The Comparison of Sweating Rate and Sweat Gland Anatomy between Simmental and Its Crossing with Ongole Crossbred (SimPO) Bulls

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Abstract. The purpose of this study was to find out the sweating rate and anatomy of the sweat glands of Simmental and their crossing with the Ongole cross bred (SimPO) bulls. The research was conducted in Authorized Slaughter House of Gadang, Malang City and the Bioscience Laboratory of University of Brawijaya. The material used were 4 Simmental, and 5 SimPO bulls with an average weight of ≥300 kg and age of ≥2 years. Sweating rate data were collected use Cobalt Chloride Disc. The anatomy of the sweat gland skin samples were observed in the Bioscience Laboratory. Data sweating rate obtained were analyzed statistically using unpaired t-test. The result showed there was significant difference (P<0,05) of sweating rate between Simmental and SimPO bulls. The sweat gland of Simmental have a smaller size and tubular likes shape than SimPO. The SimPO has a large and baggy sweat gland.

1. Introduction

Lately the government has been striving to increase beef population with the SIWAB UPSUS (Special Effort for Cows / Buffalo Buffers for Obligatory Pregnant) to meet domestic needs and achieve the goal of meat self-sufficiency in 2026. From the data [1] beef cattle population each year has increased, in 2017 as many as 16,429,000 tails, and in 2018 as many as 17,050,000 tails, the largest population was in East Java Province which was 4,511,613 tails in 2017 and in 2018 as many as 4,657,567 tails, by therefore East Java can be regarded as a national cattle barn and has the potential to be a central production of quality beef cattle breeds. From this, management of calf maintenance needs to be prepared until they are ready to slaughter in order to create quality beef cattle and animal welfare implementation in maintenance.

Many factors support the success of the beef cattle fattening business, one of which is quality feed. Apart from that, animal welfare also needs to be considered so that livestock are in a comfort zone according to their physiological status. One of the physiological status of livestock is the ability to adjust body temperature to environmental conditions (hot / cold stress) by knowing the sweating rate and the anatomy of sweat glands. This is important for policy makers because it can be used as a scientific basis in determining the choice of beef cattle breed to be developed. In Indonesia the level of heat stress is included in the moderate category because the average temperature in Indonesia ranges from 25-32 ° C.
The negative effects of heat stress can be minimized through improvements to environmental factors including feed and selection of cage types that are more appropriate to the location of the farm [2].

Heat stress is divided into 6 levels of categories, the first of which is cattle showing uneasy and many standing behavior, secondly the rate of sweating increases, salivation, and clustering, thirdly the rate of breathing increases, saliva and foam out of the mouth, standing, uneasy and flocking, the fourth respiratory rate increases, saliva and foam come out of the mouth, standing, uneasy, swarming, and breathing using the open mouth, the fifth when breathing there is pressure from the flank, the tongue sticks out, sometimes saliva comes out, the sixth when breathing presses the flank, no saliva, and isolated [3].

Heat stress can be reduced by selecting breed that are suitable for the climate. One of them is by raising cross cattle between the Bos taurus breed, namely Simmental who has superiority in daily gain which reaches ≥ 1 kg with Bos indicus local cattle, namely Peranakan Ongole who have superior resistance to heat stress in Indonesia. It is hoped that this crossed cow (SimPO) will have a combination of superiority from the two elders. Lack of information about the anatomy and physiology of cattle resulting from crossing, especially sweating rate and anatomy of sweat glands, causes it is not known in full how superior the crossed cattle are compared to other breed cattle. Therefore this research is carried out in the hope of finding out the differences and advantages of the two cows in terms of the sweating rate and the anatomy of sweat glands.

Based on literature searches, it is known that the availability of scientific data on sweating rates and the anatomy of sweat glands, especially in Simmental cattle (Bos taurus) and male SimPO is still limited. The purpose of the study was to determine the difference in sweating rate and anatomy of the sweat glands between Simmental and SimPO bulls.

2. Materials and methods
The material used in this study were 9 bulls consisting of 4 Simmental bulls with a purity of > 75% (judging from their physical characteristics) and 5 Simmental crosses with PO (SimPO) bulls with Simmental blood percentage < 75%, and PO > 25% with an average body weight of ≥ 300 kg located in the in Authorized Slaughter House of Gadang, Malang City. After the cattle arrived at the abattoir, the following day data collection of sweating rate was taken.

In the measurement of sweating rate used equipment in the form of a stopwatch (a tool to measure the length of time the change of CCD filter paper from blue to pink), Cobalt Chloride 5% solution (for manufacturing CCD), glass object (a tool for placing the CCD before attaching it to livestock), perforator (a tool to make a circle on Whatman paper number 1, oven (to heat the CCD before use), razor blade (a tool to shave the hair on the skin to be affixed with CCD), Whatman paper number 1 (CCD material), clear tape (clear tape) CCD adhesive on object glass and cow skin) and aluminium foil (a tool for wrapping CCD during oven). In making histology preparations for skin, the equipment used was skin puncher (a tool to take skin samples measuring 1x1 cm), film pots (as storage container for skin samples), 10% formaldehyde, HE (as a color indicator), paraffin (as a cover for histological preparations), microtomes (cutting tools for skin preparations) and light microscope.

