

## **Study of Sweating Rate and Microscopic Anatomy of Some Breeds Bulls Sweat Glands in Different Body Parts**

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**ABSTRACT:** The study aimed to analyze the sweating rate and the microscopic anatomy of sweat glands of many breed bulls in different parts of the body. Ten bulls of 5 breeds (Simmental, Limousin, Crossed Ongole breed (PO), SimPO (Crossed between Simmental and PO), and LimPO (Crossed between Limousine and PO) in Authorized Slaughterhouse of Malang and Surabaya city were used during the study. Two bulls of each breed were observed for the sweating rate using a Cobalt Chloride Disk (CCD). The skin samples of four places in the legs and back of the animal were taken to be observed under a light microscope in the laboratory of Biosains of Universitas Brawijaya.

The result showed that for all breeds, the sweating rates in the legs were higher ( $P < 0.05$ ) than in the back. It was observed that the sweat glands of the legs had tubular, but the back part is in irregular shapes. Based on the study result it is suggested to measure the sweating rate in the back part of the animal body.

**Keywords:** Evaporatif cooling; Local cattle; Heat stress; Tropic

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## **INTRODUCTION**

The existence of various breeds of beef cattle in Indonesia is a reality with the tendency to increase the domination of *Bos taurus* (Limousin and Simmental) over *Bos indicus* (Crossbred Ongole/ *Peranakan Ongole* /PO). On small farms, there has been continuing crossbreeding between *Bos indicus* and *Bos taurus* because of higher birth weight and faster growth calves, also higher selling price compared, for example, to pure PO cattle. Uncontrolled crosses will threaten the loss of germplasm of local beef cattle that are already adaptive to Indonesia's tropical environment. Today, it is difficult to find local livestock such as PO in the animal market or slaughterhouse. The most are Limousin and Simmental or the results of their crosses with PO. PO is found to be more resistant to high ambient temperatures, low feed quality, and parasites.

One of the factors for livestock productivity is the adaptability of livestock to its thermal environment. In tropical climates, livestock receives additional heat load from the environment in addition to the heat production due to the metabolism of the feed consumed. The ability to dissipate heat evaporatively through sweating is a determinant of the adaptability of livestock in tropical environments. Livestock in the tropics is also exposed to high humidity so it will be difficult for livestock to release their body heat into the environment. Some research on the ability of thermal environmental adaptation in bulls by measuring the sweating rate and microscopic observation of the anatomical sweat glands have been carried out. However, some of the studies were carried out on the front and the back legs of the animal. Based on the literature study it is known that the best sweating rate measurement is carried out on the back part. The study to compare the sweating rate in different parts of the body in bulls is still limited.

Based on the description above, this study is conducted to compare the sweating rate and microscopic anatomy of the sweat gland in the legs and the back part of several cattle breeds, including PO, Limousin, Simmental, SimPO cross, and LimPO cross.

## **MATERIALS AND METHODS**

The research was conducted at Slaughterhouse in Malang (for all breeds) and Slaughterhouse in Surabaya (only for PO). The animals were 2-3 years old (check the animal teeth). Microscopic analysis of sweat gland observations was carried out at the Biosciences Laboratory of Universitas Brawijaya. The method used in this research was a case study. Observed variables were sweating rate and sweat gland volume.

The tools used during the study were:

- Stopwatch: to count the time needed to change the paper color from blue to pink.
- 10% Cobalt Chloride Disc (CCD) solution: for making CCDs.
- Object glass: for placing the CCD before affixing it to the animal.
- Perforator: for making round shapes on Whatman paper no. 1.
- Oven: To heat the CCD.
- Razor (hair razor): Tool for shaving the hair on the skin that will be placed CCD.
- Whatman paper: CCD making material.
- Clear tape: *Whatmann* paper adhesive tool on glass objects and cowhide.
- Aluminium foil: for wrapping the CCD when paving.
- Skin Puncher: A tool for taking skin samples.
- Film pot: As a sample storage tool.
- Formaldehyde 10%: as a preservative for skin samples.
- Hematoxylin Eosin: as a color indicator.
- Paraffin: as a cover for histological preparations.

