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Seasonal Hair Follicle Cycle of *Camelus dromedarius*

H.R. Ansari-Renani

Animal Science Research Institute, P.O. Box 31585-1483,
Karaj, Islamic Republic of Iran

Abstract: This experiment was conducted to identify the annual changes in hair follicle activity, changes at the follicular level and to characterize some of the fibre-follicle characteristics of camels at different ages. A total of 28 camels were allocated at random on the basis of age to one of four groups (2, 4, 6 and older than 8 years). All groups of camels were fed a maintenance level of ration throughout the experiment. To determine hair follicle cycle and other follicle characteristics samples of skin were taken using a trephine from the right midside of animals at approximately 28 day intervals for a period of 12 months. Using a small hand clipper, 15 g of fibre sample was taken from the left midside region to determine fibre characteristics. Analysis of variance was performed using a one-way SAS package and the means and the standard deviations of means were generated with this program. Mean S/P ratio, primary and secondary and total follicle densities of all groups of camels were 6.85 ± 0.75 , 3.76 ± 0.63 , 22.29 ± 3.57 and 25.33 ± 3.85 , respectively. Mean fibre diameter, percentage of medullated and non-medullated fibre and clean wool percentage of all groups were 18.98 ± 1.64 , 18.10 ± 1.65 , 81.89 ± 6.98 and 77.58 ± 4.58 , respectively. Mean percentage of active primary follicles significantly ($p < 0.05$) decreased to lowest in February to a minimum of 83.1%, then significantly ($p < 0.05$) increased over spring. Secondary follicle activity decreased over winter and spring to a minimum of 60% in February.

Key words: Camel, hair, follicle, inactivity, shedding, fibre

INTRODUCTION

The fleece of camel contains two distinct population of fibre; a short and fine non-medullated insulating fibre and a long and coarse medullated guard hair which are produced by secondary and primary follicles respectively. Seasonal fibre shedding is common in camel; thus considerable amount of fibre is lost annually. There is a scarcity of information in the scientific literature on the fibre shedding and follicle cycle in the camel. Efforts need to be made to define the annual pattern of camel fibre growth manipulating the growth cycle to increase production or allow shearing at a more favourable time to prevent fibre loss. Examination of the state of activity of follicles is required for a full understanding of pelage cycles. Without such information it is difficult to develop systems of management of fibre harvesting strategies which will optimize the efficiency of fibre production (Russel, 1993). The following experiment was conducted to identify fibre-follicle characteristics and annual changes in hair follicle activity of Iranian one-humped camels. Camels (*Camelus dromedarius*) which were housed under conditions of natural photoperiod and ambient temperature at Toroud camel research station in South-Eastern Iran in Semnan province were used for this experiment.

MATERIALS AND METHODS

Selection of animals: A total of 28 one humped female camels at Toroud camel research station in south-eastern Iran in Semnan province were allocated at random on the basis of age to one of four groups (2, 4, 6 and older than 8 years). All camels were fed a maintenance level of ration throughout the experiment.

Skin sampling and staining: Samples of skin were taken from the right midside of animals at approximately 28 day intervals for a period of 12 months from August 2002 to July 2003. In order to facilitate skin sampling, camels were restrained in a laid position and a site beneath the hump on the left midside of the animal was clipped and anaesthetized with 1% lignocain. A 1 cm diameter trephine was used to make an incision to the connective tissue beneath the skin. The skin section was raised with forceps and a hand-held scalpel blade was used to cut parallel to the skin surface through the connective tissue, removing the skin section. Excess blood was wiped from the biopsies and was placed in plastic scintillation vials containing 10% buffered formalin $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$ [4] Na_2HPO_4 [6.5g], H_2O . The samples were then placed in small mell individual baskets and dehydrated through a series of graded ethanol, cleared in histoclear

using a Citadel tissue processor (Histokinette 200, Cambridge Instruments Company). Processed skin samples were embedded in paraffin using Leukhardt blocks. Embedded skin samples were sectioned in transverse plane at 8 μ m using a base sledge microtome (Model Leica rm 213s, Nussloch, Germany). Approximately 60 sections were cut per sample, but only every fifth section was retained. Twelve sections were retained per sample and transferred to slide. Before staining all sections were deparaffinised and immersed in histoclear for 2 min and rehydrated in a graded series of ethanol to water. A special tetrachrome stain sapic (Auber, 1952) was used to demonstrate follicular tissue compounds.

