermis.

P T A H x 600.

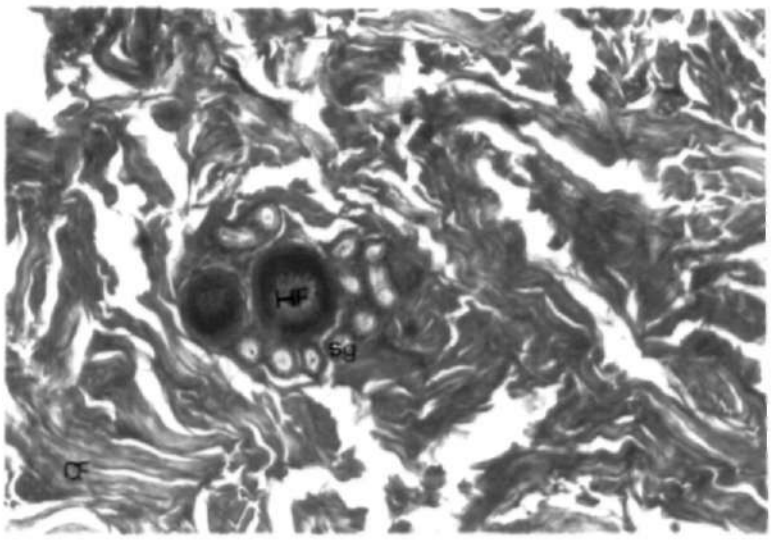
b

Camel skin, udder (oblique section), Female: Parallel archetectural distribution of the elastic fibres (EF) in the papillary layer (PL) of the skin. High epidermal keratinization (K).

Masson's Trichrome x 300.

PLATE XVI

a



b

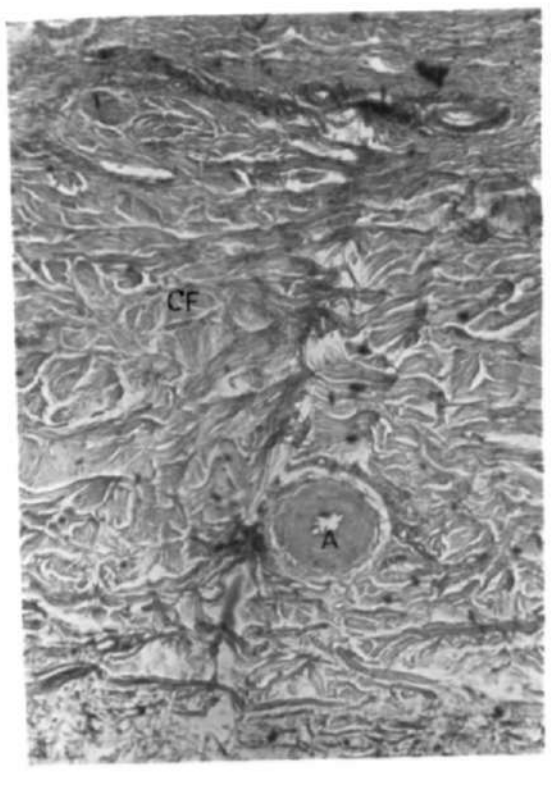


PLATE XVI

a

Camel skin, thigh (horizontal section), Male: The thick wavy collagen fibre (CF) bundles around hair follicles (HF) and the secretory portions of their sweat glands (Sg).

Masson's Trichrome x 300.

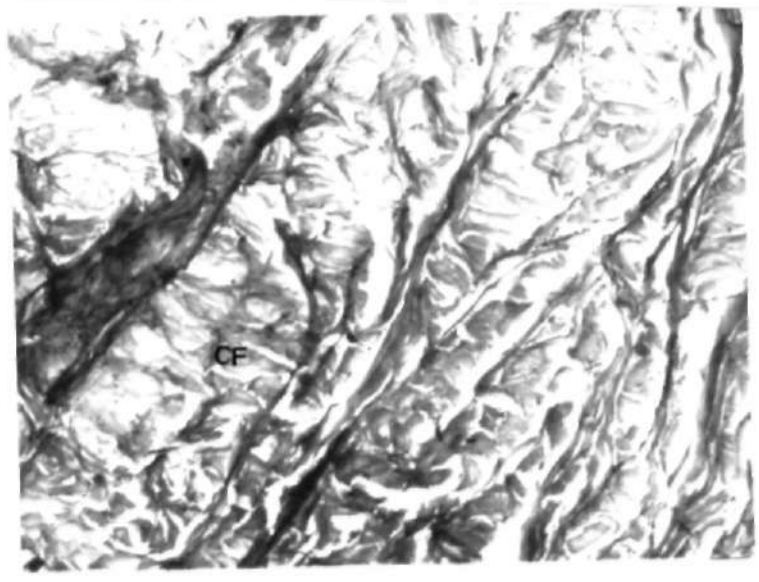
b

Camel skin, ventral abdomen (horizontal sections), Female: Wavy crosslinking of the collagen fibres (CF) around a solitary artery (A).

Masson's Trichrome x 120.

PLATE XVII

a



b

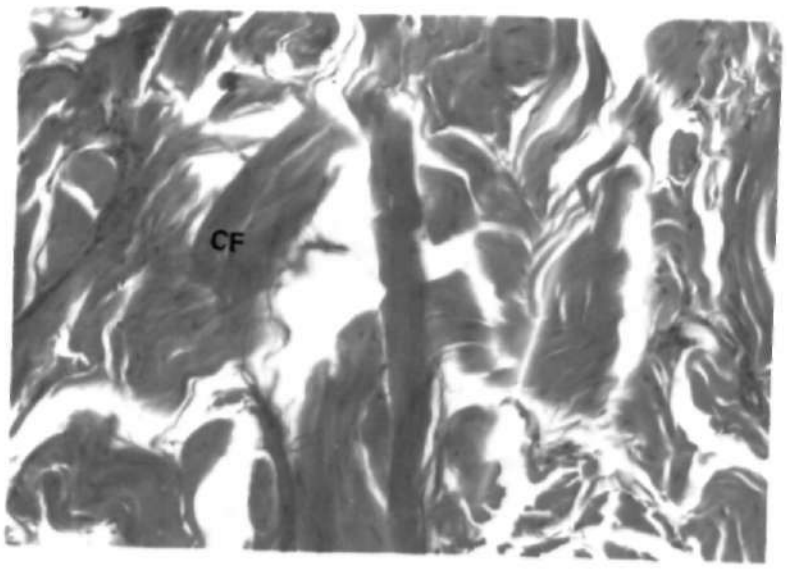


PLATE XVII

a

Camel skin, midside (horizontal section), Female: Leaflike branching of collagen fibre chunks and a regular closely knit cross-linking of the fibres.

Masson's Trichrome x 300.

b

Camel skin, neck (horizontal section), Male: Regular interconnecting slabs and special weave of the collagen fibres.

Masson's Trichrome x 600.

DISCUSSION

A. GENERAL HISTOLOGY

The epidermis of the camel skin did not vary from the general pattern that has been described by Jenkinson (1965) for the domestic animals.

Domestic animals have been divided into two classes on the basis of the arrangement of the hair follicles by Jenkinson (1965). The first one includes animals which do not exhibit hair follicle grouping, namely cow, horse and buffalo, in which individual hair follicle units are arranged at random in the skin; the second includes those which exhibit hair follicle grouping such as the camel, cat, dog, goat and sheep in which hair follicles are associated in clusters each cluster consisting of two to five large guard hairs surrounded by smaller lanugo hairs.

The arrangement of the compound follicles has been investigated by Lovell and Getty (1957) in dogs ranging in age from bith to 28 weeks of age. They found that at birth the follicles were simple (each containing a single primary or cover hair) but they develop into compound follicles by budding off six to nine accessory follicles below the level of the sebaceous glands ducts in which develop the secondary

or wool hairs. In dog therefore, each hair is in a common follicle with six to nine wool hairs and all emerge from a common orifice.

The arrangement of the hairs and their follicles in the camel is quite different from the arrangement in other animals (Lee and Schmidt-Nielson, 1962). It agrees with the findings of this study that in the camel, the cover (primary) hairs have separate follicles and each has multiple sebaceous glands and a single sweat gland. Associated with each two or three cover hairs are two to five groups of wool hairs, each group consisting of two to nine wool hairs which emerge from the common orifice of a compound follicle which branches above the level of the sebaceous glands (Lee et al., 1962).

The entire cluster is surrounded by a capsule of collagenous fibres except at the knee where it is surrounded by fibrocartilage. An unusually abundant undercoat of wool hairs is thus provided which as pointed out by Schmidt-Nielsen et al., (1957) provides an efficient barrier against heat gain from the environment. The presence of cartilage surrounding the cluster in lieu of connective tissue capsule in the skin at the knee has not been reported.

Macfarlane et al., (1958) have asserted that camels are somewhat similar to merino sheep and the two species have achieved nearly equal degrees of adaptation to hot dry environments. The follicle groupings observed in this study and by Dowling and Nay (1962) can be likened to those observed by Burns (1949) in the lambs of the English Leicester and Romney breeds. What she noticed in the lamb as the most evident unit at all ages was the single primary follicle with its corresponding cluster of secondaries, and this unit may be conveniently termed the 'primary group'. Most of the primary groups are arranged in threes to form trio groups. She found that it was often difficult to distinguish within the trio group, the secondaries pertaining to each primary; nevertheless, it remains evident that a group of secondaries develops around the ectal aspect of every primary follicle. The primary group may also be regarded as a fundamental unit of the coat.

Furthermore, like those observed in the camels here, Burns (1949), found that in the lambs, the accessory structures developed around the ental side of the follicles, and normally the secondaries corresponding to each primary were grouped around its ectal aspect. The follicle bundle seen in horizontal section at the levels of the sebaceous

glands of the primary follicles thus appears to be bounded at one side by the arrector pili muscles and sebaceous glands of the primary follicles.

According to Carter (1965), the morphology of the hair follicle group in particular or the integumental appendages at large, may fluctuate widely under the influence of endogenous cyclical change, (whether locally or systemically governed) which is the background of moulting in the pelage (hair) among so many mammals. Equally significant are the exogenous factors (e.g. environmental - food supply, rhythms of light and heat) which may modify the pelage and the skin structure. In the present study the cluster of follicles did not always exist as a trio. This is presumably in accordance with Carter's (1965) observations.

Jenkinson (1967) classified the tubular skin glands of mammals as consisting of two functional types, merocrine and holocrine. The merocrine consists of the apocrine and eccrine glands. It was distinguished by its morphological appearance during the process of secretion, its development and its position. An apocrine gland was defined as (1) developing from the hair anlage in the embryo, (2) always being situated beside or associated with a

hair follicle, and (3) exhibiting two phases of secretion - "necrobiotic" (involving partial degeneration of the secretory epithelium) and "simple". The eccrine gland in contrast was defined as one which (1) originated directly from the primitive epidermis, (2) was not associated with a hair follicle, and (3) did not exhibit necrobiotic secretion.

It was further stated that the sweat glands of the general body surface of man and certain primates, and in specialized areas of some mammals, such as footpads of the cat or dog are believed to be eccrine, while those in specialized areas of man, e.g. axilla, and in the skin of most haired mammalia are considered to be apocrine. This classification and distribution of sweat gland is still generally accepted, although some doubts have been expressed regarding its validity (Montagna and Parakkal, 1974).

But there is no unequivocal physiological evidence for the existence of a necrobiotic secretory cycle in the sweat glands of man or any other species. The presently accepted view of apocrine secretion is based mainly on the presence (after histological and histochemical processing) of cellular configurations in large sweat glands of

human axilla (Jenkinson, 1967). These configurations have been interpreted as representing different stages of necrobiotic cycle in which the epithelial cell increases in size from cubical to columnar; the luminal apex forms a bleb which breaks off to form the secretion and the cell finally reverts to its original cubical form (Jenkinson, 1967).

As presently observed in the camel there could be both types of sweat glands. In all the body areas studied, the sweat gland ducts were observed to open into the neck of the primary hair follicle above the level of the sebaceous gland ducts just like the apocrine type. However, in the skin of the neck region, the ducts were seen to open sometimes into the primary follicles as in all other sites and sometimes seen to open directly onto the skin surface, thus indicating a probable eccrine type.

It is therefore suggested that the sweat glands of the camel, instead of being called as mere apocrine (Lee and Schmidt-Nielsen, 1962; Dowling and Nay, 1962) may be classed as merocrine being mostly apocrine except in the neck region where they were both apocrine and eccrine.

The secretory portion of the sweat gland at the udder revealed bleblike protrusion of the apices of the epithelial cells, thereby representing a different stage of a "necrobiotic" cycle, which Jenkinson (1967) described as apocrine type of secretion. This interpretation has however been disputed by Montagna and Parakkal (1974), and they believed that the mechanism of secretion does not involve rupture of the cell membrane. They therefore consider it as simple form of secretion. The retention of their low columnar shape by the epithelial cells in the sweat glands at the udder region of the camel supports the latter view.

Cleland's (1909) claim, that camels visibly perspire only over a small area on the back of the neck, could be justified from the present finding of eccrine type of sweat glands in the neck region. Direct opening, might mean direct expulsion of sweat, at a probably faster rate than through the hair follicles. The fact that shorn camels were found to sweat freely than unshorn camels (Schmidt-Nielsen et al., 1957) means that the expulsion of sweat, onto the skin surface, without any obstruction by the hair was quicker and apparently more profuse.

The absence of an arteriovenous anastomoses (AVA) in the upper lip of the camel, where there are also no sweat gland are interrelated especially for heat regulation. Discrete networks were seen around hair follicles and sweat glands of the other regions but the general distribution was really one unit of interconnecting vessels of separate plexuses.

According to Rollinson et al., (1972), branches from nerve trunks in the papillary layer ramified peripherally in close association with blood vessels and innervated the epidermis, the component of the hair follicle unit and blood vessels.