How to Make Cobalt Chloride Disc (CCD) as follows (Aengwanich, 2011):

- Prepared CCD Making Equipment and Materials (Whatmann paper no.1, Cobalt Chloride 10%, oven, object-glass, masking tape, perforator, aluminum foil, Petri dishes)
- Dipped 5 sheets of Whatmann paper in 10% Cobalt chloride solution in a petri dish for 2 minutes
- Dry at room temperature (27°C) for 2 hours
- Dry in an oven at 80°C for 2 hours
- Make a circle using a perforator
- Place 3 circles in the object-glass with a distance of 5 mm - 10 mm
- Covered with tape
- Wrapped in aluminum foil and heated in the oven before using it on livestock

Sweating rate data collection is carried out at 12:00-13:00 WIB. Following is the sweating rate data retrieval procedure:

- Prepared CCD that has been made and has been heated before
- Shaved cattle hair on the thighs and back of the cow covering an area of 5 x 3 cm
- Affix the CCD on the shaved skin
- Observe the color change and note the length of time it changes from blue to pink
- Calculated sweating rate using the formula (Schleger and Turner, 1965):

$$SR (g / m^2 / hour) = 3.84 \times 10^4 / s$$

s: the time (seconds) it takes to change the CCD from blue to pink.

The stages of taking fresh skin samples at Authorized Slaughterhouse were as follows (Aengwanich, 2011):

- Prepared tools and materials (20 ml film pot, 10% formalin, skin puncher)

- Take skin samples with a size of 1x1 cm using a puncher as much as 1 piece for each leg and 4 pieces on the back
- Put in a film pot filled with 10% formaldehyde as much as 5 ml and give a label
- -Let stand for 3 weeks (21 days) counted since entering the pot film
- Sent specimens to the Bioscience laboratory after 3 weeks
- Attached paraffin to the skin sample crosswise and longitudinally, then sliced thinly using a 6 µm microtome
- Dropped with Hematoxylin-eosin
- Observed under a microscope with a magnification of 100x crosswise and averaged the number of glands per box cm.

Four measurements were taken under a microscope with a 10x magnifying glass, taken at each gland, one length (L), and three widths at three positions along with the sweat gland. The mean of the three width measurements is taken as the gland diameter (D).

The ratio of the length/diameter of the sweat glands (L / D) is used to determine the shape of the sweat glands. The sweat gland volume is calculated by the equation: Sweat gland volume ( $\mu\text{m}^3 \times 10^{-6}$ ) =  $\pi (D / 2)^2 L 10^{-6}$ , where D is the diameter and L is the length of the sweat glands (Jian *et al.*, 2014).

#### **Data analysis**

The sweating rate data obtained were analyzed using the unpaired t-test (t-test) as follows (Raditya, 2013):

$$t = (\bar{x}_1 - \bar{x}_2) / \sqrt{((s_1^2) / (n_1) + (s_2^2) / (n_2))}, \text{ where } df = (n_1 + n_2) - k$$

$\bar{x}_1$ : Average time in feet

$\bar{x}_2$ : Average time on the back

$n_1$ : The amount of time data in the leg

$n_2$ : The amount of time data on the back

$s_1^2$ : Variation of time on the leg

$s_2^2$ : Variety of time on the back

df: Degree of Freedom or degrees of freedom

k: The number of variables

The Sweat gland volume data obtained were analyzed descriptively and statistically using the unpaired t-test.

**RESULT AND DISCUSSION**

Up to the 5<sup>th</sup> month of observation, only 1 (one) PO bull was found to be slaughtered. Another PO bull was found at

RPH Surabaya after several observations. This situation shows the decreasing population of this native Indonesian local cattle. The livestock owners whose animals are to be slaughtered do not always allow it because they are worried about the given treatment will have a negative effect on their animals.

**Table 1.** Sweating Rate (SR) (g / m2 / hour) in feet and back of PO, Limousine, Simmental, SimPO, and LimPO bulls.

Breed	Leg	Back	Statistical Test Result
PO	368,7 ± 23,06	340,1 ± 15,89	P <0.05
Limousine	333,4 ± 40,29	277,5 ± 53,47	P <0.05
Simmental	274,3 ± 17,67	250,7 ± 23,42	P <0.05
LimPO	371,6 ± 51,41	312,9 ± 40, 98	P <0.05
SimPO	395,5 ± 30,92	338,6 ± 55.82	P <0.05

**Sweating Rate of different breeds of cows on different body parts.**

From Table 1, can be seen that PO (*Bos indicus*) cattle and their crosses have a higher (P<0.05) sweating rate than Limousine and Simmental (*Bos taurus*). Simmental cattle have the lowest average sweating rate of 250.7 ± 23.42 (g/m2/hour) on their back.

