



Impact of Climate on Sweat Gland Morphology of Indigenous Kangayam Over Crossbred Jersey Cattle

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ABSTRACT

The present study was conducted to evaluate the morphological changes of sweat gland of indigenous Kangayam cows over crossbred Jersey cow during different climatic conditions. About six numbers of adult Kangayam and Jersey breeds of cattle in the age range of 3 to 5 years were selected from farmer's house in the vicinity of Namakkal and Sathyamangalam districts of Tamil Nadu. The skin biopsy samples were collected in both the breeds during winter (December – February 2018) and summer (April- June 2019) seasons. Histological measurements like, sweat gland length, sweat gland diameter, depth of sweat gland and sweat gland density were recorded with the help of trinocular microscope (Leica DM 1000) with image analyzer (Leica application suit) software. The results revealed that the significant ($P < 0.01$) increase in length and diameter and number of sweat glands in Kangayam cows than Jersey cows during both environmental conditions. Whereas depth of the sweat gland was less in Kangayam cow than Jersey cow during both seasons. The observations clearly indicating the more evaporative cooling capacity of indigenous cow over cross bred Jersey cow.

HIGHLIGHTS

- The length and diameter of sweat gland in Kangayam breed is more during summer than winter.
- The numbers of sweat gland more in indigenous Kangayam than crossbred Jersey cattle

Keywords: Kangayam, Jersey cross, Sweat gland, histology, Environmental conditions

The cattle control their body temperature in a narrow range over varying climatic conditions. In body the endogenous heat is generated by metabolism, digestion and activity. The main way of generating heat transfer into animal body is radiation (Shephard *et al.*, 2023). The Cattle are homeotherms and exposure to very hot or cold environments can challenge their homeothermy, thereby inducing thermal stress. An animal's responses to stress can include behavioural, metabolic, and physiological changes. The heat stressed livestock rely heavily on the physiological response mechanisms to cope with the adverse environmental conditions and the phenotypic markers those emerge in this pathway may serve as useful indicators of animal welfare in the changing

climatic condition (Sejian *et al.*, 2018). In recent years, the environmental temperature increases gradually due to global warming and animals are susceptible to various types of stress such as physical, chemical, nutritional and physiological and thermal stress. According to the fifth IPCC Assessment report (AR5), by the end of 2100 global surface temperature is expected to rise by 1-7 °C (IPCC 2013). The rising earth surface temperature along with the increased intensity of weather and climatic

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extremities ultimately has its effects on the global food security. The Zebu cattle had a higher thermoregulatory ability by reducing metabolic heat production to minimize the heat storage and increase the heat loss capacity to the environment compared to European cattle (Pereira *et al.*, 2014).

Further, variations in physiological adaptability were also established between indigenous, cross bred and pure bred animals. The indigenous livestock breeds were tipped to be exhibiting less physiological variability as compared to their counterparts. These discussions vividly indicate the importance of studying in detail the physiological adaptive mechanisms in different farm animals and these efforts can help the farming community to identify the suitable agroclimatic zone specific livestock breeds which can go in long way to help to ensure climate resilient livestock production (Sejian *et al.*, 2018). The indigenous animals like Kangayam had good heat tolerance ability than other crossbred cattle. However, no information exists regarding the natural variation in skin properties including sweat gland histology. This is the first report to characterize important morphological parameters variations such as sweat gland length, width, numbers and depth in Indigenous Kangayam and crossbred Jersey cattle during different environmental conditions. The objectives of this study were to estimate the variations of morphological changes in sweat glands in Kangayam cattle during summer and winter seasons also compared with crossbred Jersey cattle to prove the heat tolerance ability of Kangayam cattle.

MATERIALS AND METHODS

For this study, six adult Kangayam and Jersey breeds of cattle in the age range of 3 to 5 years were selected from farmer's house in the vicinity of Namakkal and Sathyamangalam districts of Tamil Nadu to compare the differences in sweat gland morphology.

For the histo-morphological study of sweat gland, the biopsy samples of skin from two regions viz., middle third of the trunk and the intercostal space between 8th and 11th rib, 20 cm below the mid dorsal line were collected in both the breeds during winter (December – February 2018) and summer (April- June 2019) seasons. For the skin biopsy, skin biopsy puncher with a diameter of one cm was used. Initially, the skin area was cleaned with an antiseptic

and 2 percent lignocaine was infiltrated around the site of collection before the biopsy procedure. After sampling, the site of biopsy was sprayed with fly repellent. Then the biopsy samples were fixed in 10 percent neutral buffered formalin and processed and paraffin blocks were made for paraffin sectioning technique. The paraffin blocks were sectioned using Rotary Microtome (Leica RM 2145) at 5 μ thickness. The sections were mounted on a glass slide and dried at room temperature for 24 h and stained with hematoxylin and eosin stain (Nay and Hayman, 1956).