This study did not reveal any evidence of sweat gland innervation: Accordingly, the low water loss from camel skin (Schmidt-Nielson, 1964) suggests that the thermal sweating response of this species may be less efficient than that of the horse, sweat gland of which is highly innervated. The, camel depends more on heat storage in warm conditions (Schmidt-Nielson, 1964) creating a gradient on the skin surface preventing heat gain.

The manner in which the collagen fibre bundles are woven is a natural characteristic of hides and skins (Tancous, Roddy and O'Flaherty, 1959). Normally the skins of animals are of good structure; that is,

the organisation is such that the fibre bundles are closely interlaced in all directions.

Within the dermis of the camel, the papillary layer was readily distinguished not only by the different pattern of the fibre network, but also the coarseness of the collagen fibres in the reticular layer. The wavy cross-linkage of the collagen at the female ventral abdomen region would make a fairly weak resultant leather. But the dermis at the midside with their regular interconnecting slabs of spatial weave and a leaflike branching chunks of collagen with a regular closely knit cross-linking of the fibres, will condition the skin, and would make superior material for sole leather.

According to Tancous et al., (1959), the fibre pattern characteristically will vary within a skin with high angle of weave (collagen fibres not entirely lying parallel to each other) in the midside areas and with very low angle of weave (collagen fibres existing parallel and close to each other) in the ventral abdomen. There are some leather making skins in which the angle of weave is low in all areas. High angle, low angle and intermediate angle of weaves were observed in the various sites in this study.

B. MEASUREMENTS

I. HAIR FOLLICLES - DEPTH (FD), LENGTH (FL), DIAMETER (FDM) AND MEDULLATION RATIO

Jenkinson and Nay (1968), found that there was a tendency for cattle with a wide length to diameter ratio (L/D) to have a high follicle depth value. That tendency was not found in the camel in this study. The hair follicle depth in relation to the thickness of the dermis varied within regions and between sexes. This was probably due to the fact that the deepest hair follicle within the cluster was measured, not considering at what stage of the hair follicle cycle it was in. This relationship is important because the possession of a low follicle depth could be an adaptive feature in cattle in tropical environments (Amakiri, 1974b).

The variation in the values of the hair follicle depth and length from region to region and within sex, and the higher values of the length than the depth indicates that the hair follicles within the cluster variously exist at some particular angles to the surface of the skin. The angle of the hair follicle to the surface may therefore determine the angle of the hair (shaft) on the surface of the skin. The hair that exists at a more acute angle should provide

greater insulation and prevent heat gain from the environment.

Ratio of hair follicle length to its diameter determines the shape of the hair follicle. Areas which had a high follicle length to diameter ratios had more slender follicles than those with lesser ratios. The thicker follicles are thus able to contribute to better heat tolerance than the thinner ones because according to Jenkinson and Nay, (1968), the cattle follicle is thicker in the hot environment than in the colder temperate zones.

The shapes of the hair follicles at the common sites did not show any significant differences between the two sexes, though the female, from the values got, could be slightly less tolerant to the heat of the environment; but not significantly so.

The short and thick spring and summer hair have lower (narrower) medullation ratios than the long and thin hairs of the winter coats. These thick, stiff hair fibres with low medullation ratio are known to facilitate air movement at the skin surface and thus aid evaporation of moisture. In addition they are better infrared reflectors (Blackburn, 1965 and are therefore highly correlated with heat tolerance (Dowling, 1959a). On the basis of the lower medullation ratio observed in the White Fulani cattle as compared

to the Friesian one by Amakiri and Hill (1975), the White Fulani was found to be more heat tolerant than the Friesian. It could be that the male camel is relatively more heat tolerant than the female due to its narrower ratio. Judging from the overall medullation ratio, the camel is highly heat tolerant. The more the medulla, the narrower the ratio, and so, the more heat tolerance.

II. HAIR FOLLICLE DENSITY AND SWEAT GLAND DENSITY

According to Carter and Clarke (1957) follice density values usually are modified by variation in age and general body condition at sampling. The follicle population of the camel in this study was not determined in follicle groups but was done individually in fields because of the possible effect of genetic selection on follicle group size. Dowling and Nay (1962), established in the Autralian camel that there were on the average 28 hair follicles in each group, and the number of follicle group per square centimeter was 63 to 65 at the midside region. Measurements such as this can result in dissimilar group size with similar follicle productivity. This view is strengthened by the presence of club and regenerating hairs in the skin samples of the camels observed in this study.

The density of hair follicles which can be related to that of sweat glands because of the association of the ducts with the primary hair follicle, is an indicator of heat tolerance. An unusually abundant undercoat of hairs when provided is an efficient barrier against heat gain from the environment (Schmidt-Nielsen et al., 1957).

An important aspect of the hair follicle density is the ratio of the number of secondary hair follicles to primary hair follicles. If the ratio is high, it is an indicator that there is a small number of sweat glands in relation to the dense fine undercoat, which mitigates against efficient heat loss (Jenkinson, 1972).

Dowling and Nay (1962), counted 200 sweat glands per square centimeter of skin in the (Australian desert) camel, at the midside region.

At the midside regions of the Nigerian male and female camels, 317 sweat glands per square centimeter of skin were counted. The data varies from counts in the Australian camel. The probable reason for this difference could be the biotic, physical and environmental variables prevalent in the two different regions. Physiologically, the more sweat glands in an animal, the more efficient heat loss.

Jenkinson (1972), stated that sweat glands per unit area of skin varies among species, between individuals and breeds. The differences in density between the domestic mammals are even more marked. For example there are about 20 to 30 sweat glands per square centimeter skin in pig, compared with 200 in sheep and goat, 400 in buffalo (Bos bulbalis) and as many as 2,000 in some Zebu cattle (Jenkinson, 1972).

The main variation according to Carter (1965) are those which occur during growth and development; those which are part of the general skin pattern of the individual; those which arise in the course of t the physiological cycles or events, and those which arise and establish themselves by various genetic mechanisms within the population.

Although differences have been noted in sweat gland density and possibly sweating efficiency in the different domestic mammals, the physiological activity of the gland appears to be a more important factor (Jenkinson, 1972). In the cow the density of sweat glands is similar over the general body surface yet the evaporative loss from the skin is considerably greater on the neck than on the ventral surface of the body (Mclean, 1963).

III. SWEAT GLANDS - DEPTH (SGD), LENGTH (L), DIAMETER (D) SHAPE (L/D) RATIO

Dowling and Nay (1962), in supporting Leonard's (1894) failure to detect sweat glands in the skin of the camel, claim that the glands in the camel are deeper than in other species of animals, making it easy to miss in sections.

In this study, it was found that the sweat glands were not too deeply situated in the skin of the neck region. This may be why Cleland (1909) thought that they perspired only on the back of the neck. The eccrine glands found at the neck in this study were usually histologically not too deep into the dermis and their ducts opened directly at the epidermis. The depths of the glands also varied significantly from site to site.

The length of the sweat gland decides the degree of coil. Mammalian atrichial (eccrine) and epitrichial (apocrine) sweat glands are variously coiled (Amakiri, 1975). Morphologically the sweat glands of the camels appear to occupy a position intermediate between those of man and cattle (Dowling and Nay, 1962). According to them, the glands of the camel, though more slender and more coiled than those of the cow, are thicker and less coiled than those of man. They

were referred to by Lee and Schmidt-Nielsen (1962), as simple coiled tubular sweat glands.

The high measurement values obtained in this study confirm the highly coiled nature of the sweat gland of the camel. There were no significant variations between the sites in both sexes. It means that there are no extensive variations in the lengths of the glands from site to site.

Differences for the sweat gland diameter (D) were significant ($P<0.05$) in the male but not in the female. It could be that physiologically, the female out of necessity maintains a fairly uniform diameter throughout the body.

Sweat gland shape, which was defined as the ratio of sweat gland length to sweat gland diameter L/D, has been found to be a reliable indicator of skin type in the cattle when measured on skin samples from the neck or midside of adult animal. Other skin measurements such as hair follicle depth (FD) may also prove useful under restricted conditions and in the subclassification of skin type based on sweat gland shape (Jenkinson and Nay, 1968).

Jenkinson and Nay (1968, 1972 and 1973) classified three skin types in European, African, Asian and South American cattle. The type I skin with L/D less than 8.0 and FD less than 1.5 mm had saclike sweat glands. These were predominant among African and Asian cattle. The type II skin, with L/D greater than 12.0 and FD greater than 2.0 mm had coiled serpentine sweat glands. These were predominant in European cattle. Type III skin, predominantly found in South American cattle had L/D greater than 12.0 and FD less than 1.5 mm. The glands of these cattle were also highly coiled and serpentine, but their hair follicle level is similar to type I.

Types I and III cattle are mostly found in the tropics, and are known to be tolerant to hot environments (Jenkinson and Nay, 1973). They further established that the features of these two skin types, probably result from adaptation to tropical conditions, or more likely from natural selection and selective breeding in hot environments. Common to both types is a shallow hair follice depth, of less than 1.5 mm.

In this study, the camel, showed at the neck, a hair follicle depth, both in the male and female, less than 1.5 mm. The camel skin can thus be classified as similar to the type III cattle skin of

South America, based on its highly coiled serpentine sweat gland shape. Unlike in the cattle, the camel's hair follicles are in clusters and there are two different kinds (secondary and primary). The deepest hair follicle within the cluster was measured in this study, thus leaving numerous shorter hair follicles unmeasured.

Jenkinson and Nay (1973), concluded that cattle with lesser hair follicle depth are likely to be more tolerant to tropical environments. Consequently, animals with skin types I and III and types intermediate to them would appear to be more adapted to tropical conditions than animals with type II skin, which are not indigenous to Africa or Asia. This conclusion was supported by the fact that European breeds resident in South Africa and South America have lesser hair follicle depths, thicker hair follicles and a tendency towards smaller sweat gland volume than their counterparts in Europe.

It was earlier mentioned in this study that an unusually abundant undercoat of hairs when provided is an efficient barrier against heat gain from the environment (Schmidt-Nielsen et al., 1957). This is to emphasize the fact that since the deepest follicle measured within the follicle cluster of the camel

gave a value less than 1.5 mm, and since the lesser hair follicle depths are to be more tolerant to tropical environments (Jenkinson and Nay, 1973), it is reasonable to conclude for this study that the remaining unmeasured hair follicles, which were even less deep than the ones measured, contribute to making the camel even more tolerant to the heat of its environment than any type III cattle which does not exhibit hair follicle groupings.

Sweat gland shape does not appear to reflect glandular activity since similar ranges of shape in cattle are found in different continents (Jenkinson and Nay, 1973). But animals with large saclike glands are initially at a greater advantage when sweating is required of them, since they can carry large reserves (Nay, 1959), for there is a correlation between sweat gland shape and sweat gland volume (Nay and Hayman, 1963). Sweat gland volume in cattle is known to decrease in summer after heat exposure (Hayman and Nay, 1958; Findlay and Jenkinson, 1964), whereas Amakiri and Mordi (1975) established that mean sweat gland volume has no direct effect on sweating rate. Rather, they attributed sweating rate to differences in sweat gland sizes and densities.

Further studies on the sweating rate at different body regions of the camel are required, and correlating these with skin and ambient temperatures with a view to validating the extent to which sweat glands are responsible for the camel's adaptation to its hot desert environment.

This might be necessary in the sense that the insulation of a super cutaneous coat against solar radiation may be, or has been, more advantageous than a capacity to discharge sweat onto relatively naked skin (Bligh, 1972).

SUMMARY AND CONCLUSIONS

The histology of the skin of the camel has been found to be basically similar to that of domestic animals. But, the hair follicle cluster within the dermis at the knee rather than being embedded as usual in reticular connective tissue was surrounded by fibrocartilage.

Because the two types of sweat glands (eccrine and apocrine) were found in the neck region, it is deemed more appropriate to refer to the camel's sweat glands as merocrine with preponderance of apocrine gland, rather than the usual reference to it as mere apocrine. The term merocrine embraces both eccrine and apocrine.

From the nature of the weave of the collagen fibres of the dermis, the camel skin when put to leather manufacture could be superior material for sole leather if the flaying of the skin is done to include the midside region.

The overall low hair follicle depth, in relation to the thickness of the dermis, could be a factor to be considered in the camel's superior heat tolerance. The morphology of the hair follicles, (they being thick), may be contributing to the camel's

better capacity for heat tolerance. Also relevant to this animal's adaptation on its environment is its low (narrow) medullation ratio.

The camels under this study had relatively low sweat gland density when compared with cattle, but fairly high secondary hair follicle density; thus sweating proficiency as compared to the coat's insulation value in terms of adaption to environmental heat could be less paramount.

Sweat glands of the camel were deep within the sections but relatively shallow in the neck region. Eccrine glands are not usually very deep into the dermis. The shape of the sweat gland of the camel has been determined to be highly coiled, and with its low follicular depth was classified as comparable to the type III skin of the South American cattle.