The highest average sweating rate was found in PO cattle. In the tropics, removing heat from the body by sweating (evaporation) is the main route of heat release from the body of livestock. Sweating is an effective way of dealing with environmental heat stress, especially in tropical areas like Indonesia. The results of this study corroborate the opinion that the measurement of sweating rate in the legs should be avoided because it will be influenced by the activity of the limb. A representative measurement of sweating rate is in the dorsal region.

The effort of crossing *Bos taurus* cattle from temperate regions with thermotolerant PO (*Bos indicus*) cattle can help these cattle adapt to environmental conditions in the tropics. However, it is still necessary to save the genetic source of this

PO heat-resistant cow so that the population does not continue to decline or even become extinct.

This can be indicated by the increasing difficulty of finding PO cattle in the field, especially in East Java, which is well known as the warehouse for Indonesian cattle.

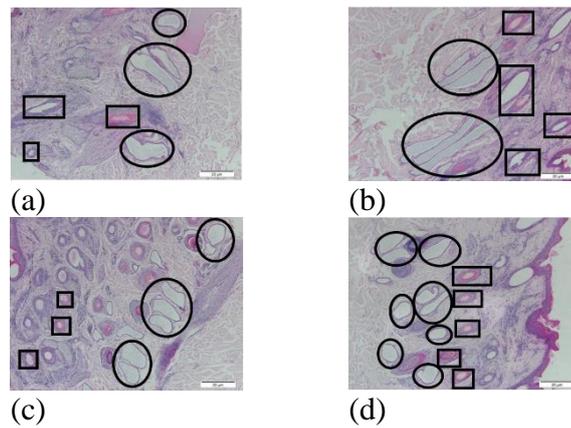
**Microscopic Anatomy of the Sweat Glands of several breeds of cattle on different parts of the body.**

Microscopic observations show that the shape of the sweat glands found on the legs and back is different. Observations on Limousine cattle show that the shape of the sweat glands on the back is elongated like a tube (tubular), while the legs are irregular, not long or round.

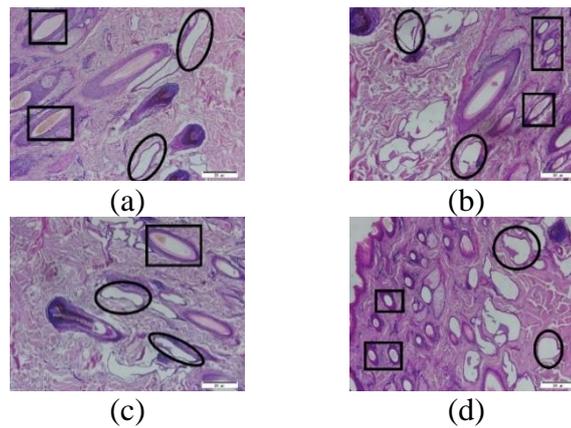
This is consistent with the statement of Hernandez *et al.* (2011) which states that a marked difference in the shape of the sweat glands was observed in that normal haired animals were found to have long, thin sweat glands with walls containing several cells and tubular or tubular shaped. In contrast, downy animals were found to have medium-sized glands with a wider lumen and thick walls containing many cells and a slightly baggy shape.

**Table 2.** The volume of sweat glands ( $\mu\text{m}^3 \times 10^{-6}$ ) on the legs and back of PO, Limousine, Simmental, SimPO, and LimPO bulls.

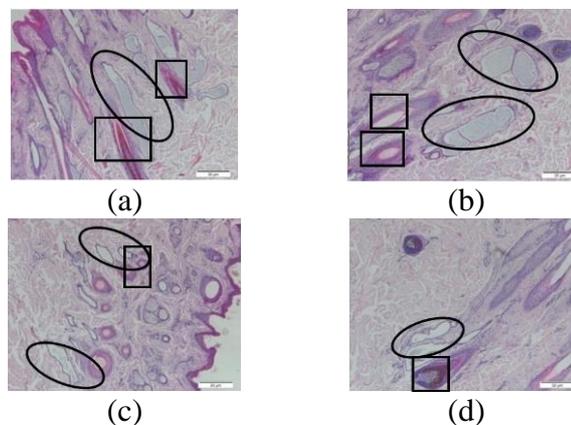
Breed	Legs	Back	Statistics
PO	3628,0 ± 1879,63	3403,3 ± 1256,14	P < 0.05
Limousine	4468,0 ± 2801,46	3519,6 ± 1961,47	P > 0.05
Simmental	3628,0 ± 1879,63	3403,3 ± 1256,14	P > 0.05
LimPO	4320,7 ± 4118,70	5604,6 ± 2765,55	P > 0.05
SimPO	3810,3 ± 1868,15	3520,3 ± 1404,02	P > 0.05