Histometric measurements like sweat gland length, diameter, numbers and depth of sweat gland from the skin were recorded with the help of trinocular microscope (Leica DM 1000) with image analyzer (Leica application suit) software to reveal the sweat gland morphology of the indigenous and cross bred Jersey breeds of cattle. The data collected were analyzed using one-way ANOVA and independent *t*-test in SPSS Version 21.0 software package. Results are presented as means with a standard error of mean.

Diameter and length of the sweat gland were measured randomly from 60 skin biopsy samples of both the breeds. Four measurements were taken from each sweat gland under 40X magnification. One measurement from the top of the gland to bottom of the gland was taken as length (L), and three measurements at three levels (top, mid and bottom) of the sweat gland as taken as width. Mean of the three width measurements was taken as the diameter of the gland (D).

The depth of sweat gland in skin was recorded by measuring the length from the epidermal layer to the top of sweat gland. Totally 60 measurements were made from skin samples of both the breeds and the mean values were calculated. The density of sweat gland was determined by counting the number of sweat glands per cm² of the skin section under microscope with 40X magnifier.

RESULTS AND DISCUSSION

The different breeds of cattle differ in their skin morphology and thermal tolerance depending upon their adaptation. The size and number of sweat glands and number of hair follicles and heat tolerant ability are more in Sahiwal (*Bos indicus*) than Holstein Friesian (*Bos taurus*). In response to thermal stress, the physiological changes like

increased respiration rate, increased blood flow to the peripheral tissues, increased skin temperature and increased sweat rate will occur to facilitate the heat loss from body of the animal. About 15% of heat was eliminated through respiration and the remaining was dissipated through skin via sweating (Finch *et al.*, 1986). In the present study, the heat tolerant ability of the two different breeds of cattle was studied by comparing the sweat gland morphology.

Length of Sweat Gland

The mean length of sweat gland in Kangayam breed of cattle during winter and summer seasons was $237.26 \pm 15.05 \mu\text{m}$ and $323.61 \pm 16.14 \mu\text{m}$ respectively. However, the mean length of sweat gland in Jersey cross bred animal during winter and summer season was $162.51 \pm 12.05 \mu\text{m}$ and $174.23 \pm 11.71 \mu\text{m}$ respectively. Both the breeds showed significant ($P < 0.05$) variation in sweat gland length between seasons. The length of sweat gland was significantly ($P < 0.05$) higher during summer than winter. Among two breeds, the sweat gland length was higher in Kangayam animal than crossbred Jersey animal.

Jian *et al.* (2014) reported that length of sweat gland in Sahiwal ($415 \mu\text{m}$) was higher than the HF ($381 \mu\text{m}$) cattle breed. In agreement with his findings, the length of sweat glands in the skin of Kangayam breed ($323 \mu\text{m}$) of cattle was higher than the Jersey cross ($174 \mu\text{m}$) bred (Table 1). This may be due to more cutaneous evaporation in *Bos indicus* than *Bos taurus*. Rohankar *et al.* (2008) stated that sweat gland length in Deoni, Red Kandhari, Dangi and Gaolao breeds of cattle were $203 \mu\text{m}$, $213 \mu\text{m}$, $198 \mu\text{m}$ and $299 \mu\text{m}$ during summer and $168 \mu\text{m}$, $185 \mu\text{m}$, $159 \mu\text{m}$ and $199 \mu\text{m}$ during winter respectively. The size of sweat gland in calves, heifer and adult cows of Nellore breed of cattle was $324.30 \pm 109.82 \mu\text{m}$, $344.20 \pm 112.48 \mu\text{m}$

and $406.70 \pm 145.94 \mu\text{m}$ respectively (Nasimento *et al.*, 2015). Similar to present findings higher ($798 \mu\text{m}$) sweat gland length was reported in Brahman cattle against its crossbred with Angus cattle (Mateescu *et al.*, 2023). The values were double the time increased than the Kangayam cattle. This may be due to influence of change in environmental condition of southeastern regions of the United States and heat tolerance ability of Brahman cattle by more evaporative cooling through sweating.

Diameter of Sweat Gland

The mean diameter of sweat glands in Kangayam cattle breed during winter and summer seasons were $77.93 \pm 4.86 \mu\text{m}$ and $99.58 \pm 5.25 \mu\text{m}$ respectively. The mean diameter of sweat gland in Jersey crossbred animal during winter and summer season was $53.84 \pm 5.52 \mu\text{m}$ and $67.61 \pm 2.02 \mu\text{m}$ respectively. Both the breeds showed a significant ($P < 0.05$) increase in sweat gland diameter during summer compared to winter.