Follicle density, S/P ratio and follicle activity (morphology): For each camel at least 300 follicles per skin sample (August) were used to estimate follicle density and S/P ratio. Primary and secondary follicles were identified through the associated gland structures. To determine the percentage of active and inactive primary and secondary follicles of skin samples taken from August 2002 to July 2003 approximately 300 follicles were counted per midside skin sample from 20 to 30 randomly selected follicle groups as described by Nixon (1993).

Fibre diameter: Using a small hand clipper, 15 g of fibre sample was taken from the animal midside region beneath the hump on the left of camels in August 2002. To determine the percentage of clean wool weight, net bags containing samples were weighed immediately, immersed in three scouring bowls solution containing 0.3% of Na_2CO_3 and 0.1% of soap and water and stirred for 15 min at a temperature of $52 \pm 3^\circ\text{C}$. This procedure was repeated once more but only with warm water. Washed samples were oven-dried and weighed and the percentage of clean wool weight was estimated. The mean fibre diameter of the washed wool sample was measured using microprojector (D 2130-61) with a magnification 500X.

Statistical analysis: Analysis of variance was performed using a one-way SAS package and the means and the standard deviations of the means were generated with this program. The measurement of each characteristic was treated independently and Duncan's new multiple range test was then used to compare the characteristics between groups. SAS was used to test the effects of time and age on the follicular activity. Results were considered significantly different when $p < 0.05$.

RESULTS

Follicle characteristics: There was no significant difference in the mean S/P ratio and follicle densities of groups (Table 1). Mean S/P ratio, primary and secondary and total follicle densities of all groups of camels were 6.85 ± 0.75 , 3.76 ± 0.63 , 22.29 ± 3.57 and 25.33 ± 3.85 , respectively.

It was observed that only about 70% of follicle groups, consisted 3 primary follicles and about 30% of follicle groups contained 2, 4 or more primary follicles (Table 2) (Fig. 1).

Fibre characteristics: There was no significant difference in the mean fibre diameter, fibre types and percentage of clean wool weight between camel groups (Table 3).

Effect of season on primary and secondary follicle activity: The annual pattern of primary follicle activity is shown in Fig. 2. Mean percentage of active primary follicle decreased to lowest in February to a minimum of 83.1, then significantly ($p < 0.05$) increased over spring. Camels of 4 and over 6 years old had significantly ($p < 0.05$) lower percentage of active primary follicles.

Secondary follicles of all groups of camels were more susceptible to follicle inactivity than primary follicles. Figure 3 shows the pattern of secondary follicle activity

Table 1: Follicle characteristics of groups of camels of different ages

Age (year)	Follicle density (mm^2)			
	S/P ratio	Primary	Secondary	Total
2	6.16 ± 0.56	3.61 ± 0.37	24.40 ± 3.07	27.71 ± 3.14
4	6.68 ± 0.91	3.28 ± 0.88	21.39 ± 5.43	24.68 ± 6.00
6	6.78 ± 0.63	3.83 ± 0.61	21.76 ± 2.60	24.27 ± 2.65
Over 8	6.90 ± 0.84	3.95 ± 0.21	21.62 ± 2.13	24.58 ± 2.17
Average	6.85 ± 0.75	3.76 ± 0.63	22.29 ± 3.57	25.33 ± 3.85

Table 2: Percentage of primary follicles per follicle group in camels of different ages