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TABLES

TABLE 1:

Male Camel Average Hair Follicle Depth in Millimeters (mm)

Body Site	Mean Measurement (mm)	S.E. ±
Hump	1.52	0.57
Upper lip	1.35	0.42
Breech	1.12	0.34
Neck	0.95	0.25
Knee	0.84	0.23
Thigh	0.82	0.37
Midside	0.72	0.24
Back	0.48	0.19
Average	0.98	0.34

STATISTICAL ANALYSIS

	d.f.	M.S.	F	COMMENT
Variation between sites	7	9750.3	15.040	Significant
Error	89	648.3		P<0.05

TABLE 2:

Female Camel Average Hair Follicle Depth in Millimeters (mm)

Body Site	Mean Measurement (mm)	S.E. ±
Midside	1.82	0.71
Hump	1.52	0.04
Back	0.98	0.22
Ventral abdomen	0.90	0.28
Neck	0.80	0.25
Udder	0.78	0.46
Average	1.13	0.43

STATISTICAL ANALYSIS

	d.f.	M.S.	F.	COMMENT
Variation between sites	5	10175	8.965	Significant
Error	46	1135		P<0.05

TABLE 3:

Male Camel Average Hair Follicle Length in Millimeters (mm)

Body site	Mean Measurement (mm)	S.E. ±
Neck	1.91	0.33
Hump	1.81	0.62
Upper lip	1.41	0.44
Breech	1.23	0.30
Knee	0.95	0.30
Thigh	0.89	0.38
Midside	0.84	0.28
Back	0.58	0.27
Average	1.20	0.48

STATISTICAL ANALYSIS

Variation between	d.f.	M.S.	F.	COMMENT
sites	7	10448.3	12.960	Significant
Error	89	806.2		P<0.05

TABLE 4:

Female Camel Average Hair Follicle Length in Millimeters (mm)

Body site	Mean Measurement (mm)	S.E. ±
Midside	2.54	0.82
Hump	1.12	0.08
Back	1.2	0.22
Ventral abdomen	1.02	0.31
Udder	0.97	0.56
Average	1.25	0.64

STATISTICAL ANALYSIS

Variation between sites	d.f.	M.S.	F	COMMENT
	5	26001	16.695	Significant
Error	46	1557		P<0.05

TABLE 5:

Male Camel Average Hair Follicle Diameter in Micrometer (um)

Body site	Mean Measurement (um)	S.E. ±
Hump	305.50	108.43
Upper lip	145.0	47.94
Breech	107.50	47.27
Thigh	85.75	20.95
Neck	81.25	46.58
Back	81.25	17.92
Knee	72.50	10.46
Midside	43.77	6.45
Average	115.31	82.17

STATISTICAL ANALYSIS

Variation between	d.f.	M.S.	F	COMMENT
sites	7	2255.974	26.073	Significant
Error	53	9.818		P<0.05

TABLE 6:

Female Camel Average Hair Follicle Diameter in Micrometer (um)

Body site	Mean Measurement (um)	S.E. ±
Hump	137.50	17.70
Ventral abdomen	104.10	17.40
Udder	103.80	29.72
Back	70.0	16.87
Midside	67.50	32.38
Neck	41.30	10.29
Average	87.4	34.30

STATISTICAL ANALYSIS

Variation between sites	d.f.	M.S.	F	COMMENT
	5	42.32	3.861	slightly significant
Error	42	10.96		P<0.05

TABLE 7:

Male Camel Average Sweat Gland Depth in Millimeters (mm)

Body site	Mean Measurement (mm)	S.E. ±
Breech	*4.35	1.09
Thigh	*3.50	1.17
Hump	3.01	0.86
Neck	2.03	0.63
Midside	1.96	0.17
Back	1.63	0.22
Knee	1.60	1.49
Average	2.58	1.06

*Oblique sections

STATISTICAL ANALYSIS

Variation between	d.f.	M.S.	F	COMMENT
sites	6	71530	19.437	Significant
Error	63	3680		P<0.05

TABLE 8:

Female Camel Average Sweat Gland Depth in Millimeters (mm)

Body site	Mean Measurement (mm)	S.E. ±
Hump	2.27	0.11
Midside	2.25	1.0
Udder	1.66	0.32
Back	1.63	0.24
Ventral abdomen	1.57	0.26
Neck	1.45	0.20
Average	1.81	0.36

STATISTICAL ANALYSIS

Variation between sites	d.f. 5	M.S. 6671	F 5.169	COMMENT significant
Error	49	1290		P<0.05

TABLE 9:

Male Camel Average Sweat Gland Length in Micrometer (um)

Body site	Mean Measurement (um)	S.E. ±
Neck	1766.4	319.66
Back	1683.2	555.66
Breech	1078.0	71.27
Thigh	1051.6	89.68
Hump	826.0	125.87
Midside	807.6	106.90
Average	1202.1	289.5

STATISTICAL ANALYSIS

Variation between	d.f.	M.S.	F	COMMENT
sites	5	197677	2.359	Not significant
Error	21	83789		P>0.05

TABLE 10:

Female Camel Average Sweat Gland Lertth in Micrometer (um)

Body site	Mean Measurement (um)	S.E. ±
Udder	2371.6	438.72
Ventral abdomen	2048.0	546.96
Neck	1830.4	463.74
Midside	1418.4	239.96
Back	1153.2	164.95
Average	1764.3	397.90

STATISTICAL ANALYSIS

Variation between sites	d.f.	M.S.	F	COMMENT
	4	295862	1.869	Not significant
Error	20	158297		P>0.05

TABLE 11:

Male Camel Average Sweat Gland Diameter in Micrometers (um)

Body site	Mean Measurement (um)	S.E. ±
Thigh	66.32	11.01
Breech	62.38	29.15
Neck	57.76	10.83
Midside	52.72	19.36
Back	48.28	17.73
Hump	42.40	21.24
Average	55.06	19.31

STATISTICAL ANALYSIS

Variation between sites	d.f. 5	M.S. 2102.2	F 5.637	COMMENT Significant
Error	21	373		P<0.05

TABLE 12:

Female Camel Average Sweat Gland Diameter in Micrometer (um)

Body site	Mean Measurement (um)	S.E. ±
Udder	66.24	38.24
Ventral abdomen	65.12	27.28
Back	62.32	33.87
Neck	60.72	25.01
Midside	58.90	9.09
Average	62.66	28.50

STATISTICAL ANALYSIS

Variation between	d.f.	M.S.	F	COMMENT
sites	4	289.8	0.357	Not significant
Error	20	812.4		P>0.05

TABLE 13:

Male Camel Average Sweat Gland Shape (Length: Diameter Ratio)

Body site	Length/Diameter Ratio	Comment
Back	34.86	Highly coiled tubular
Neck	30.58	Highly coiled tubular
Hump	19.48	coiled tubular
Breech	17.14	coiled tubular
Thigh	15.86	coiled tubular
Midside	15.31	coiled tubulat
Overall Mean ($\bar{x}$)	22.21	Highly coiled tubular

TABLE 14:

Female Camel Average Sweat Gland Shape (Length: Diameter Ratio)

Body site	Length/Diameter Ratio	Comment
Udder	35.80	Highly coiled tubular
Ventral abdomen	31.45	Highly coiled tubular
Neck	30.14	Highly coiled tubular
Midside	24.08	coiled tubular
Back	1808	coiled tubular
Overall Mean ($\bar{x}$)	28.0	Highly coiled tubular

TABLE 15:

Average Primary and Secondary Hair Follicle and Sweat Gland Density Per Square Centimeter of Camel Skin - Male and Female

Male Camel			Female Camel		
Body Sites	Primary Follicle & Sweat Gland	Secondary Follicle	Body Site	Primary Follicle & Sweat Gland	Secondary Follicle
Midside	317	2133	Midside	317	2550
Neck	350	1400	Neck	283	1233
Back	433	1717	Back	550	1633
Hump	33	583	Hump	200	600
Thigh	400	1816	Udder	33	500
Upper lip	Nil	750	Ventral abdomen	466	1700
Breech	233	1983			
Mean	294.3	1483.1		308.2	1369.3
S. E.	145.6	604.5		185.2	766.7

TABLE 16:

Average Hair Follicle and Sweat Gland Density of Male Camel in Six Random Micrometer Fields of One Square Millimeter Each

Body Site	Primary Follicle n=6	S.E. ±	Secondary Follicle n=6	S. E. ±	Sweat Gland n=6	S. E. ±
Midside	19	1.72	128	6.25	19	1.72
Neck	21	1.76	84	4.16	21	1.76
Back	26	1.03	103	3.97	26	1.03
Hump	2	0.51	53	1.94	2	0.51
Thigh	24	10.9	109	5.08	24	1.09
Breech	14	0.81	119	7.91	14	0.81
Upper lip	Nil	Nil	45	2.25	Nil	Nil
Knee	Calloused		Calloused		Calloused	

TABLE 17:

Average Hair Follicle and Sweat Gland Density of Female Camel in Six Random Micrometer Fields of One Square Millimeter Each

Body Site	Primary Follicle n=6	S.E.	Secondary Follicle n=6	S.E. ±	Sweat Gland n=6	S.E. ±
Midside	19	0.75	53	5.16	19	0.75
Neck	17	1.67	74	3.20	17	1.67
Back	33	2.07	98	3.98	33	2.07
Udder	2	0.51	30	2.09	2	0.51
Ventral abdomen	28	1.37	102	6.38	28	1.37
Hump	12	0	36	1.72	12	0

TABLE 18:

Comparison of Hair Follicles and Sweat Gland Density Per Square Centimeter of Skin Between Male and Female Camel at Common Sites

	Male				Female			
Body Site	*Sweat Glands	S.E. ±	Secondary Follicles	S.E. ±	*Sweat Glands	S.E. ±	Secondary Follicles	S.E. ±
Midside	317	172.20	2133	625.03	317	75.28	2550	516.72
Neck	350	176.06	1400	416.73	283	167.33	1233	320.42
Back	433	103.28	1717	397.07	550	207.36	1633	393.33
Hump	33	15.64	583	194.08	200	0.0	600	172.24
Overall Mean ($\bar{x}$)	283	173.82	1458	656.17	338	149.94	1504	816.78

*Number of Sweat glands equivalent to the number of primary hair follicles

STATISTICAL ANALYSIS

Sweat Glands and Primary Follicles: t value = 0.34 Not significant P>0.05

Secondary Follicles t value - 0.062 Not significant P>0.05

TABLE 19:

Secondary Hair Follicle to Primary Hair Follicle (S/P) Ratio

Male Camel		Female Camel	
Body Site	Ratic	Body Site	Ratio
Midside	7:1	Midside	8:1
Neck	4:1	Neck	4:1
Back	4:1	Back	3:1
Hump	18:1	Hump	3:1
Upper lip	0	Udder	15:1
Thigh	5:1	Ventral abdomen	4:1
Breech	9:1		
Knee	Calloused		
Overall Mean ($\bar{x}$)	6:1	Overall Mean ($\bar{x}$)	4:1

TABLE 20:

Medullation Ratio in Male and Female Camel's Hair

Male		Female	
Body Site	Ratio	Body Site	Ratio
Upper lip	0.98:1	Neck	0.86:1
Neck	0.93:1	Hump	0.93:1
Hump	Calloused	Back	0.93:1
Back	0.96:1	Midside	0.89:1
Midside	0.89:1	Udder	0.92:1
Breech	0.98:1	Ventral abdomen	0.57:1
Thigh	0.98:1		
Knee	Calloused		
Overall Mean ($\bar{x}$)	0.95:1	Overall Mean ($\bar{x}$)	0.85:1
Coefficient variation (%)	4.2	Coefficient of variation (%)	16.5

TABLE 21:

Thickness of the Camel Epidermis and Dermis in Millimeters (mm)

Male			Female		
Body Site	Epidermis	Dermis	Body Site	Epidermis	Dermis
Upper lip	0.88	5.1	-	-	-
Neck	0.03	3.59	Neck	0.05	3.50
Hump	0.25	4.43	Hump	0.60	2.95
Midside	0.28	3.53	Midside	0.05	5.28
Back	0.05	3.73	Back	0.05	3.01
Breech	0.02	4.17	Udder	0.22	1.76
Thigh	0.07	2.62	Ventral abdomen	0.11	2.50
Knee	0.04	3.40			
Average ($\bar{x}$)	0.20	3.82	Average ($\bar{x}$)	0.18	3.16

TABLE 22:

Thickness of the Male and Female **Camel Epidermis and Dermis at** Common Sites in Millimeters (mm)

Male			Female		
Body Site	Epidermis	Dermis	Body Site	Epidermis	Dermis
Neck	0.03	3.59	Neck	0.05	3.50
Hump	0.25	4.43	Hump	0.60	2.95
Midside	0.28	3.53	Midside	0.05	5.28
Back	0.05	3.73	Back	0.05	3.01
Average ($\bar{x}$)	0.15	3.82	Average ($\bar{x}$)	0.19	3.69

STATISTICAL ANALYSIS

	t value	Comment
Epidermis	0.18	Not significant P>0.05
Dermis	0.17	Not significant P>0.05

TABLE 23:

Hair Follicle Shape (FL/FDM) of Male and Female Camel at Various Body Sites

Male		Female	
Body Site	Ratio	Body Site	Ratio
*Neck	23.52	*Neck	20.50
*Hump	5.93	*Hump	8.15
*Midside	19.20	*Midside	37.63
*Back	7.14	*Back	14.57
Breech	11.44	Udder	9.34
Thigh	10.38	Ventral abdomen	9.80
Knee	13.10		
Upper lip	9.72		
Average ($\bar{x}$)	12.55	Average ($\bar{x}$)	16.67