The present study concurs with the study of sweat gland in Sahiwal and HF cattle breeds by Jian *et al.* (2014). The sweat gland diameter was higher in Sahiwal breed ($69.4 \mu\text{m}$) than HF ($41.3 \mu\text{m}$) breed of cattle. The sweat gland diameter in Kangayam and Jersey crossbred animal more during summer than winter reported in present study relate with findings of Rohankar *et al.* (2018).

Depth of Sweat Gland

The mean depths of sweat gland in Kangayam animal during winter and summer seasons were $672.13 \pm 19.17 \mu\text{m}$ and $568.29 \pm 17.28 \mu\text{m}$ respectively. The mean depth of sweat gland in Jersey cross animal during winter and summer season was $956.62 \pm 33.94 \mu\text{m}$ and $744.91 \pm$

Table 1: Histometry of sweat gland of Kangayam and Jersey crossbred in winter and summer

Parameters	Kangayam		Jersey	
	Winter	Summer	Winter	Summer
Length (μm)	$237.26^a \pm 15.05$	$323.61^b \pm 16.14$	$162.51^a \pm 12.05$	$174.23^b \pm 11.71$
Diameter (μm)	$77.93^a \pm 4.86$	$99.58^b \pm 5.25$	$53.84^a \pm 5.52$	$67.61^b \pm 2.02$
Depth (μm)	$672.13^b \pm 19.17$	$568.29^a \pm 17.28$	$956.62^b \pm 33.94$	$744.91^a \pm 51.39$
Number ($/\text{cm}^2$)	816.67 ± 122.25	933.33 ± 88.19	533.33 ± 42.18	656.67 ± 74.36

Each value is mean of ten observations; Means with different superscripts in a row differ significantly ($P < 0.05$).

51.39 μm respectively. The values were compared between these two breeds and two seasons. There was a significant ($P < 0.05$) difference in sweat gland depth between seasons in both Kangayam and Jersey breeds of cattle. Contrary to this, Nascimento *et al.* (2015) reported no change in depth of the gland between different age groups of Nellore cattle.

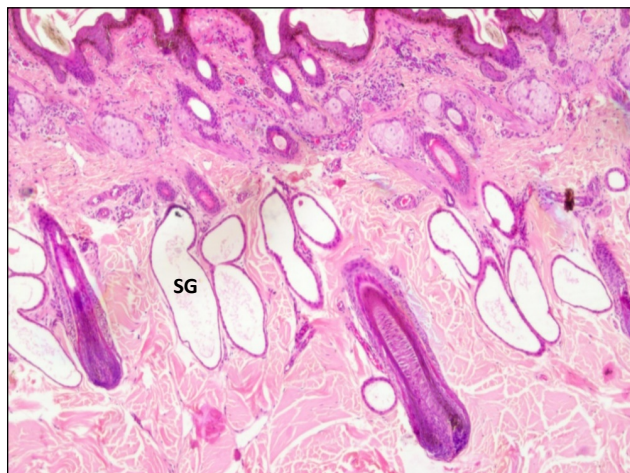


Fig. 1: SG – Sweat glands in the skin of Kangayam cattle during summer season H & E $\times 40$

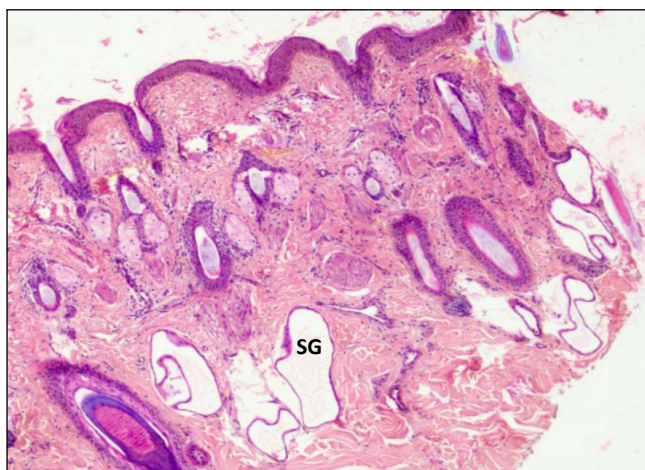


Fig. 2: SG – Sweat glands in the skin of Kangayam cattle during winter season H & E $\times 40$

The sweat glands in the skin of Kangayam cattle was located superficially than in Jersey crossbred to dissipate more heat from the body to adapt for the environmental temperature of Tamil Nadu. The change in depth of sweat gland during summer and winter seasons could be related

to the change in length and diameter of sweat gland as an adaptive physiological change. Rohankar *et al.* (2018) also observed that in Deoni, Red Kandhari, Dangi and Gaolao breeds of cattle, the depth of sweat gland during summer was 670 μm , 530 μm , 572 μm and 540 μm whereas in winter was 705 μm , 620 μm , 657 μm and 648 μm respectively. Thakur *et al.* (2018) identified that the sweat gland length and diameter of crossbred (Deoni $\times$ Holstein F1 generation) pregnant cow more than the heifer and lactating cow but the length was doubled than current observation in Kangayam cow.