Age (year)	Primary follicles/group (%)				
	2	3	4	5	6
2	5.77	71.54	18.85	3.08	0.77
4	5.28	68.59	19.89	4.19	2.09
6	7.30	68.75	18.54	4.39	0.95
Over 8	5.23	57.59	29.84	5.76	1.57
Average	5.68	67.21	21.54	4.25	1.30

Table 3: Mean fibre diameter, clean wool weight and of medullated and fibre type of camels with different age

Age (year)	Diameter (μm)	Fibre type (%)		CWW* (%)
		Medullated	Non-medullated	
2	18.74 ± 1.63	18.51 ± 1.25	81.46 ± 7.61	79.68 ± 4.34
4	18.23 ± 1.42	19.69 ± 1.78	80.31 ± 6.32	73.01 ± 5.72
6	18.81 ± 0.87	14.42 ± 1.15	85.58 ± 5.17	74.18 ± 4.74
Over 8	20.04 ± 2.13	19.76 ± 1.85	80.21 ± 6.28	82.46 ± 3.10
Average	18.98 ± 1.64	18.10 ± 1.65	81.89 ± 6.98	77.58 ± 4.58

*: Clean wool weight

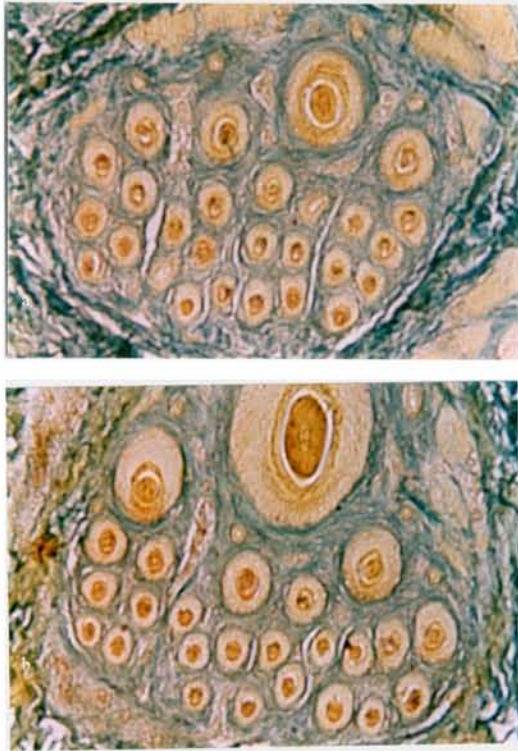


Fig. 1: Transverse section through the skin sample (at the sebaceous gland level) from an adult *dromedarian* camel indicating more than 3 primary follicles per follicle group

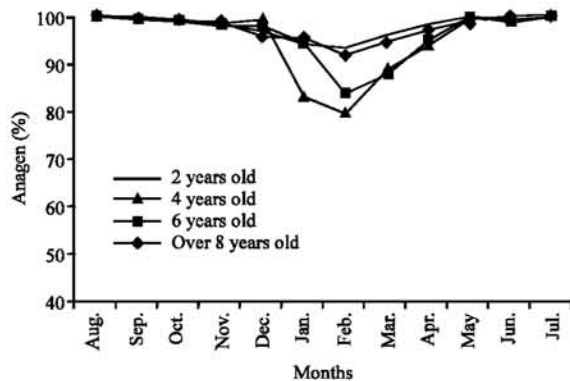


Fig. 2: Mean primary hair follicle activity (% anagen) of camels of different ages

for all groups of camels over different seasons. Secondary follicle activity decreased over winter and spring to a minimum of 60% in February. Camels at 6 and over 8 years of age had a significantly ($p < 0.05$) lower percentage of active follicles. Activity of secondary follicles sharply