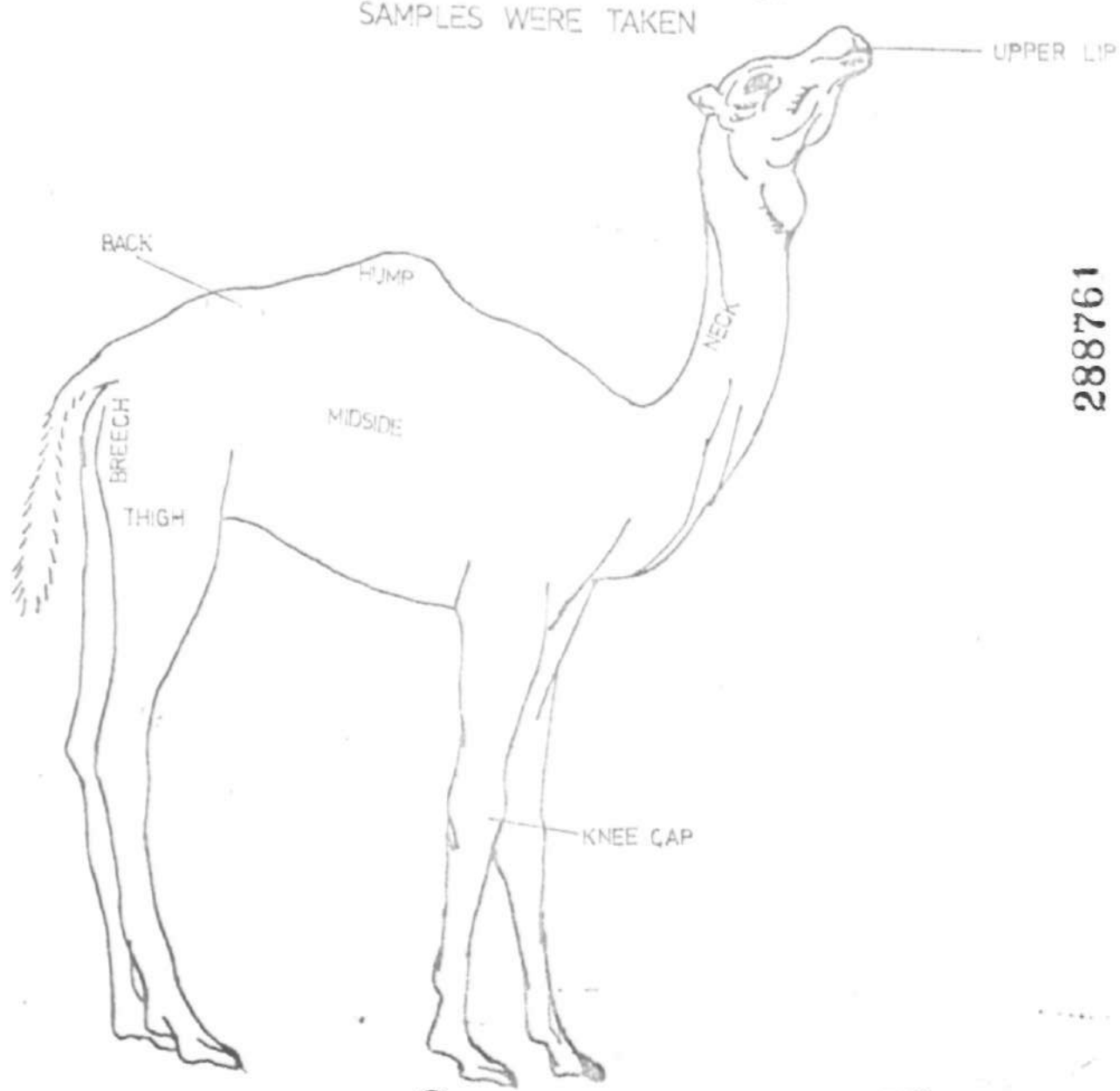
* Common sites

t value for common site = 0.81 Not significant P>0.05

APPENDIX

SKETCH 1

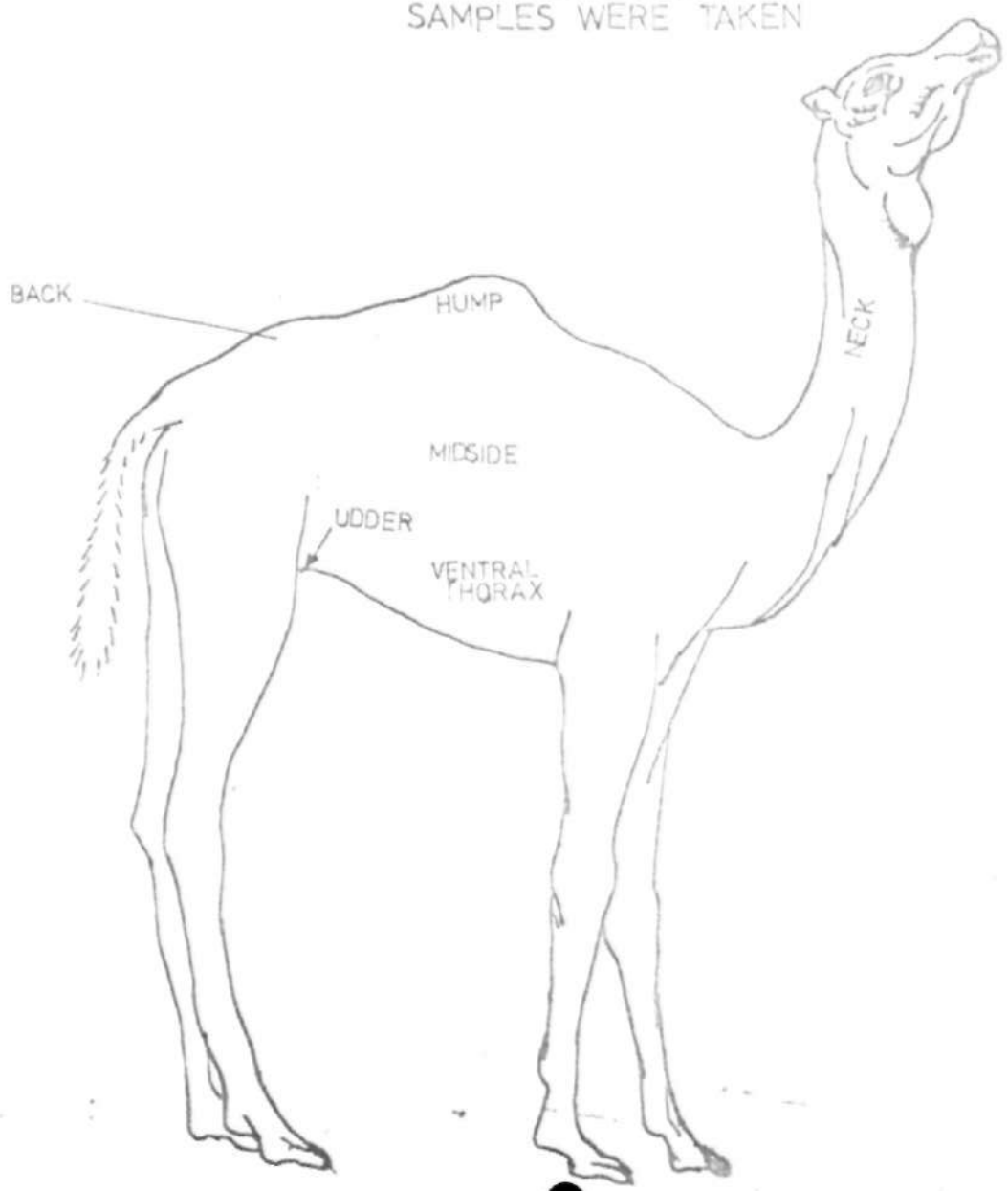
THE MALE CAMEL—SHOWING THE SITES FROM WHICH SAMPLES WERE TAKEN



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SKETCH 2

THE FEMALE CAMEL SHOWING THE SITES FROM WHICH SAMPLES WERE TAKEN

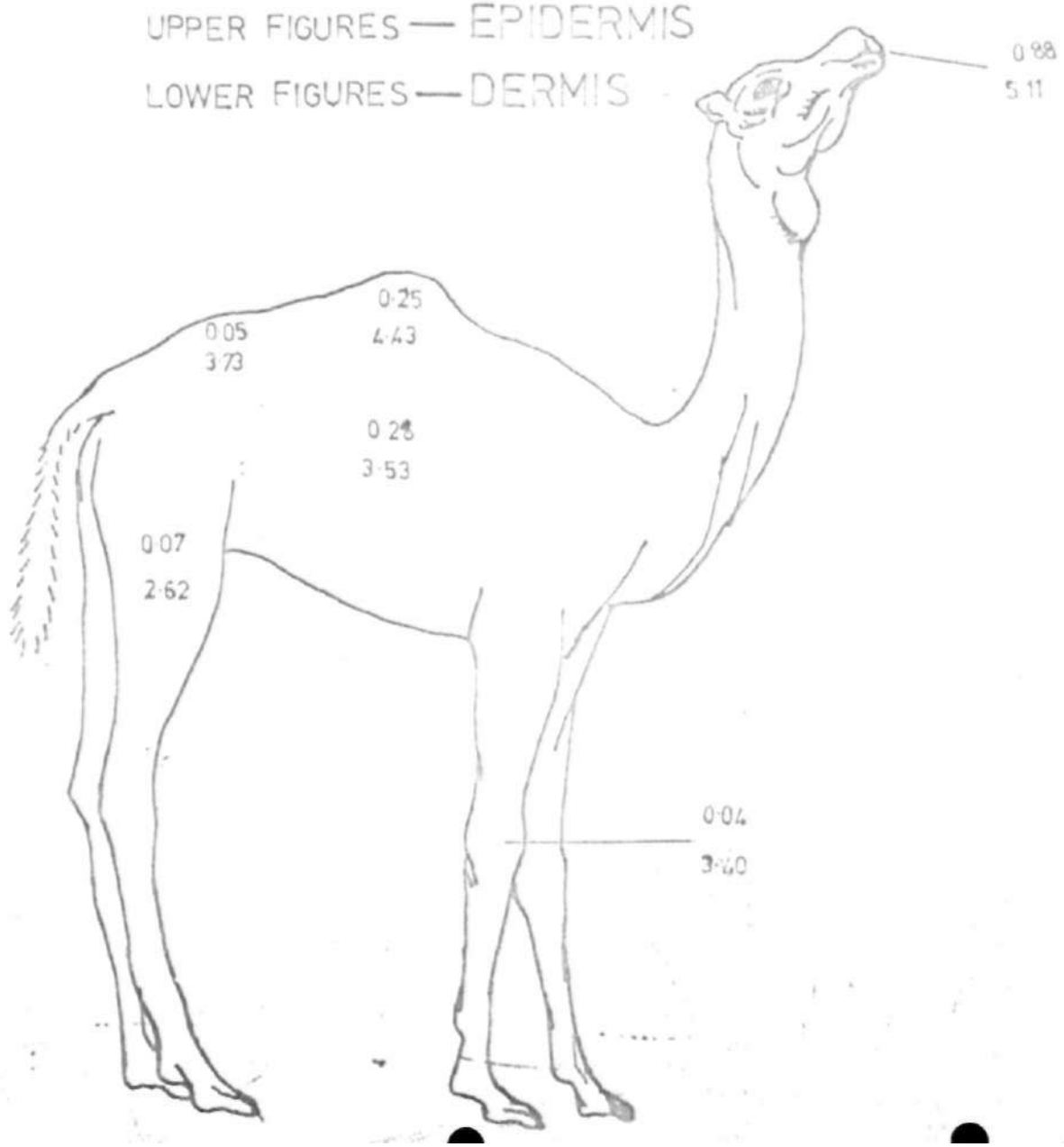


SKETCH 3