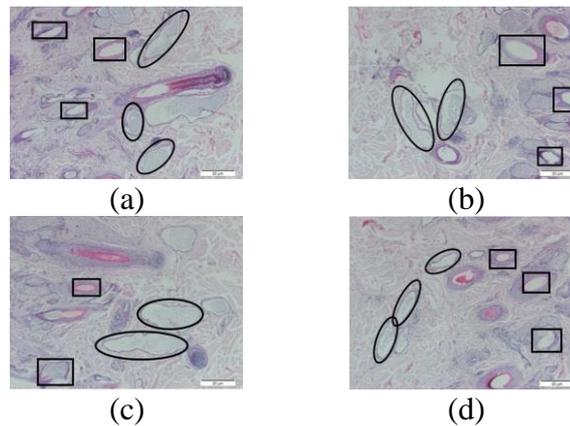
**Figure 1.** Anatomy of a cow's sweat gland PO bulls



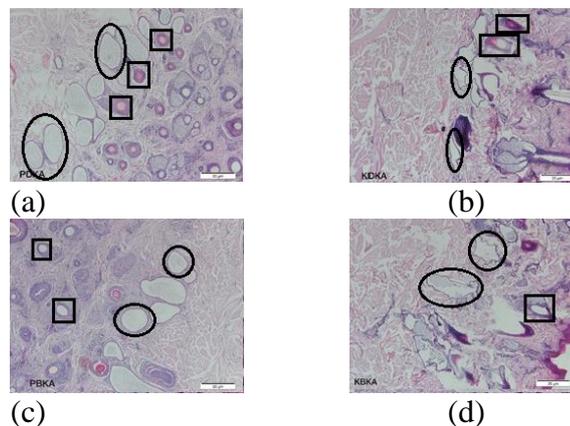
**Figure 2.** Anatomy of a cow's sweat gland Limousine bulls.



**Figure 3.** Anatomy of a cow's sweat gland Simmental bulls



**Figure 4.** Anatomy of a cow's sweat gland LimPO bulls



**Figure 5.** Anatomy of a cow's sweat gland SimPO

Note: (a) & (b) Back; (c) & (d) Legs

□: Hair follicle, ○: Sweat gland

Measurement of sweat gland volume in different breeds of cattle gives different statistical test results. However, it can be said that in general there is a tendency that the volume of the sweat glands on the legs to be greater than that on the back. The average volume of sweat glands on the legs and back of several cow breeds that were observed can be seen in Table 2.

Mostly, the sweat glands on the legs and back of cattle in this study showed the same volume. The rate of sweating on the legs is higher than that of the back. This can be explained that the feet are active limbs. Even though the cattle during the observation are in a relatively narrow pen area and in limited conditions for movement (the cattle are tied), the legs are moved relatively more than the back, for example, the cattle are standing up from a lying position or rotating their body, all

movements of the cattle will be using both the front and back legs to support the body and allow the movement to be done.

## CONCLUSIONS

Based on the results of this study, it can be concluded that the sweating rate of the legs is higher than that of the back. The recommended measurement of sweating speed is on the back. Ongole crossbred cattle (*Bos indicus*) have the highest sweating speed while the lowest is Simmental (*Bos taurus*).

The volume of the sweat glands in the legs tends to be greater than that of the back. There is no difference in the volume of the sweat glands in the legs and back. The shape sweat glands on the back have a sweat gland that extends like a tube (tubular), while the legs have an irregular shape.

