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Differences in Microclimate Characteristics Influencing the Physiological Values and Productivity of Beef Cattle in Central Lampung

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Abstract. The research aimed to study the physiological response and productivity of beef cattle to different microclimatic characteristics of pens in Terbanggi Besar, Central Lampung District. Ten beef cattle, five each, were placed in two different pens. Pen A was in an open-green environment with an enclosure height of 4 meters, while pen B was in a residential environment with an enclosure height of 3 meters. Microclimate profile measurements were taken three times a day, while physiological values (rectal temperature, heart rate and respiratory frequency) were taken twice a day. Daily Body Weight Gain (DBWG) measurements were taken to determine cattle productivity. This study showed that the microclimate conditions of pen A had lower temperature, humidity, Temperature Humidity Index (THI), and ammonia, as well as higher wind speed compared to pen B. This has implications for the physiological values of beef cattle. Although both pens showed signs of moderate stress with THI (80.69±1.18) in pen A and THI (82.10±0.82) in pen B, beef cattle in pen A still showed better physiological values than beef cattle in pen B ($p < 0.05$). The productivity of beef cattle in pen A was indicated by better DBWG values than beef cattle in pen B, namely (1.59±0.16) kg/day and (1.30±0.23) kg/day ($p < 0.05$).

Keywords : Beef Cattle; Environmental Differences; Microclimate of the Pen; Physiological Response; Lampung Tengah.

INTRODUCTION

The demand for animal protein is increasing every year, and beef has become one of the animal proteins favored by the Indonesian people. The development of per capita beef equivalent consumption among the Indonesian population from 2018 to 2022 fluctuated and tended to increase at an average rate of 1.64% per year. (Pusat Data dan Sistem Informasi Pertanian 2022). Therefore, efforts to increase domestic production are necessary to maintain the price of beef in the community. There are several regions that serve as national livestock hubs, and Lampung Province is one of them. Based on data from the Livestock and Animal Health Service of Lampung Province, the population of beef cattle in Lampung reaches 860,951 heads, making it the second-largest population on the island of Sumatra and contributing 4.9% to the national beef cattle population. (Suroso *et al*. 2023). Terbanggi Besar District is one of the districts in Central Lampung Regency that has the potential to be a beef cattle farming area. The beef cattle population in this region is about 12.82% of the beef cattle population in Central Lampung Regency, which has an area of 212.33 km^2 (Dhita *et al*. 2017).

Although it has great potential, farmers in this area still face several problems that affect the productivity of beef cattle. Livestock productivity is influenced by several factors, including genetic factors, feed, management, housing, disease eradication and prevention, and environmental factors (Yani and Purwanto 2006). According to Atrian

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and Shahryar (2012), environmental factors have a more dominant influence than genetic factors. Environmental changes such as temperature increases, humidity, wind speed, and sunlight intensity, as well as ammonia levels, can affect the physiological responses of livestock. Because livestock will respond to these environmental conditions adaptively through physiological changes, including changes in body temperature, heart rate, and increased respiratory frequency.

Beef cattle grow optimally at temperatures of 17-27 °C with ideal humidity ranging from 60-80%. (Adithia *et al.* 2022). The Terbanggi Besar District, located in Central Lampung Regency, has an average temperature of 31.7 °C and high humidity throughout the year. (BPS Lampung Tengah 2023). The climate that differs from the optimum value is feared to disrupt the productivity of beef cattle. Thus, it necessitates the penetration of a more comfortable environmental climate in the pen for livestock, in order to achieve good livestock productivity and health. Considering this, it is important to understand the impact of different stable microclimates on the physiological values and productivity of beef cattle in Terbanggi Besar District, Lampung.