THICKNESS IN MILLIMETER (mm) — MALE CAMEL

UPPER FIGURES — EPIDERMIS

LOWER FIGURES — DERMIS

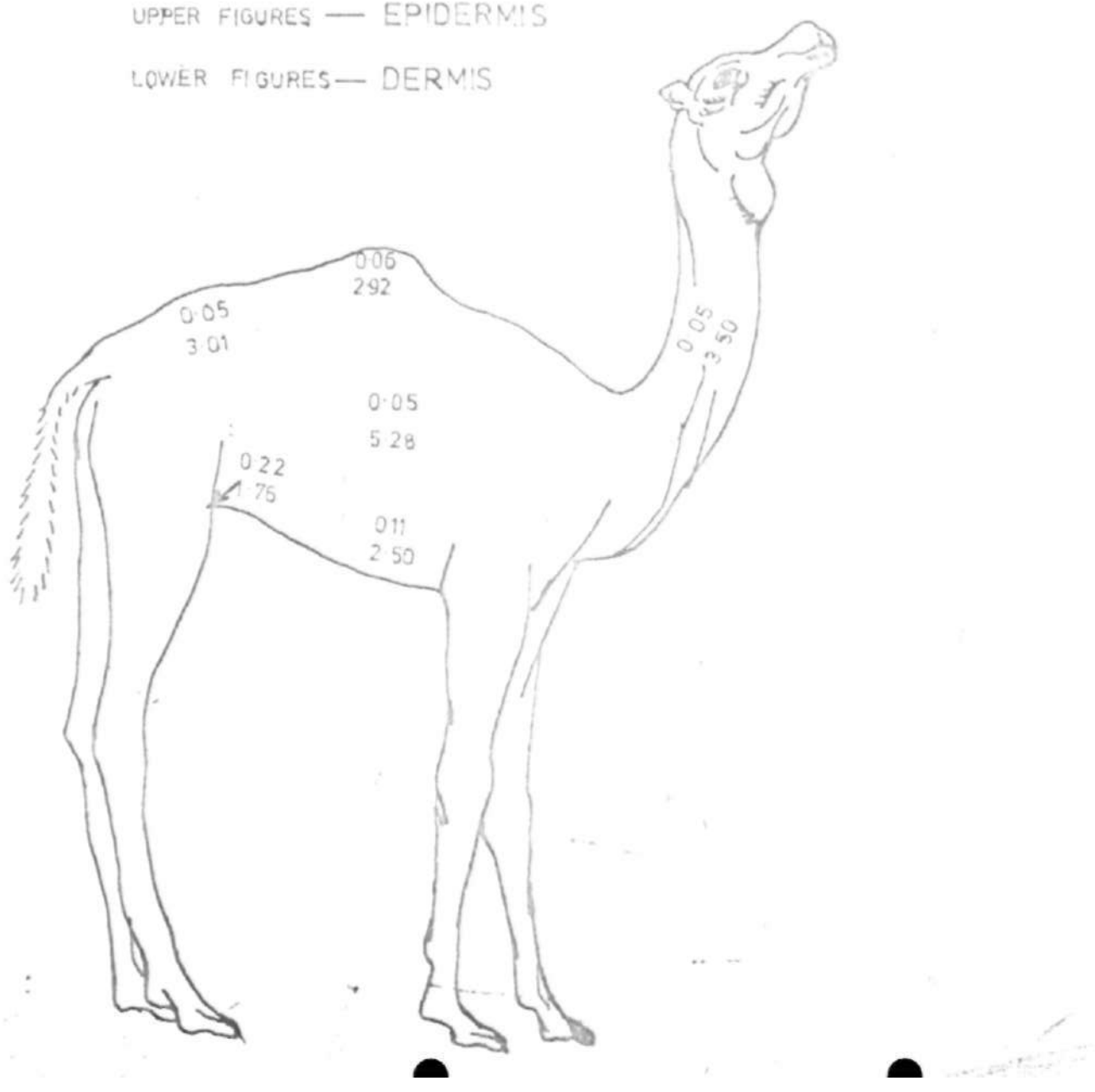


SKETCH :-

THICKNESS IN MILLIMETER (mm) — FEMALE CAMEL

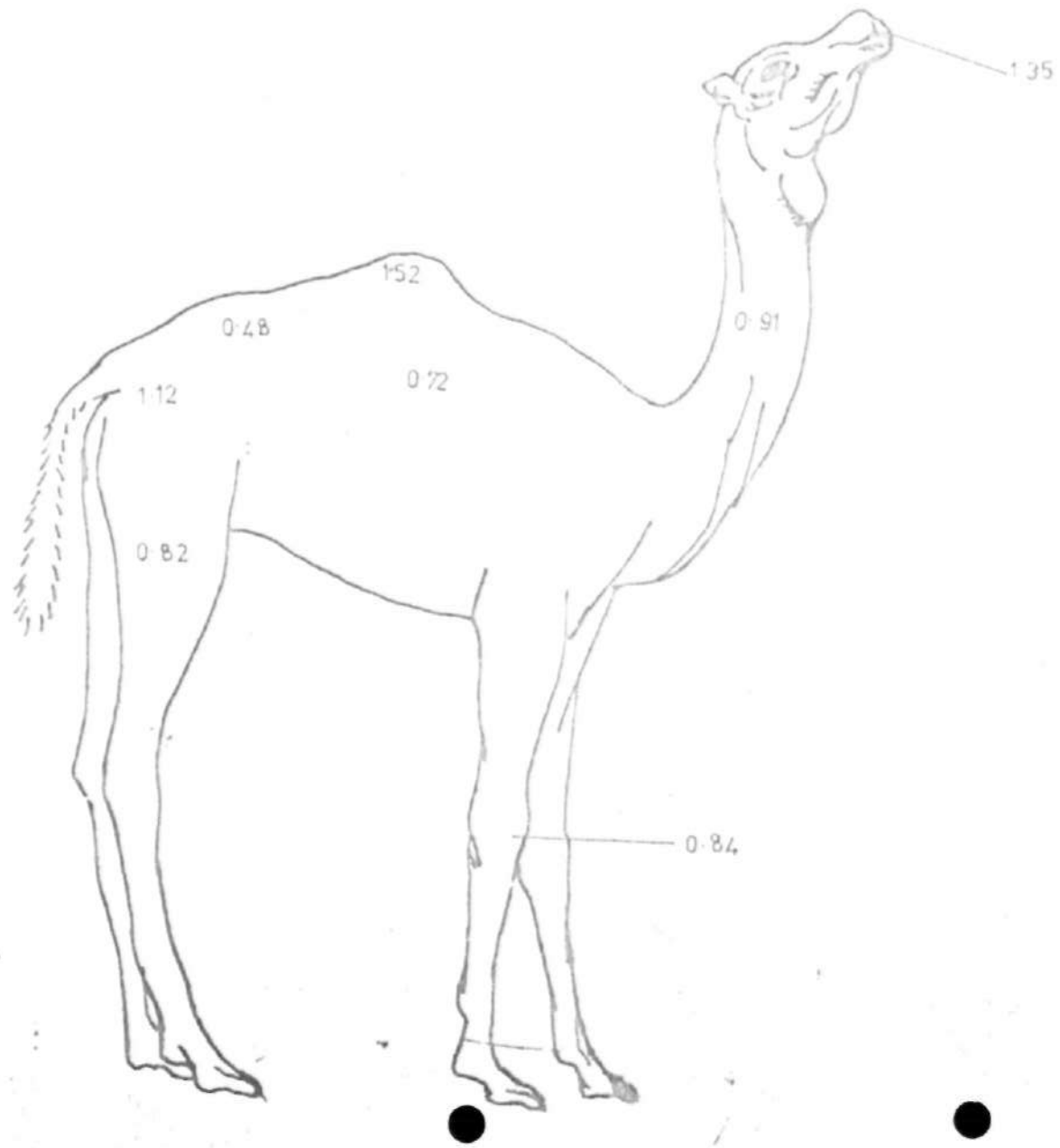
UPPER FIGURES — EPIDERMIS

LOWER FIGURES — DERMIS



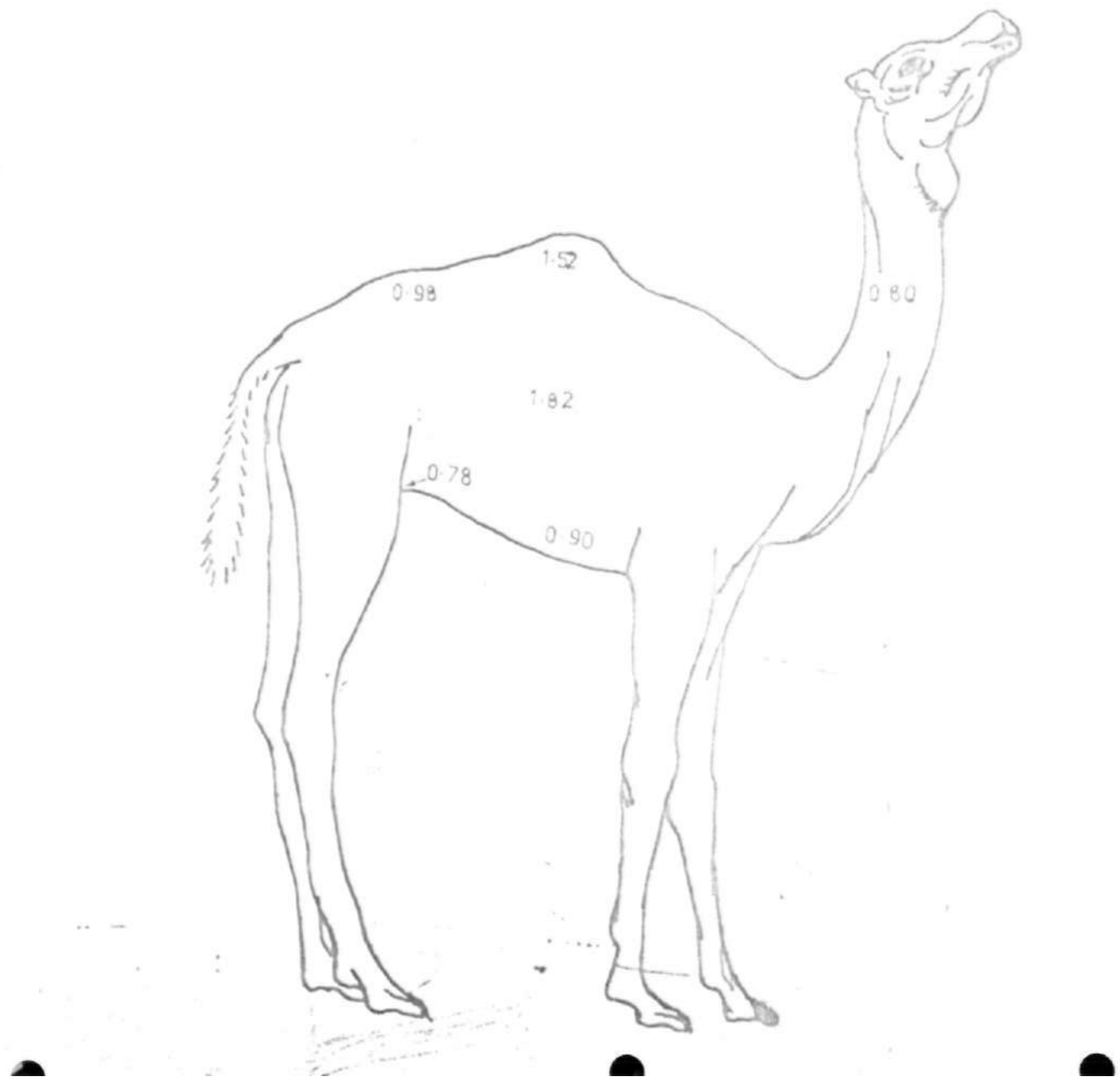
SKETCH 5(a)

HAIR FOLLICLE DEPTH IN MILLIMETER (mm)— MALE CAMEL



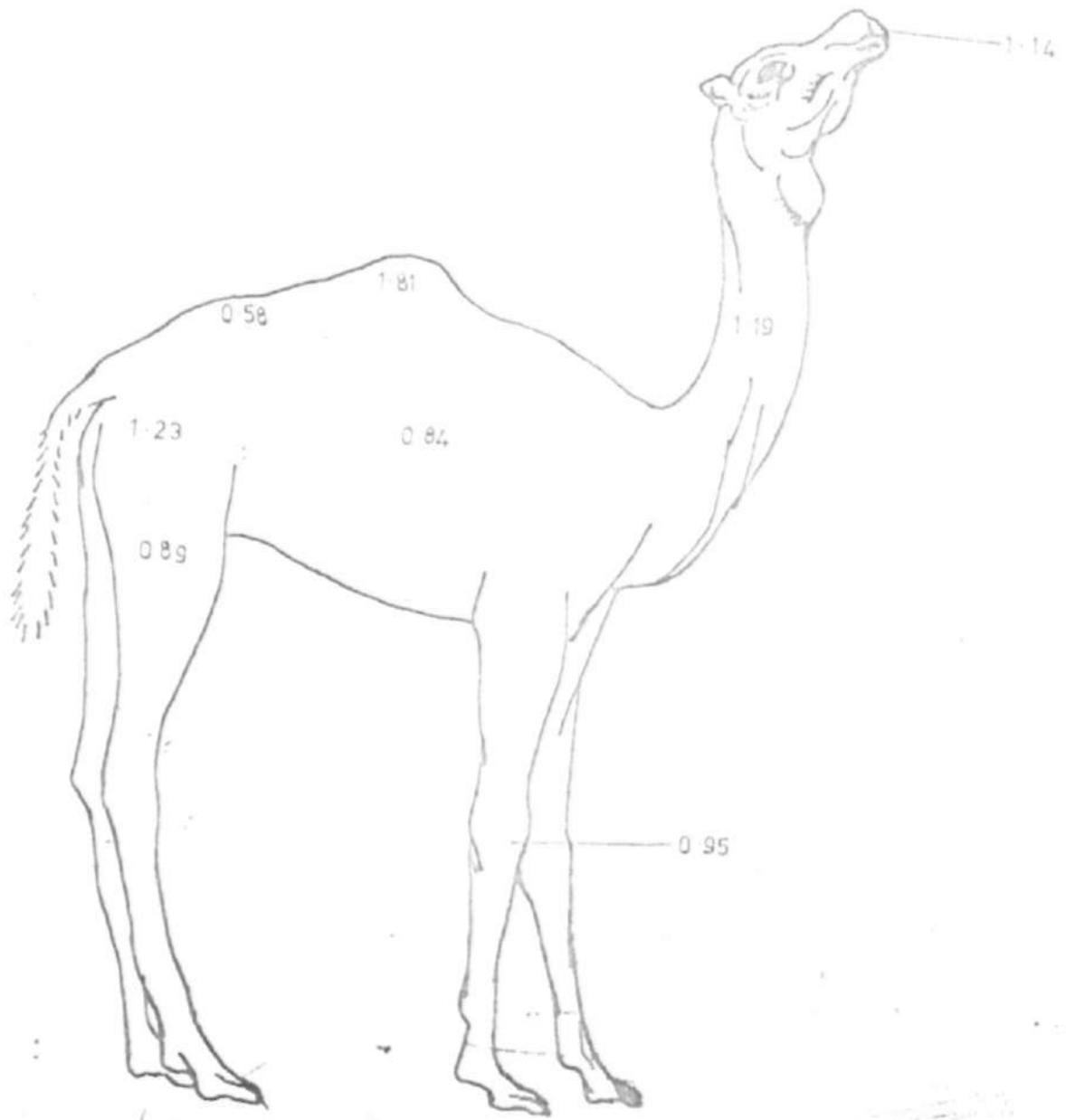
SKETCH 5(b)