2.1. Procedure for Making Cobalt Chloride Disc (CCD)
The following is a chart of the procedure for making Cobalt Chloride Disc (CCD) which is used in taking data sweating rate in Authorized Slaughter House of Gadang, Malang City.
2.2. Data Sweating Rate Retrieval Procedure

Sweating Rate was observed at 12.00-13.00 WIB

- Allow animals to be as comfortable as possible
- Hair removed for the CCD stick
- A CCD was attached to the part where the hair was removed
- Observed time of CCD color change from blue to pink (seconds)
- The time is recorded and calculated using a formula

Figure 2. Data sweating rate retrieval procedure
The sweating rate calculation is done using the following formula [4]:

\[
\frac{4 \times 3600}{2.06 \times t} = \frac{6990}{t}
\]

Description: \( t \) = time needed to change the CCD from blue to pink (seconds)

2.3. Variables observed
1. Sweating rate (rate of sweating by measuring the time needed to change the color of the CCD from blue to pink) (seconds)
2. Anatomy of the sweat glands by observing using a light microscope at the Bioscience Laboratory

2.4. Data analysis
Data was collected during the day with an average temperature and humidity for several months as follows: Temperature 30.10 ± 0.06 °C, and Humidity 66.22 ± 6.43%. Sweating rate data is statistically analyzed using the unpaired student-t test (t test). Anatomical data of sweat glands were analyzed descriptively. The unpaired t-test formula used in processing the data is as follows:

\[
\frac{[X_A - X_B]}{\sqrt{(n_A)(S^2_A) + (n_B)(S^2_B)} / n_A + n_B \times \left(\frac{1}{n_A} + \frac{1}{n_B}\right)}
\]

Description:
\( X_A \): Average Simmental Cow
\( X_B \): Average SimPO Beef
\( n_A \): Amount of Simmental Cow data
\( n_B \): Amount of SimPO Cattle data
\( S^2_A \): Variety of Simmental Cows
\( S^2_B \): Variety of SimPO Cows

3. Results and discussion

3.1. Characteristics of bulls

3.1.1 Simmental bulls
The characteristics of Simmental cattle used in data collection are as follows: skin color/red brownish brown hair, white on the front of the head or forehead and hair at the end of the tail, thinly sagged, some have horns and some are not horned, but the exact purity of the Simmental cow is unknown, based only on physical characteristics. This is in accordance with the statement of [5] which states that Simmental cattle have body features including, a brick red or red brown body with a white front head with slightly thick curly hair, no sagging, white tail tip, part lower legs (tarsal / metatarsal) are white and those that are red are like body color. [6] states that this cow has the characteristics of large body size, good muscle growth, low fat accumulation under the skin, hair color is generally beige brown or slightly red, face, four legs from the knees, and the tip of the tail is white. The size of the small horn, the weight of female cows reaches 800 kg, and males 1150 kg. The following Figure 3 is a documentation of one of the Simmental cattle used in the study.
3.1.2 SimPO Bulls
SimPO cattle are the result of crossing between Simmental cows with PO, both females and males. The bulls we use in this study have more faded color characteristics than Simmental cows or tend to be mixed with grayish black, thin sagging, some are horned and some are not horned, the head is white with a clear color border. But in this study it is not known with certainty the proportion of blood crossed, only referred based on physical characteristics. This is in accordance with the statement of [7] which states that the SimPO poel 2 cow in Terbanggi Besar District has a hump of 52% and 48% without humps. PO and SimPO cows with 2 incisors in Terbanggi Besar sub-district have whip (100%). This is consistent with [8] [7] that PO cows have skin folds that are under the neck and abdomen but are not in accordance with the opinion [9] [7] which states that SimPO cows do not have whip, it is suspected that SimPO Cows in Terbanggi Besar District mostly inherited genetic PO Cows. SimPO cattle with incisors changing 2 in the district of Terbanggi Besar have skin color (fur) namely white brown (62%), white dark brown (14%), and white black (24%). The following is a documentation of one of the SimPO cows used in the study.

3.2. Sweating Rate Simmental and SimPO Bulls
From the results of measurements that have been made, the average rate of sweating is as follows: Simmental cattle 87.58 ± 9.87 g / cm² / hour, while SimPO cattle 124.61 ± 22.97 g / cm² / hour. SimPO cows have a higher sweating rate compared to Simmental (Bos taurus) allegedly due to the inheritance of genetic traits of PO (Bos Indicus) cattle that are resistant to tropical climates. This is also supported
by statements [10][11] which state the level of sweating for Bos indicus is higher than the Bos taurus. This is also supported by statements [10] [12] that Bos taurus is less adaptable to heat conditions and at a lower air temperature has more sweating rates big from Bos indicus.

| Bull breed | SR Forefoot Average (g/cm²/jam) | SR Rear Leg Average (g/cm²/jam) | Whole (g/cm²/jam) |
|------------|----------------------------------|---------------------------------|-------------------|
| Simmental  | 89.31±5.29 a                     | 85.86±14.24                    | 87.58±9.87 a      |
| SimPO      | 131.83±26.38 b                    | 117.40±20.28                   | 124.61±22.97 b    |

Note: Notations with different superscripts in the same column are significantly different (P <0.05)

At the same skin temperature, Bos taurus cows will sweat less than Bos indicus because of the vasodilation effect. When animals get hotter, skin vasodilation increases, which causes an increase in skin temperature. This is also supported by the statement of Thomson et al. [11] which states that Bos taurus is more dependent on respiration to release body heat because the capacity to sweat is less than Bos indicus.