METHODS

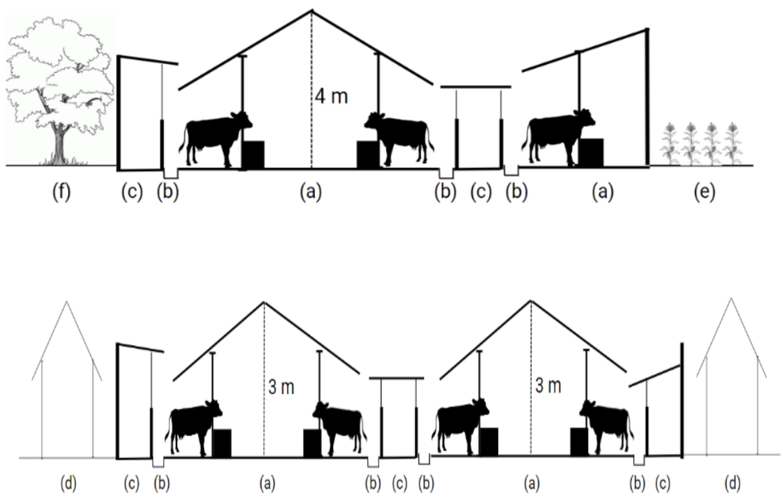
Time and Place

The research was conducted from August 2023 to December 2023 at the people's farm in Karang Endah Village, Terbanggi Besar District, Central Lampung Regency. Both cages have the same pen management and feed (agricultural waste and concentrate), but different environmental conditions and roof heights. Pen A is located in an environment surrounded by green open fields and corn plantations, with a roof height of 4 meters. Meanwhile, pen B is situated around residential areas and has a pen height of 3 meters, as shown in Figure 1.

Figure 1. Condition of pen A and pen B

(A)

(B)



Information: (a) pen room, (b) drainage (c) Feses reservoir, (d) residential areas, (e) plantation, (f) open land - green

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Tools and Materials

The tools used in this study are the HTC-1 thermohygrometer, digital anemometer, ammonia test paper, digital thermometer, and stethoscope. The observed beef cattle consisted of 10 adult male Limousin and Simmental cattle aged ≥ 2 years, in healthy condition, randomly selected from two different pens.

Research Procedure

Cage Microclimate Measurement

The measurement of temperature and humidity in the pen was conducted using the HTC-1 thermohygrometer for one week. The measurement of temperature and humidity in the cage was performed three times a day, namely at 06:00 AM, 12:00 noon, and 06:00 PM. Each pen had 3 placement points for the HTC-1, which were at the entrance, the center, and the side of the pen. The measurement of wind speed in the pen was also conducted for a week with three repetitions per day, namely at 06:00 AM, 12:00 noon, and 06:00 PM, by placing a digital anemometer at the entrance and recording the stable reading on the digital anemometer's screen. The temperature humidity index (THI) is calculated using the formula $THI = 0.8T + RH (T - 14.4) + 46.4$, where T is the air temperature (°C) and RH is the air humidity (%). The THI threshold values consist of normal levels ($THI \leq 74$), mild stress ($75 \leq THI \leq 78$), moderate stress ($79 \leq THI \leq 83$), and severe stress ($THI \geq 84$). (Bulitta *et al*. 2015). Ammonia measurements were conducted using ammonia test paper (Hydron AM-40) for one week. The measurements were taken three times a day, at 06:00 AM, 12:00 noon, and 18:00 PM. The testing was carried out at two locations in each pen, namely at the feces collection area and on the pen floor where feces were present.

Physiological Response

The measurement of physiological responses was conducted on 10 adult Bos Taurus cattle from two different pens, with two repetitions per day, at 10:00 AM and 4:00 PM, over the course of one week during the research period. Rectal temperature was measured using a digital thermometer by inserting the thermometer into the cow's rectum for approximately one minute at a depth of ± 5 cm until the digital thermometer beeped. The measurement of respiratory frequency is done by placing the back of the hand near the nostrils of the cow. And the measurement of heart rate frequency is done by auscultating at the maximum point (punctum maximum) located in the axilla. The respiratory and heart rates are counted for 15 seconds, then multiplied by four to obtain the frequency result for 1 minute. In addition, data on the weight gain of the cattle was also collected by measuring the difference in weight gain from 3 months prior.

Data Analysis

The microclimate data of the pens (temperature, humidity, and THI), ammonia, and physiological responses (rectal temperature, body surface temperature, respiratory rate, and heart rate) were analyzed using Microsoft Excel and GraphPad Prism 8 software. Unpaired T-test analysis was conducted to determine the level of significant differences in the microclimate of the pens and the physiological values of beef cattle between the two pens, with the following details: no significant difference (ns indicates $p > 0.05$); significant difference (* indicates $p \leq 0.05$); highly significant difference (** indicates $p \leq 0.01$); and extremely significant difference (*** indicates $p \leq 0.001$).

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RESULTS AND DISCUSSION

Microclimate measurements of the pens show that the temperature in pen B is higher compared to pen A and the difference is highly significant ($p \leq 0.01$). Table 1 also shows that the humidity in pen B is higher compared to pen A, but there is no significant difference ($p > 0.05$). The high temperature and humidity in pen B directly cause the THI in pen B to be higher compared to pen A, indicating a significant difference ($p \leq 0.05$). Additionally, the wind speed in pen A is higher compared to pen B, and there is a significant difference ($p \leq 0.05$). On the other hand, the ammonia level in pen B is higher compared to pen A, and there is an extremely significant difference between the two pens ($p \leq 0.001$).