HAIR FOLLICLE DEPTH IN MILLIMETER (mm) – FEMAL CAMEL



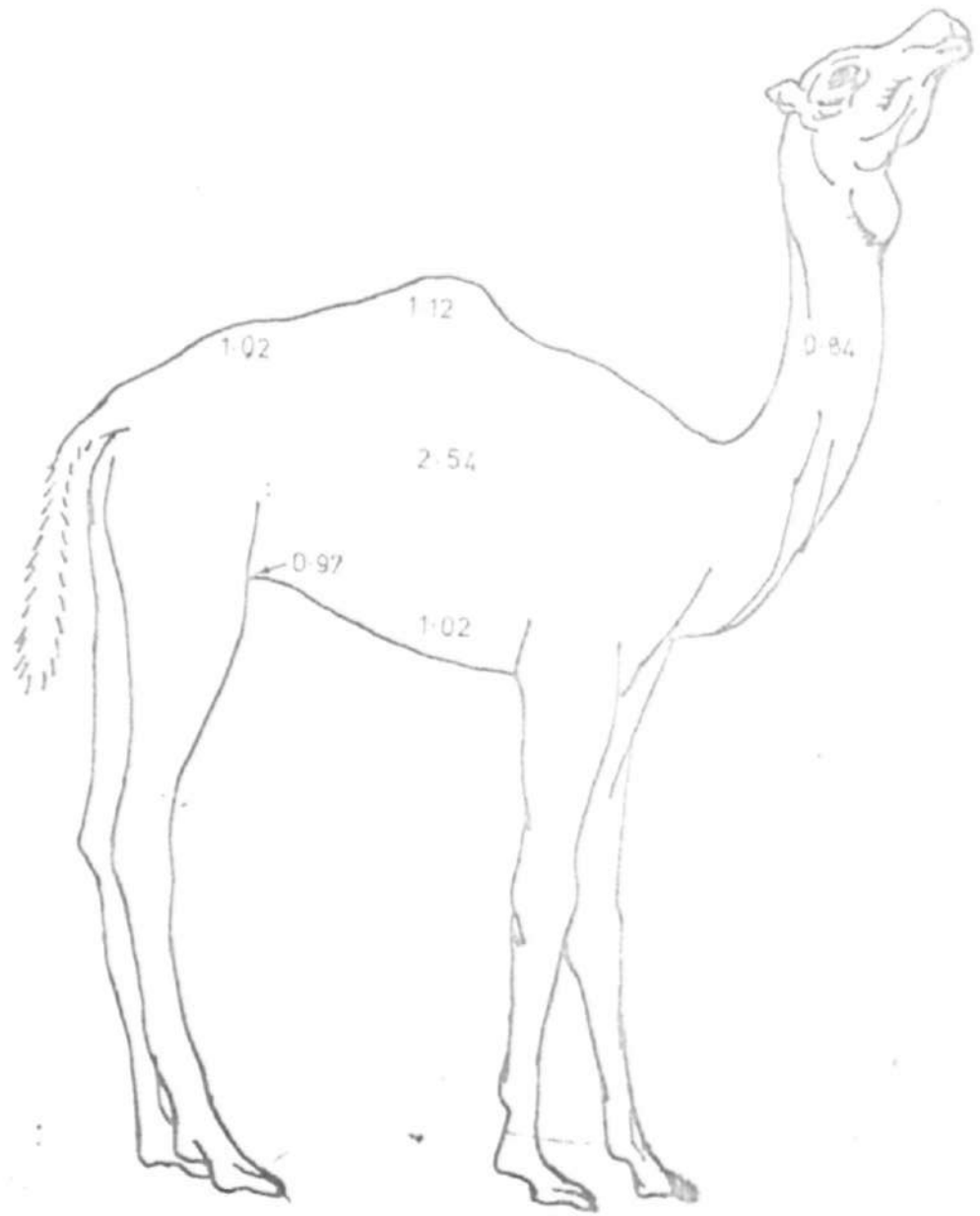
SKETCH 6/01

HAIR FOLLICLE LENGTH IN MILLIMETER (mm) MALE CAMEL



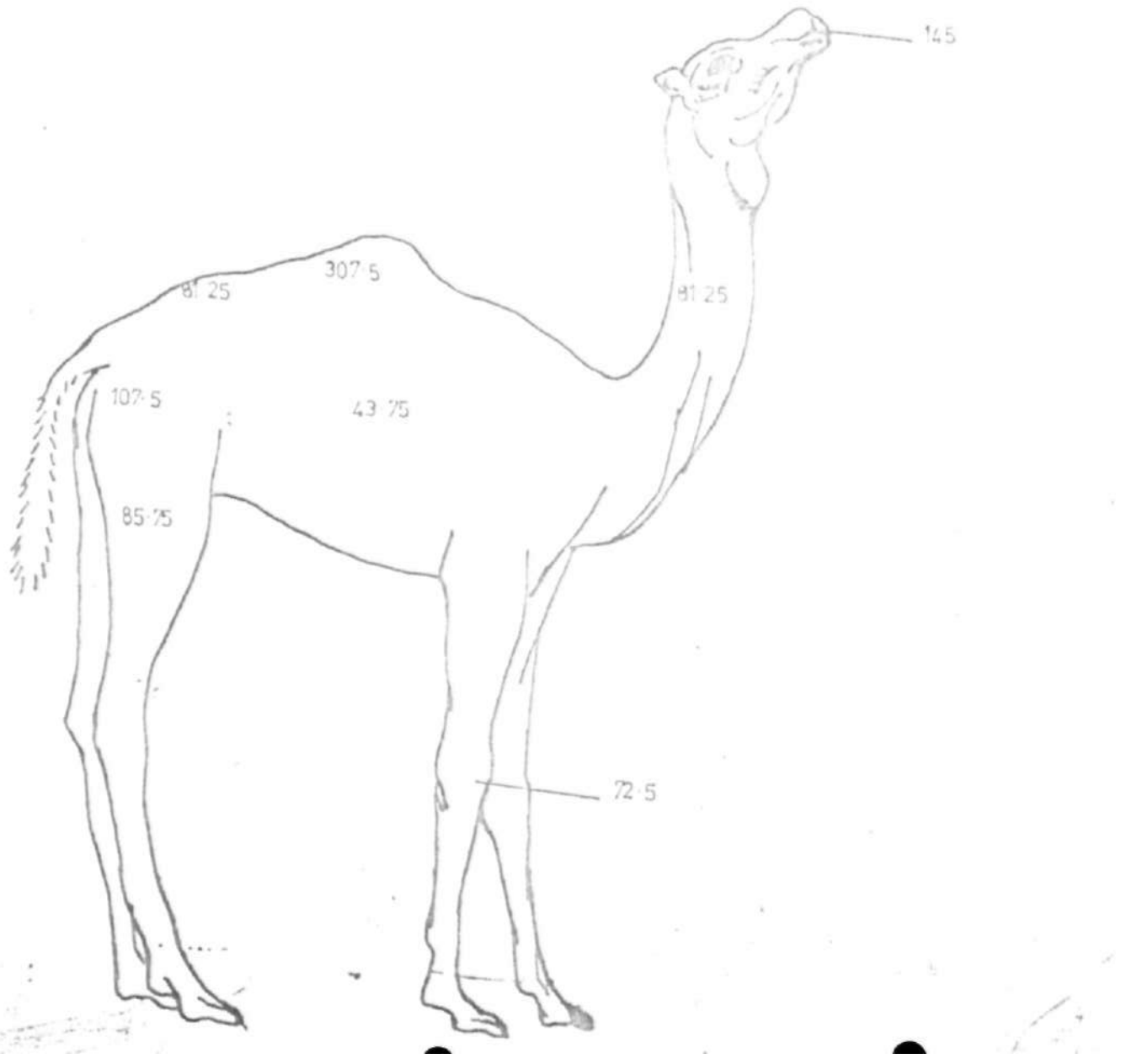
SKETCH 6(5)

HAIR FOLLICLE LENGTH IN MILLIMETER (mm) – FEMALE CAMEL

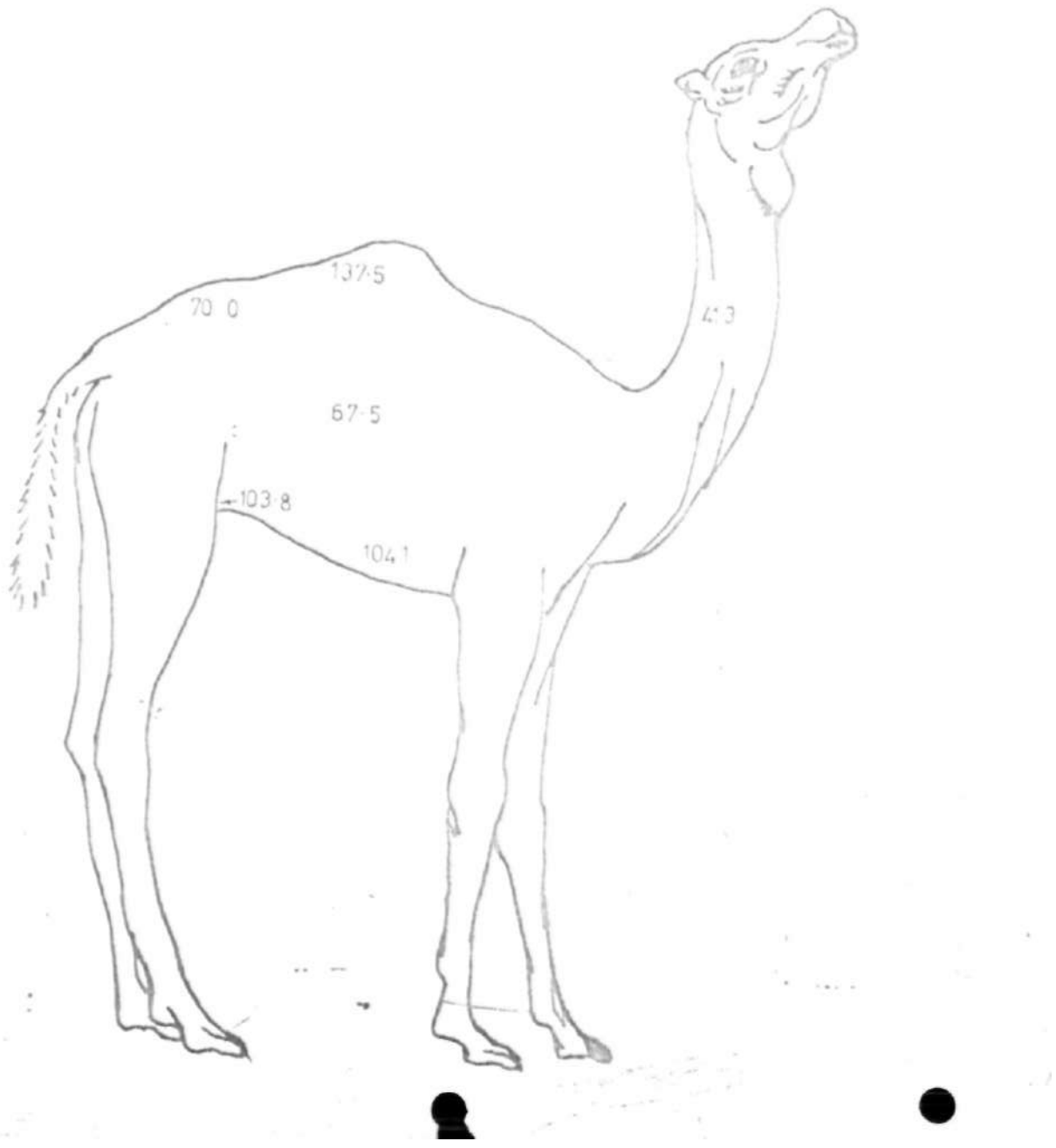


SKETCH 7(a)