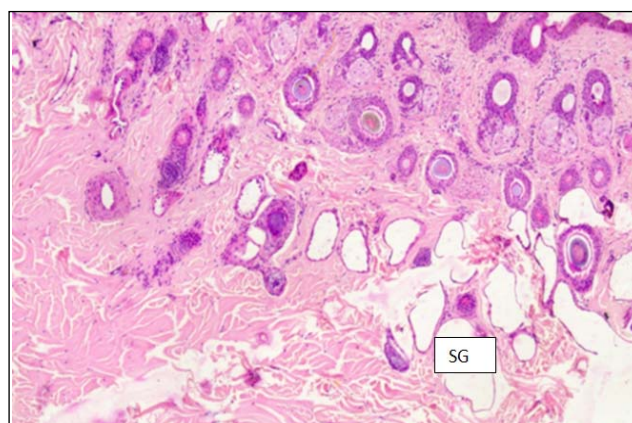


Fig. 3: SG – Sweat glands in the skin of cross bred Jersey during summer season H & E $\times 40$

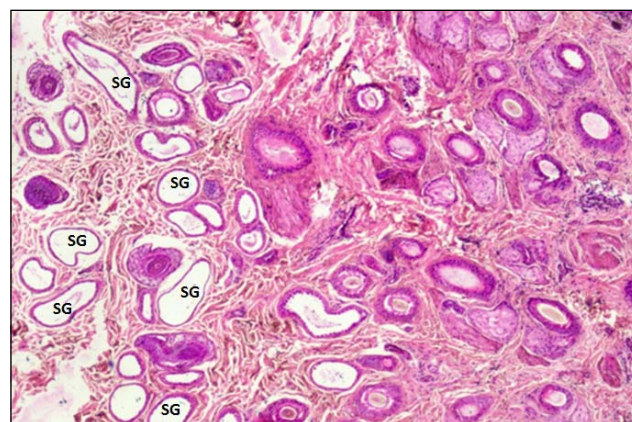


Fig. 4: SG – Sweat glands in the skin of cross bred Jersey during winter season H & E $\times 40$

Density of Sweat Gland

The mean density of sweat glands in Kangayam and Jersey cross bred cow during winter and summer seasons

were 816.67 ± 122.25 and 933.33 ± 88.19 ; 533.33 ± 42.18 and 656.67 ± 74.36 /cm² respectively. Within the breeds, the number of sweat glands were more in summer than winter. Irrespective of the season, the number of sweat glands were more in indigenous Kangayam breed than exotic Jersey crossbred of cattle. (Fig 1-4).

In this study, the number of sweat glands were more in Kangayam (933/cm² and 816/cm²) than Jersey crossbred (656/cm² and 533/cm²) during summer and winter respectively. This increased number of sweat glands in Kangayam cattle concurs with the observations of Jian *et al.* (2014) who reported that *Bos indicus* cattle had larger and more numerous sweat glands, and consequently greater capacity to maintain their thermal equilibrium by evaporation of sweat. Nascimento *et al.* (2015) stated that Gir breed of cattle had more density of sweat gland in summer (3359.8 sweat glands cm² area of skin) than in winter (1779.38 sweat glands cm² area of skin). The greater number of sweat glands during summer is to combat with the environmental temperature as described by Hayman and Nay (1958) who observed that seasonal variation in sweat gland volume more in Zebu $\times$ Jersey cattle than Jersey cattle as the result of smaller rise in rectal temperature.

CONCLUSION

The number of sweat glands were more in Kangayam animals (933/cm² and 816/cm²) than Jersey crossbred animals (656/cm² and 533/cm²) during summer and winter respectively. The active sweating ability in Kangayam cattle during summer revealed significant ($P < 0.05$) difference in length and diameter of sweat glands. The variation in sweat gland length, diameter, depth and density between Kangayam and Jersey crossbred cattle during different seasons could be correlated to their breed specific adaptational response to the environmental temperature. This correlation depicts the role of sweat gland in animal adaptation to different seasons especially in indigenous cattle.

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