Table 1. Average pens microclimate and P value

Parameter	Cage A	Cage B	P *Value*
Temperature (°C)	30,03±0,45	30,83±0,35	0,0056 (**)
Humidity (%)	65,63±3,79	67,55±2,20	0,2690 (ns)
THI	80,69±1,18	82,10±0,82	0,0234 (*)
Wind speed (m/s)	1.25±0,32	0,79±0,26	0,0112 (*)
Amonia (ppm)	9,65±1,16	15,42±2,39	0,0003(***)

Information: no significant difference (ns indicates $p > 0.05$); significant difference (* indicates $p \leq 0.05$); highly significant difference (** indicates $p \leq 0.01$); and extremely significant difference (*** indicates $p \leq 0.001$).

The microclimate conditions of an area will affect the physiological parameters of livestock (Suprayogi *et al*. 2017) and impact their productivity. As Yani and Purwanto (2006) stated, a microclimate in a location that is not conducive to livestock life prevents the genetic potential of an animal from being optimally displayed. In Table 1, it can be seen that the average temperature of both pens is above the optimal growth value for beef cattle. However, the temperature in pen A is lower, making it considered better. Meanwhile, there is no significant difference in humidity between pen A and pen B, and both remain within the optimal humidity range. From the temperature and humidity data, the temperature humidity index (THI) of the pen can be calculated, which is a method to determine the comfort level of living beings through two main climate parameters: temperature and relative humidity of the environment. (Azahra dan Kartikawati 2021). Although the THI values of both pens still indicate moderate heat stress in the cattle, the THI in pen A is considered better due to a significant difference between the two pens ($p \leq 0.05$). Heat stress occurs due to high temperature and humidity in the pen, causing livestock to experience heat stress. This results in a decrease in livestock productivity because feed consumption decreases, and the feed that is consumed will be used more for regulating the livestock's body temperature. (Habeeb *et al*. 2018).

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On the other hand, the ammonia concentration circulating in both pens is still below the maximum limit of 25 ppm. (Tiffani *et al.* 2017). The concentration of ammonia in the pen is influenced by factors such as air temperature, air humidity, air velocity, and air change rate. As shown in Table 1, pen A has a lower ammonia concentration because it has better barn temperature and humidity, as well as wind speed, compared to pen B, thereby reducing the circulating ammonia levels in the pen. High levels of ammonia in the air can cause health and productivity problems in cattle, such as skin irritation and tissue inflammation. Even prolonged exposure to ammonia can lower the immunity of cows and increase disease morbidity. Highly productive cattle require a lot of fresh air of suitable quality, as insufficient oxygen can slow down the metabolism of the cattle. Thus, it disrupts the fattening process in beef cattle (Herbut dan Angrecka 2014). From the explanation above, it is illustrated that the microclimate of pen A is more supportive of optimizing the productivity of beef cattle. This is influenced by the difference in roof height and the environment of the two pens, which results in a significant difference in the wind speed blowing inside the pen. In Table 1, it can be seen that the wind speed in pen A is higher, which will improve the air circulation inside the pen, resulting in better temperature, humidity, THI, and ammonia levels in pen A compared to pen B. The wind speed functions to carry away the higher temperature air around the livestock to other areas, and it can help the process of convection and evaporation of heat from the livestock's body to the environment. The higher the wind speed, the faster the process of heat transfer from the body will be. (Suherman *et al*. 2013).

The differences in the microclimate of the pens will affect the physiological values of the cattle, as seen in Table 2, where the rectal temperature, respiratory rate, and heart rate of the cattle in pen B are higher compared to those in pen A, with a significant difference in heart rate ($p \leq 0.05$); a highly significant difference in respiratory rate ($p \leq 0.01$); and an extremely significant difference in rectal temperature ($p \leq 0.001$). Conversely, for Body Weight Gain (BWG) and Daily Body Weight Gain (DBWG), the cattle in pen A have higher values compared to those in pen B, with a significant difference ($p \leq 0.05$) between the two pens.

Table 2. Average physiological value and productivity and P value

Parameter	**Cage A**	**Cage B**	**P *Value***
Physiological value			
Rectal temperature (°C)	38,49±0,12	38,76±0,12	0,0009 (***)
Respiratory rate (times/minute)	41,54±2,47	48,43±4,75	0,0052 (**)
Heart rate (times/minute)	84,63±4,50	96,34±9,45	0,0119 (*)
Productivity			
BWG (kg)	143,20±14,48	117,20±20,32	0,0481 (*)
DBWG (kg)	1,59±0,16	1,30±0,23	0,0498 (*)

Information: no significant difference (ns indicates p > 0.05); significant difference (*indicates ≤ 0.05); highly significant difference (** indicates p ≤ 0.01); and extremely significant difference (*** indicates p ≤ 0.001).