HAIR FOLLICLE DIAMETER IN MICROMETER(µm)—MALE CAMEL

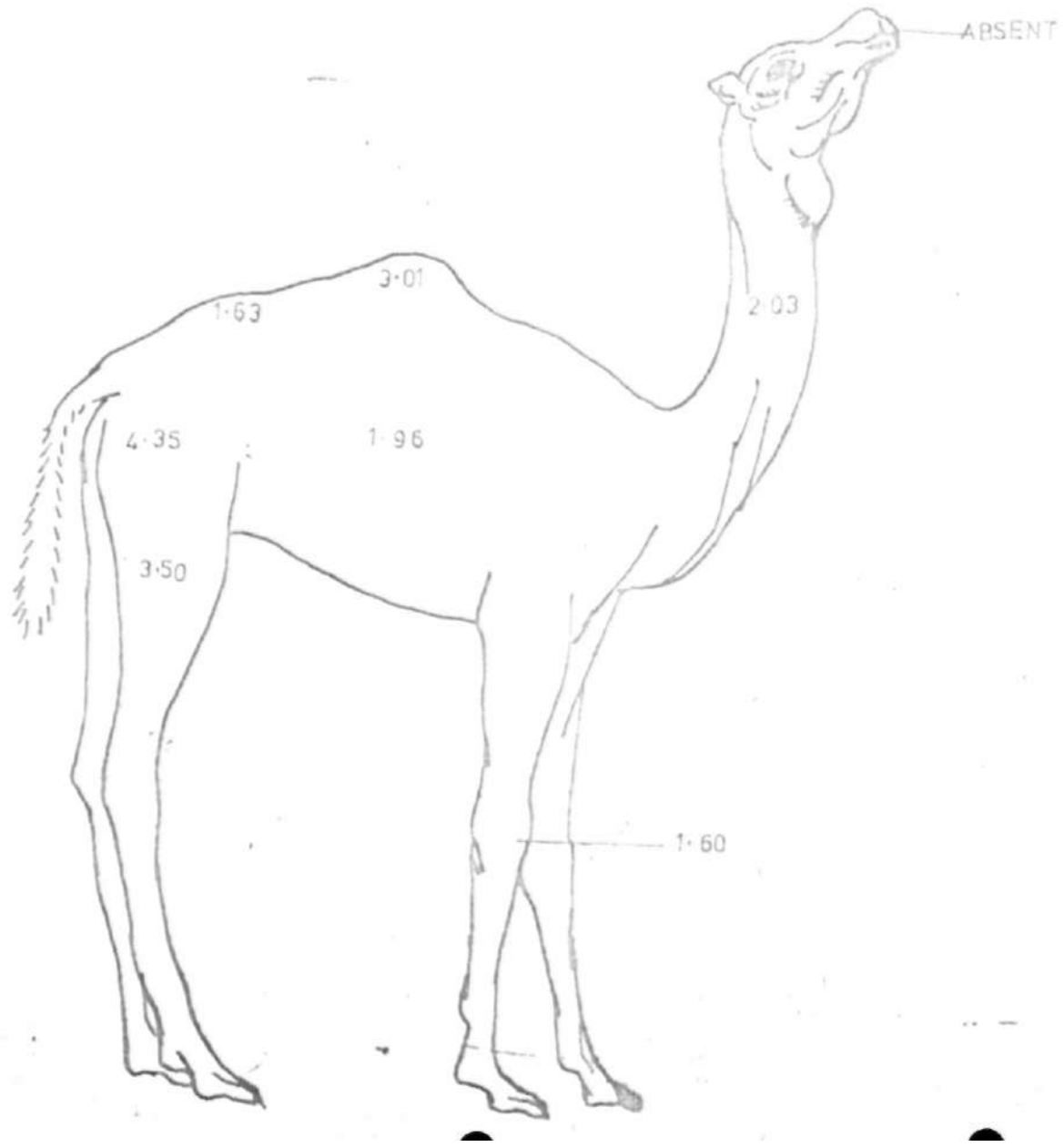


HAIR FOLLICLE DIAMETER IN MICROMETER (μm) FEMALE CAMEL



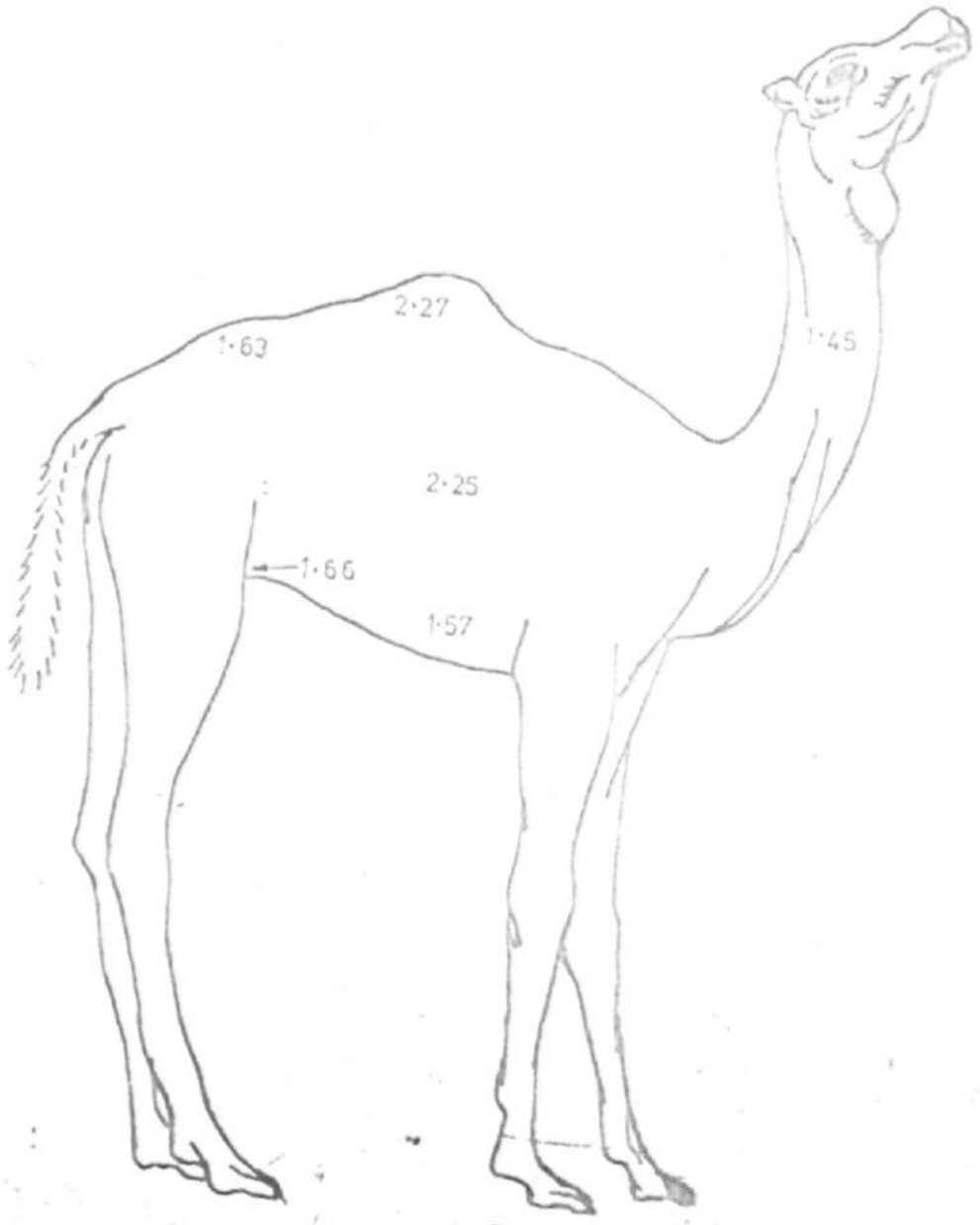
SKETCH e (a)

SWEAT GLAND DEPTH IN MILLIMETER (mm) — MALE CAMEL



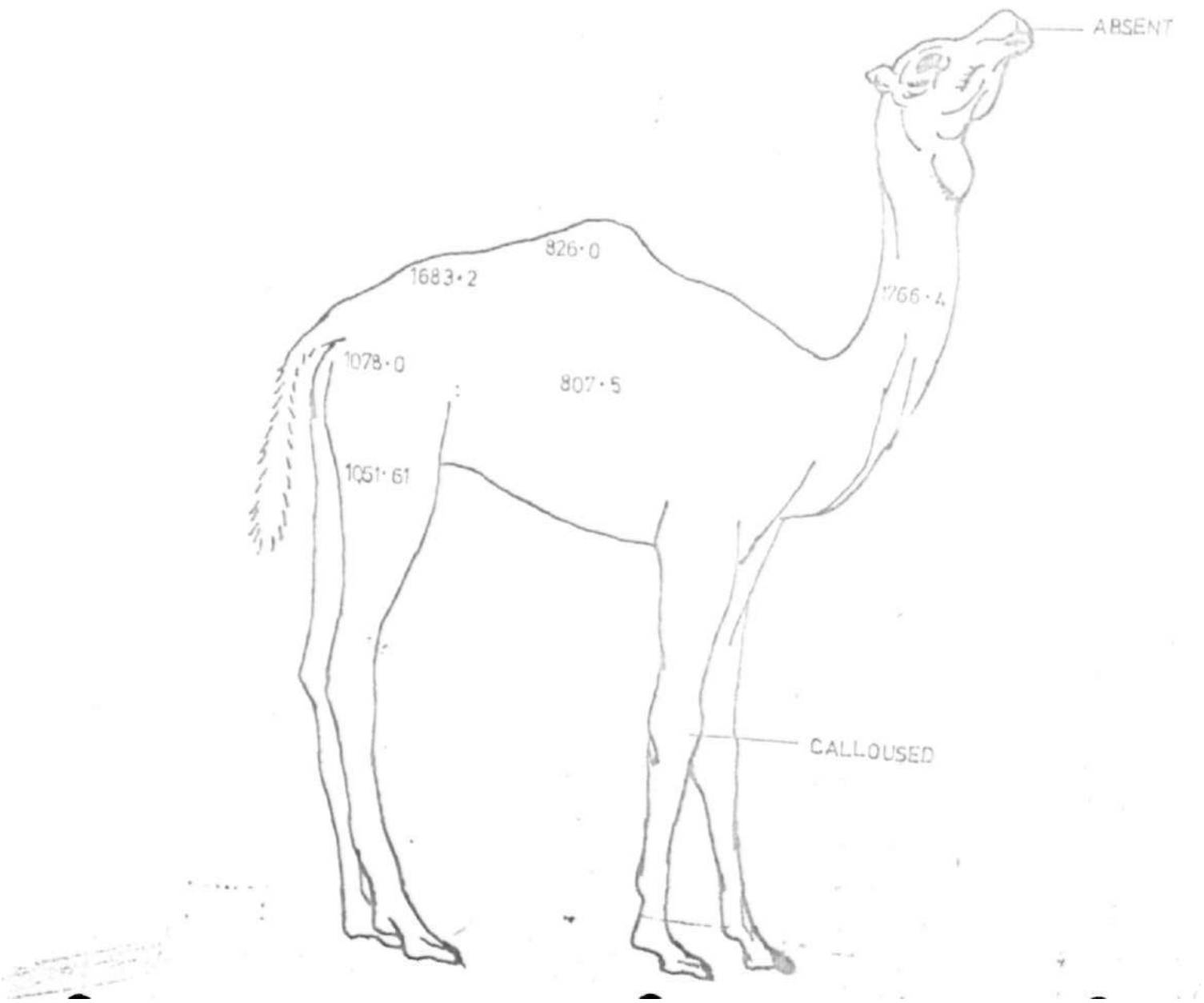
SKETCH 8(b)

SWEAT GLAND DEPTH IN MILLIMETER (mm) FEMALE CAMEL



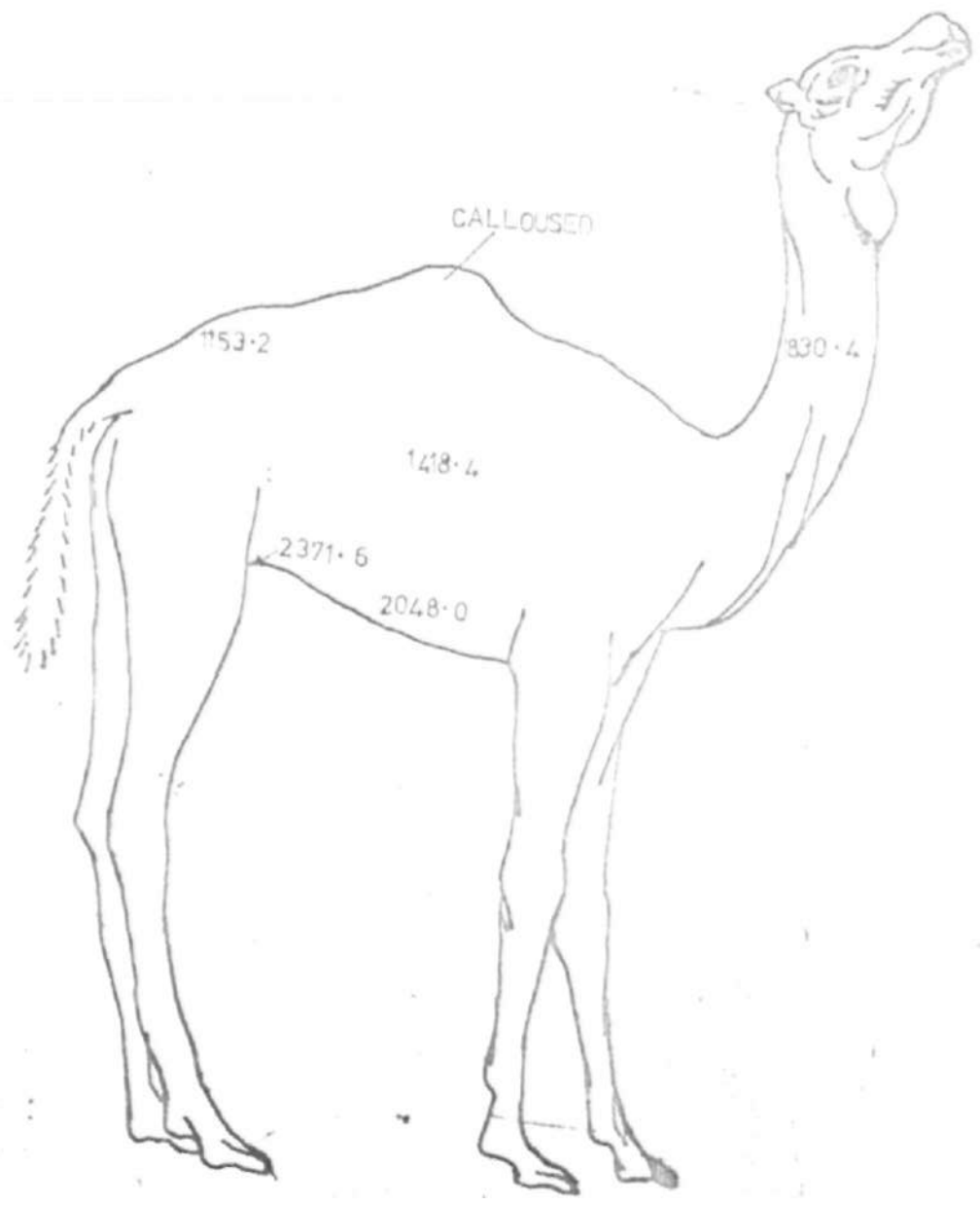
SKETCH 9 (a)

SWEAT GLAND LENGTH IN MICROMETER (μm) — MALE CAMEL

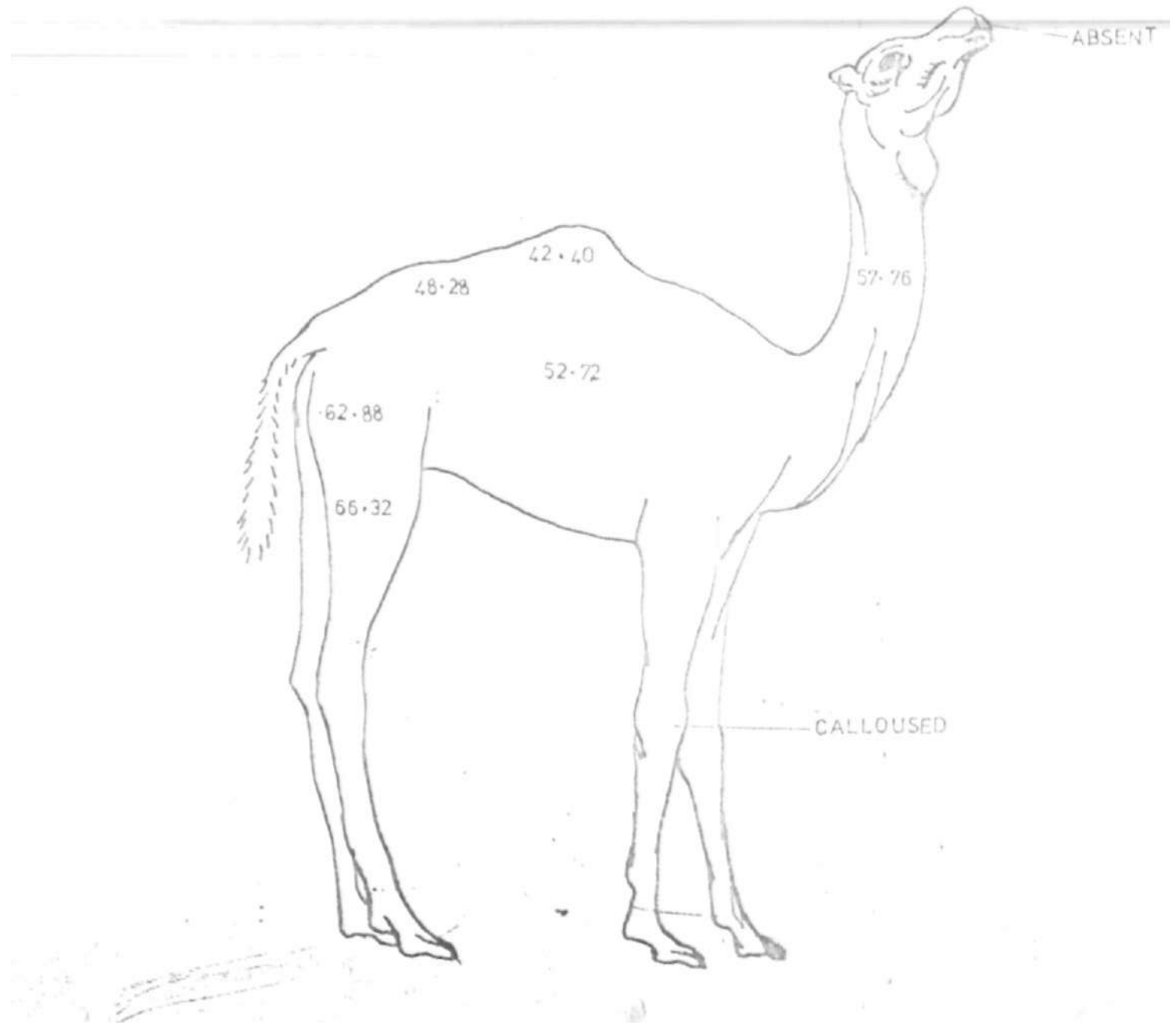


SKETCH 9(b)