Some factors that can affect the rate of sweating include cattle breed, environmental temperature, treatment of livestock when collecting data, equipment used (CCD), selection of CCD attachment positions on body parts, and the human factor itself in determining observations of color changes CCD from blue turns pink. Retrieval of data usually uses limbs because it is considered as an active body part that moves so that it will sweat more than other body parts. In this data retrieval we use four legs namely on the shank. This is consistent with the statement of [11] which states one of the locations in animals chosen to measure the sweating rate. [13] found that compared to the waist, other areas such as the front of the shoulder can produce 60% more sweat per hour. Gatenby [14] found that the backs of zebu cows can sweat 3 times compared to the abdomen. Gatenby [14] also found a local effect on skin temperature, where an animal's skin area receives direct sunlight so that the area sweats more than other regions.

3.3. Anatomy of the sweat glands

3.3.1 Histology of sweat glands

The skin is divided into three main parts namely Epidermis, Dermis and Endodermis. The epidermis is located in the outermost part of the skin which is in contact or direct friction. The dermis is located after the epidermis, in which there are many glands and tissues. While the endodermis is located closer to fat and muscle. Next is the histology of the skin in studies with a 100x magnification.

Figure 5. Anatomy of the skin gland. (A) Sebaceous gland; (B) Sweat gland; (C) Nerves; (D) Dermal papilla; (E) Hair Follicle; (F) Binding network
3.3.2 Comparison of anatomy of Simmental cow and SimPO sweat glands

The following is a comparison of the anatomy of the forefoot sweat glands between Simmental and SimPO bulls.

![Comparison of Simmental and SimPO forefoot sweat glands](image)

**Figure 6.** Simmental cattle and SimPO forefoot sweat glands (100x magnification). (A) Simmental right front foot; (B) SimPO right front leg; (C) Simmental left foreleg; (D) SimPO left foreleg.

The following is a comparison of the anatomy of the rear leg sweat glands between Simmental cattle and SimPO cattle.

![Comparison of Simmental and SimPO hind leg sweat glands](image)

**Figure 7.** Simmental and SimPO bulls hind leg sweat glands (100x Magnification). (A) Simmental right back leg; (B) SimPO right rear leg; (C) Simmental left back leg; (D) SimPO left back leg.
Sub-tropical cattle (Bos taurus) namely Simmental has a smaller and rounder form of sweat glands compared to cross-cow sweat glands namely SimPO which has a larger and elongated shape. This is presumably because SimPO cattle inherit genetic PO cows originating from the tropics (Bos indicus) which have a larger sweat gland size, making them more tolerant of the heat stress experienced because they can sweat more as an effort to dissipate body heat compared to sub-tropical cows which has a smaller sweat gland size. This is comparable to the statement of Thomson et al. [11] which states the difference in sweating rate among offspring can be related to physiological differences in sweat gland size, shape, and density. [11, 15] found Bos indicus has a greater sweat gland than Bos taurus. [11] found that Bos Indicus not only has a greater sweat gland, but also a greater sweat density than the Bos taurus gland, which is directly related to an increase in sweating rate. [11, 16] found that "baggy" sweat glands from Bos indicus were associated with heat tolerance compared to the "narrow, circular" glands of Bos taurus. This combination of anatomical and physiological differences results in increased sweating rate capacity for Bos indicus, as found in the literature [10, 11].

Some cattle from Simmental and PO (SimPO) have a gray-black color, this is thought to affect the size of sweat glands, because cows that have a darker skin color will receive more heat exposure, so they experience greater heat stress compared to cows the white one. The size of the larger sweat glands owned by a dark colored cow is an effort to adjust the body to the state of the environment so that it remains in the comfort zone to live and breed. This is consistent with [16] which states that previous studies have shown that skin color affects heat evaporation. It was also reported that cows with dark skin had a greater number of sweat glands compared to cows with light skin [16]. The same study also reported higher nerve density in blacks than in whites [16]. Because Frisien Holstein and crosses are generally covered by hair surface areas that are proportional to black and white skin, the proportion of skin color can affect the ability of animal heat tolerating [16].

4. Conclusion
The rate of sweating between Simmental cattle (Bos Taurus) is 87.58 ± 9.87 g / cm² / hour, while the cattle crossed with PO (SimPO) are 124.61 ± 22.97 g / cm² / hour. And the sweat glands of Simmental cattle (Bos Taurus) are smaller and rounder than those of large, long-stretched "baggy" SimPO cows, so that SimPO cattle are superior in terms of resistance to climate heat stress in Indonesia.

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