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Considering the differences in microclimates that occur, these conditions will directly affect the physiological responses of beef cattle in the pen. Rectal temperature is one of the commonly used parameters for body temperature regulation, as its range is relatively more constant and easier to measure in the field. (Suherman *et al*. 2013). According to Sokku and Harun (2019), the normal body temperature range for cattle is 38 °C to 40 °C, with a critical temperature of 41 °C. In the data from Table 2, it can be seen that the rectal temperature of the cattle in both pens is still within the normal range, with the value of the cattle in pen A being lower and closer to the optimum value. As stated by Sokku and Harun (2019), beef cattle have an optimum body temperature of 38.33°C. Meanwhile, in the respiratory frequency data, the cattle in both pens experienced an increase from their normal range, which is around 15-35 times per minute. (Jackson and Cockroft 2002).

The increase in respiratory frequency occurs due to the body's heat dissipation mechanism by increasing CO2 output. This increase in respiration is caused by high humidity, which will hinder the process of body heat dissipation through evaporation. (Suprayogi *et al*. 2006). In addition, ammonia levels also become one of the factors because cows will try to inhale air more frequently since high ammonia levels in the air can reduce the circulating oxygen content. The same thing also happens with heart rate frequency, where the cows in both pens have an average heart rate frequency higher than the normal value, which ranges from 55-80 beats per minute. (Kelly 1984). The increase in heart rate is one of the livestock's efforts to maintain body temperature balance. This increase is a response from the livestock's body to disperse metabolic heat through the dilation of skin arterioles, then enhancing peripheral circulation as an effort to accelerate the release of body heat. (Reece *et al*. 2015).

The productivity of beef cattle is influenced by temperature and humidity factors, as they can cause changes in the body's heat balance, water and energy balance, and the behavioral balance of the livestock. (Esmay 1982). The statement is consistent with the data in Table 2, which shows a significant difference in the values of PBB and PBBH between the two pens. Environmental temperature greatly affects the level of livestock consumption, as livestock require an optimal environmental temperature for their life and production. At environmental temperatures below neutral, livestock will increase their consumption; conversely, at temperatures above neutral, livestock will decrease their consumption. According to Esmay (1982), Bos Taurus cattle will reduce their consumption by 2% for every 1 °C increase in temperature above the average temperature of 25 °C. When cows are continuously exposed to a high-temperature environment, they will experience heat stress. This heat stress will reduce appetite, increase water consumption, decrease metabolism and increase catabolism, increase heat release through evaporation, decrease hormone concentration in the blood, as well as increase body temperature, respiration, and heart rate. (McDowell,1972).

On the other hand, it is also necessary to discuss the height of the pen and its influence on the microclimate and livestock productivity. According to Carpenter (1981), when pen is built with a high roof, the volume of air and the airflow entering the barn become larger, and the air exchange is faster, resulting in a decrease in the temperature inside the pen. According to Hahn (1985), in sunny areas with full sunlight, the height of the pen roof should be between 3.6 – 4.2 m, while in somewhat cloudy areas, the pen roof height should be between 2.1 – 2.7 m. This pen height is quite effective in limiting the diffusion of solar radiation received by livestock inside the pen. Thus, pen A, which has a

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height of 4 meters, is considered to meet the good standard for pen height compared to pen B, because the Terbanggi Besar area is located in a tropical region with a hot and dry climate. This is supported by research data showing better microclimate values and physiological responses in pen A, which in turn supports the productivity of beef cattle.

CONCLUSION

The microclimate conditions in pen A are better with an average THI of 80.69 compared to pen B with an average THI of 82.10. Although both show signs of moderate stress, this condition still indicates better physiological values for the cattle in pen A compared to pen B. This has implications for the productivity of the cattle in pen A, which is much better than that of the cattle in pen B, with a DBWG value of (1.59±0.16) kg/day in pen A and (1.30±0.23) kg/day in pen B.

This research can serve as a guideline for farmers in determining the location and construction of the pen roof height, especially for farmers in Central Lampung, in order to achieve optimal productivity for beef cattle. Further research is needed to determine the impact of differences in farm management related to the microclimate conditions of the pen and the correlation between farm management, microclimate, and productivity.

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