SWEAT GLAND LENGTH IN MICROMETER (um)—FEMALE CAMEL



SWEAT GLAND DIAMETER IN MICROMETER (µm)-MALE CAMEL

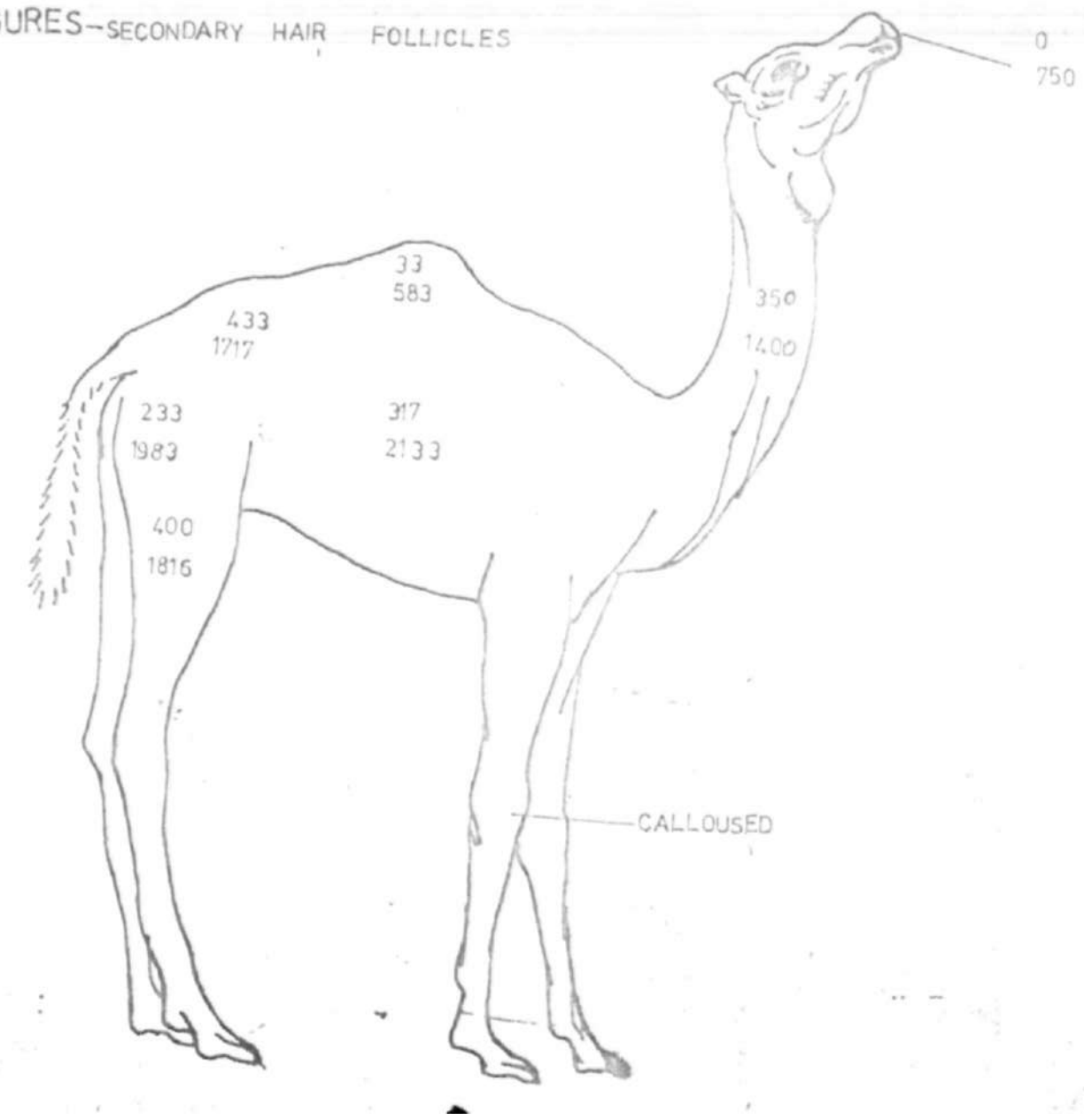


SKETCH 11 (a)

HAIR FOLLICLE AND SWEAT GLAND DENSITIES PER SQUARE CENTIMETER (cm^2) OF SKIN AREA —— MALE CAMEL

UPPER FIGURES – PRIMARY HAIR FOLLICLES/SWEAT GLAND

LOWER FIGURES – SECONDARY HAIR FOLLICLES

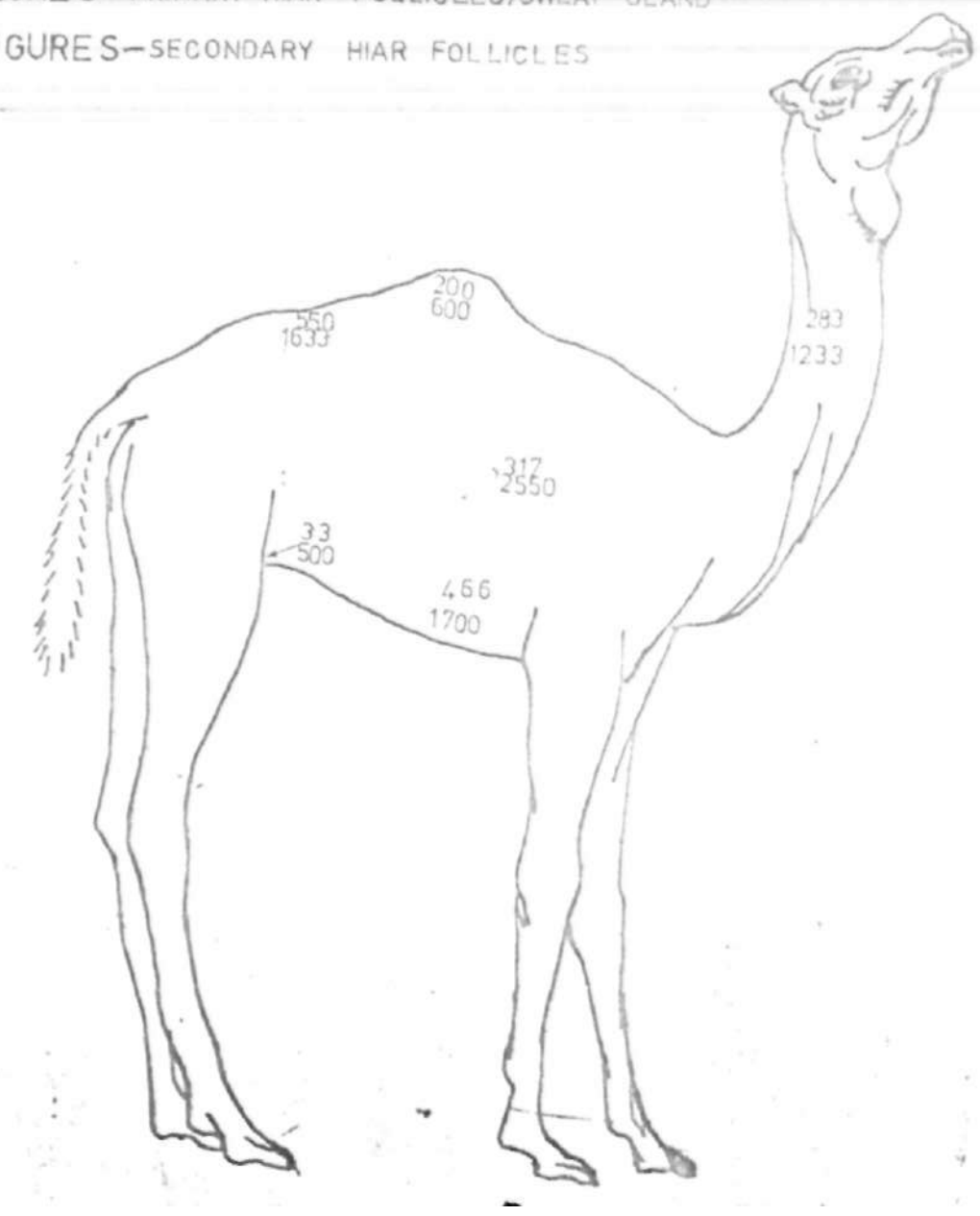


SKETCH (11b)

HAIR FOLLICLE AND SWEAT GLAND DENSITIES PER SQUARE CENTIMETER (cm^2) OF SKIN AREA —— FEMALE CAMEL

UPPER FIGURES—PRIMARY HIAR FOLLICLES/SWEAT GLAND

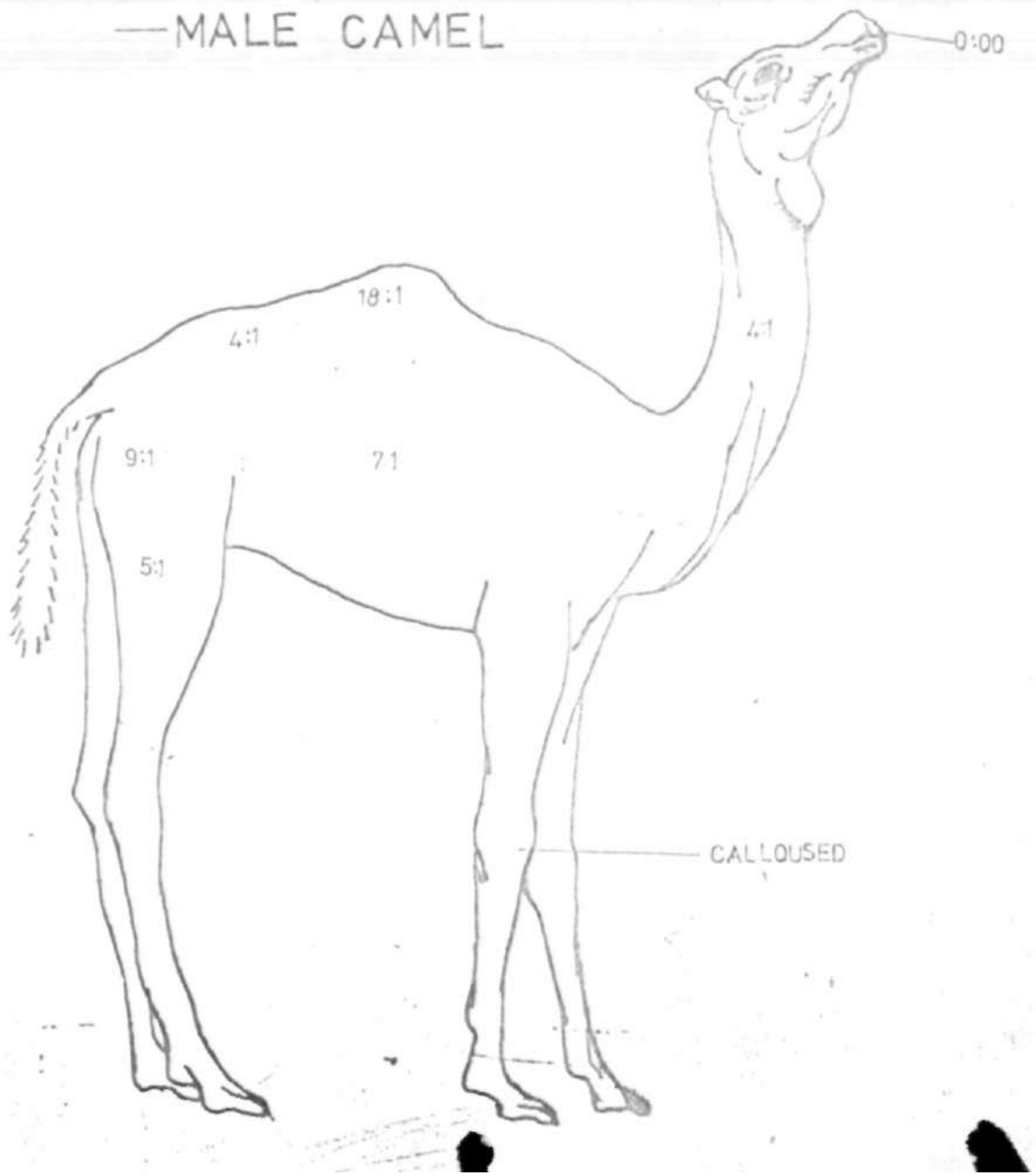
LOWER FIGURES—SECONDARY HIAR FOLLICLES



SKETCH 12(a)

SECONDARY TO PRIMARY HIAR FOLLICLE RATIO (S/P)

—MALE CAMEL



SKETCH 12 (b)

SECONDARY TO PRIMARY HAIR FOLLICLE RATIO (S/P)

FEMALE CAMEL