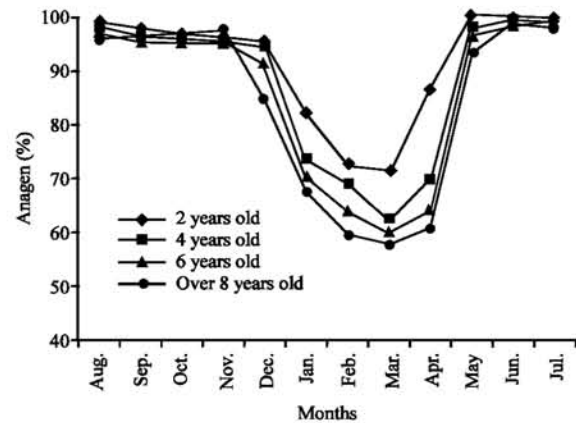


Fig. 3: Mean secondary hair follicle activity (% anagen) of camels of different ages

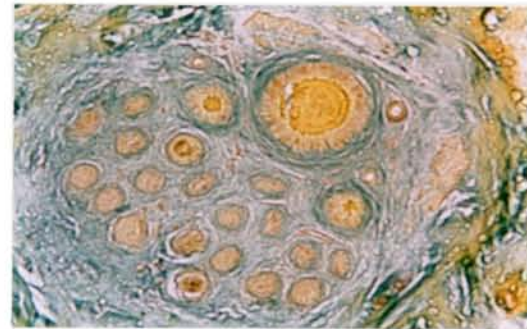


Fig. 4: Transverse section through the skin sample of *dromedarian* camel indicating that most secondary follicles are in telogen stage

increased during mid-spring in May and reached to a maximum of 100% in June until mid-Autumn in November.

It was observed that smaller secondary follicles not only regressed earlier but also regenerated later than larger secondary follicles. Histological examinations revealed that follicle morphology had undergone substantial changes (Fig. 4). The earliest histological changes associated with inactivity were detected in fibre, the inner root sheath and the outer root sheath cells. In inactive follicles the structure of fibre and inner root sheath cells was disrupted. In such follicles the outer root sheath cells were often columnar and radially or spirally arranged in contrast to the randomly- arranged cells in normal follicles.

DISCUSSION

In the present study, the follicle characteristics and inactivity of Iranian dromedarian camel has been

described using follicle histology. The camel's hair follicle group consisting of more than 3 primary follicles and several secondaries is similar to that in *Camelus dromedarius* (Dowling and Nay, 1962; Mahdi, 1979; Kamel *et al.*, 1986; Quasem *et al.*, 1992) but different from that in Iranian fat-tailed carpet wool sheep breeds (Ansari-Renani, 2005) and cashmere goat breeds (Ansari-Renani, 2004) and different from that in Indian camel (Mara and Khalil, 2000) in which 3 primary follicles in each follicle group were recorded. The contradiction between the present result and those of other camel results may be because of differences in the breeds or the place of origin at which these studies were carried out. The average number of hair follicles per square millimeter of skin of Iranian dromedarius camel (25.33) was lower than that recorded (65) by Dowling and Nay (1962) in the same species and cashmere goats (30.51-36.19) (Ansari-Renani, 2004) but higher than that recorded in buffaloes (3.4) (El-Shafie, 1954) and sheep (13.7-18.75) (Badreldin and Marai, 1966; Ansari-Renani, 2005). Criteria for estimating camel S/P ratio was 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 and apocrine sweat gland and an arrector pilli muscle with no discernible follicle group.