## REFERENCES

- Adhianto, K., Siswanto, & Kesuma, C. N. (2015). Pengaruh frekuensi penyiraman air menggunakan sprinkler terhadap respon fisiologis dan pertumbuhan sapi peranakan simmental. *Buletin Peternakan*, 39(2), 109. <https://doi.org/10.21059/buletinpeternak.v39i2.6715>
- Murda, A. T. (2013). Penentuan tren arah pergerakan harga saham dengan menggunakan moving average convergence divergence (Studi Kasus Harga Saham pada 6 Anggota LQ 45). *Perspektif Pelajar Terhadap Kurikulum Sejarah Peringkat Menengah Di Malaysia*, 2(4), 249–258.
- Aengwanich, W., Kongbuntad, W., & Boonsorn, T. (2011). Effects of shade on physiological changes, oxidative stress, and total antioxidant power in Thai Brahman cattle. *International Journal of Biometeorology*, 55(5), 741–748. <https://doi.org/10.1007/s00484-010-0389-y>
- Astuti, A., Erwanto, & Santosa, P. E. (2015). Pengaruh cara pemberian konsentrat-hijauan terhadap respon fisiologis dan performa sapi peranakan simmental. *Jurnal Ilmiah Peternakan Terpadu*, 3(4), 201–207.
- Beatty, D. T., Barnes, A., Taylor, E., Pethick, D., McCarthy, M., & Maloney, S. K. (2006). Physiological responses of *Bos taurus* and *Bos indicus* cattle to prolonged, continuous heat and humidity. *Journal of Animal Science*, 84(4), 972–985. <https://doi.org/10.2527/2006.8444972x>
- Bertipaglia, E. C. A., da Silva, R. G., Cardoso, V., & Fries, L. A. (2007). Hair coat characteristics and sweating rate of Braford cows in Brazil. *Livestock Science*, 112(1–2), 99–108. <https://doi.org/10.1016/j.livsci.2007.01.159>
- Das, P., Ranjan, R., & Paul, S. (2014). A comparative histological study on the sweat gland of cattle (*B. Indicus*) and yak (*P. Poepagus*). *Exploratory Animal and Medical Research*, 4(2), 183–187.
- de Paula Xavier de Andrade, R., de Andrade Ferreira, M., de Azevedo, M., da Silva, E. C., Urbano, S. A., da Conceição, M. G., & de Lima Silva, J. (2017). Feed handling of lactating crossbred cows maintained in a semi-arid region during the hot season: physiological parameters, ingestive behavior and performance. *Animal Science Journal*, 88(1), 166–172. <https://doi.org/10.1111/asj.12618>
- Fikar, S., & Ruhyadi, D. (2010). *Beternak dan Bisnis Sapi Potong*. AgroMedia Pustaka.
- Jian, W., Duangjinda, M., Vajrabukka, C., & Katawatin, S. (2014). Differences of skin morphology in *Bos indicus*, *Bos taurus*, and their crossbreds. *International Journal of Biometeorology*, 58(6), 1087–1094. <https://doi.org/10.1007/s00484-013-0700-9>
- Kalangi, S. J. R. (2014). Histofisiologi kulit. *Jurnal Biomedik (JBM)*, 5(3), 12–20. <https://doi.org/10.35790/jbm.5.3.2013.4344>
- Muada, D. B., Paputungan, U., Hendrik, M. J., & Turangan, S. H. (2017). Karakteristik semen segar sapi bangsa limousin dan simmental di balai inseminasi buatan lembang. *ZOOTEC*, 37(2), 360. <https://doi.org/10.35792/zot.37.2.2017.16156>
- Nascimento, M. R. B. de M., Dias, E. A., Santos, T. R. dos, Ayres, G. F., Nascimento, C. C. N., & Beletti, M. E. (2015). Effects of age on histological parameters of the sweat glands of Nellore cattle. *Revista Ceres*, 62(2), 129–132. <https://doi.org/10.1590/0034-737X201562020001>
- Ridwan, M. H., Arifin, M., & Purbowati, E. (2019). Karakteristik karkas sapi peranakan simmental jantan di rumah potong hewan kota semarang. *Jurnal Pengembangan Penyuluhan Pertanian*, 14(25), 33–44. <https://doi.org/10.36626/jppp.v14i25.49>
- Rohankar, R. U., Waghaye, Y., Kapadnis, P. J., Thakur, P. N., & Kapadnis, P. J.

- (2018). Histological study of sweat glands of cattle breeds of maharashtra in different climatic condition. *International Journal of Science, Environment and Technology*, 7(3), 1221–1230.
- Schleger, A., & Turner, H. (1965). Sweating rates of cattle in the field and their reaction to diurnal and seasonal changes. *Australian Journal of Agricultural Research*, 16(1), 92–106. <https://doi.org/10.1071/AR9650092>
- Suherman, D. (2014). Efek waktu pemberian pakan dan level energi terhadap cekaman panas berdasarkan suhu rektal dan kulit sapi dara fries holland. *Jurnal Sain Peternakan Indonesia*, 9(2), 117–129. <https://doi.org/10.31186/jspi.id.9.2.117-129>
- Wati, R., & Mayasari, E. (2015). Sistem pendukung keputusan pemilihan bibit sapi unggul dengan metode simple additive weighting (SAW) pada peternakan sapi Sriagung Padangratu Lampung Tengah. *Jurnal TAM (Technology Acceptance Model)*, 5.