The seasonal follicle cycle of dromedarian camel has been described in this study. In winter and spring, follicle activity was found to decline and some of the winter coat was shed over winter and spring. Most secondary follicles lost activity in February and March and remained in telogen for 3 to 4 months before returning to anagen. At the peak of inactivity about 30 to 40% of follicles lost activity and the rest of secondary follicles remained in anagen and continued fibre production. There are similarities and differences between the shedding and follicle activity of camel and of cashmere-bearing goats. In an experiment with Raeini cashmere goats in Kerman province, south of Iran at a latitude of 29° 17'N, Ansari-Renani (2001) found that mean activity of primary and secondary follicles was lowest in February and March and maximum in July. It was indicated that Raeini goat began shedding of fibre over winter and spring. This is similar to local experience in the lower North Island of New Zealand which has shown that after mid-winter, most cashmere-bearing goats do not regrow substantial protective coat for several month (Mitchell *et al.*, 1991). Even though these studies were carried out at substantially different latitude from the present study but the timing of fibre shedding is similar. This similarity

could be explained by the similarity in photoperiodism. Timing of fibre growth in mammal is known to be influenced by photoperiod (Hart *et al.*, 1963; Ling, 1970; Panaretto, 1979; McDonald *et al.*, 1987). Holst *et al.* (1982) also suggested that the apparently earlier moulting season of goats in Central New South Wales compared with that of goats in Victoria may be the result of differences in photoperiod.

About 40% of secondary follicles pass into telogen in winter and remain dormant until spring. McDonald *et al.* (1987) suggested that summer solstice is an important photoperiodic event responsible for the initiation of cashmere growth. This hypothesis is supported by follicle activity of camel in the present study. It was found that as photoperiod increased in summer, follicle activity was initiated and in short photoperiod season of winter follicles were at telogen stage. As in other species, changes in photoperiod modify neuro-secretory rhythms via the pineal gland, which ultimately affect the initiation of hair growth (Hoffman, 1981; Rougeot *et al.*, 1984; Lynch and Russel, 1990).

Unlike some cashmere goats which undergo two subsidiary hair cycles, it was shown in present study that camels of present study only have one cycle. Nixon *et al.* (1991) described a subsidiary hair cycle in the secondary follicles of cashmere-bearing goats with the production of very small fine velus fibers in spring before the growth from the same follicle. The results of present study indicate that the hair growth cycle of dromedorian camel is a simple one of active growth in summer-autumn followed by inactivity in winter-spring.

In many species the shedding of old fibers is closely associated with the growth of new fibre (Ebling and Hale, 1970). This does not appear to be true of the camel because there was a pronounced period of telogen in primary-secondary follicle following the initiation of follicle inactivity and onset of shedding of fibre. In contrast, it has been clearly demonstrated that in camels that a proportion of primary and secondary follicles are in anagen over this period and continued producing hairs of the outer coat and cashmere of under coat to provide thick late winter coat and maintained continuous hair cover. The mechanism by which some follicles are in anagen and some others in telogen during shedding season remains unknown. Unlike cortisol injected sheep where shedding of fibre starts from rump and belly areas extending to shoulders (Ansari-Renani and Hynd, 2001) it was observed that natural shedding of camel fibre follows a sequential, bilaterally-symmetric pattern, commencing on the neck, chest and shoulders and spreading to the back and rump.

Hair harvested from Iranian dromedarian camels does have commercial value. In terms of harvesting maximum weight of cashmere, the optimal time for a single shearing for camels would be in winter season in January or early February at the peak of follicle inactivity or before onset of shedding. At the time of cashmere harvesting camels are in their poorest body conditions for the cold weather and very limited feed availability. It is important from the point of the welfare of the camel that some hair is left on the animal after cashmere harvesting as this hair provides an essential protective layer (McGregor, 1988) against adverse weather conditions. Use of shearing methods either machine or hand shearing which removes the entire fleece pose a serious threat and is inconceivable under such conditions. In addition, the presence of unshed long hair and cashmer in the fleece help cashmere fibre loss once cashmere shedding has begun by acting as a physical barrier restraining the cashmere in its position (McGregor, 1988). This allows owners to time cashmere harvesting either using combs or by collection the clumps of hair retained in the fleece. Use of combs reduces further cashmere loss during the shedding season. Unshed cashmere and hair could be sheared in mid-spring in late may or early June when adverse weather conditions is over.

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