Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan
ISSN 2303-2227 eISSN 2615-594X
Accredited by National Journal Accreditation No. 105/E/KPT/2022

Vol. 12 No. 2 Juni 2024, Hlm: 94-100
DOI: https://doi.org/10.29244/jipthp.12.2.94-100
Available online at https://journal.ipb.ac.id/index.php/ipthp/index

The Impact of Barns Microclimate Modification on the Beef Cattles Physiological Responses Raised in the Peatlands of Central Kalimantan

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(Received 27-03-2024; Revised 13-05-2024; Accepted 20-06-2024)

ABSTRACT

This study aimed to evaluate the effect of cattle barns microclimate modification on the physiological response of beef cattles reared on peatland. This study used direct observation and experimental research methods. Microclimate modification is done by using asbestos material, gable roof type and roof height ≥3.5 meters, and vegetation arrangement. Data were collected through measurements of microclimatic parameters and physiological responses in the morning (06.30–07.30), at noon (11.30–12.30), and in the afternoon (16.30–17.30), with measurement intervals every month. The number of cattle barns observed was 46 units. The physiological parameter measurements involved 124 female beef cattle, consisting of 70 Bali and 54 crossbred cattle with physiological stages, gestating cows and lactation period. The results showed that modifying cattle barns and the surrounding environment can reduce the microclimate in the cattle barn as indicated by a decrease in THI from emergency to dangerous levels during the noonday and from dangerous to caution levels in the afternoon. The improvement in microclimate conditions was also followed by a decrease in the level of heat stress as indicated by a decrease in the physiological responses of cows.

Keywords: beef cattle, microclimate modification, peatland, physiological responses

ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi pengaruh modifikasi mikroklimat kandang terhadap respon fisiologis sapi potong yang dipelihara di lahan gambut. Penelitian ini menggunakan metode observasi langsung dan eksperimental riset. Modifikasi mikroklimat dilakukan dengan menggunakan bahan asbes, tipe atap gable dan tinggi atap ≥3.5 meter, serta penataan vegetasi. Data dikumpulkan melalui pengukuran variabel mikroklimat dan respon fisiologis pada pagi (06.30–07.30), siang (11.30–12.30), dan sore (16.30–17.30) dengan interval pengukuran setiap bulan. Jumlah kandang yang diobservasi sebanyak 46 units. Pengukuran respon fisiologis melibatkan 124 ekor induk sapi, terdiri dari 70 sapi bali dan 54 ekor sapi silangan dengan status fisiologis bunting dan menyusui. Hasil penelitian menunjukkan bahwa modifikasi kandang sapi dan lingkungan sekitarnya dapat menurunkan iklim mikro di dalam kandang syang ditunjukkan dengan penurunan THI dari level darurat ke level berbahaya pada siang hari dan dari level berbahaya ke level waspada pada sore hari. Perbaikan kondisi iklim mikro ini juga diikuti dengan penurunan tingkat cekaman panas yang ditunjukkan dengan penurunan respon fisiologis sapi.

Kata kunci: lahan gambut, modifikasi mikroklimat, respon fisiologis, sapi potong

INTRODUCTION

The microclimatic environmental conditions are crucial factors that need attention and influence beef cattle productivity in tropical regions such as Indonesia. The reason is that the microclimate environment directly affects livestock productivity. An inappropriate microclimatic environment can trigger stress, negatively impacting well-being, health, and productivity (Lees *et al*. 2019). Microclimatic parameters influencing stress in beef cattle include temperature, relative humidity, solar radiation, and wind speed (Brown-Brandl 2018; Mader *et al*. 2006). High temperature and relative humidity are the main microclimate parameters that cause stress (Brouek *et al*. 2006), while low wind speed will increase heat stress (Mader *et al*. 2006). Beef cattle will respond to microclimatic stress by increasing physiological parameters such as rectal temperature, heart rate, and respiration rate, which are the leading indicators of discomfort (Helal *et al*. 2010).

Central Kalimantan has a humid and hot tropical climate with an air temperature of 20.6-35.2 °C, air humidity of 43-100%, and wind speed of 3.7-5.0 knots (BPS Kalteng 2020). According to Adrial (2023), microclimate environmental issues are one of the critical factors influencing the development of beef cattle on the peatlands of Central Kalimantan. The hot and humid climatic conditions of Central Kalimantan, accompanied by low wind speeds, cause the microclimate conditions in the barn not to be in the comfort zone required by livestock with a THI of 74.00–87.00 (alert to emergency category) so that livestock kept in this environment experience Heat stress is indicated by physiological responses in the form of rectal temperature, heart rate, and respiratory frequency, which are above-average conditions.

Along with its effect on physiological reactions, heat stress in this area affects cattles' ability to consume less feed. Heat stress also significantly impacts the productivity of beef cattle raised on peatlands, so cattle raised in this area cannot perform optimally. This is characterized by production performance such as low body weight and body measurements, as well as low reproductive performance including delayed age at puberty and first calving, delayed postpartum estrus and longer calving interval. Heat stress will harm reproductive function and embryonic development, resulting in impaired growth, decreased milk production, and health problems (Dobson and Smith 1995; Gupta *et al*. 2013; Ullah *et al*. 1996).

The immense influence of microclimate stress on beef cattle productivity in peatlands is a severe problem affecting population development. On the other hand, this problem has yet to receive serious attention from breeders and related stakeholders. Efforts to control microclimatic stress in beef cattle businesses will become increasingly important as the earth's temperature increases due to global warming, so heat stress will seriously threaten livestock businesses. In order to create comfortable microclimate conditions for livestock, appropriate microclimate control efforts are urgently needed. Hence, this research aimed to evaluate the effect of modifying the housing microclimate on the physiological response of beef cattle kept on peatlands.

MATERIAL AND METHODS

Location and Period of Research

This research was conducted on the communities's beef cattle smallholder farms in Pulang Pisau Regency, Central Kalimantan, from December 2020 to January 2022.

Research Samples and Instruments

This research exploits 46 barns, comprising 41 existing conditions (without modification); the other five barns are modified. The physiological responses were evaluated on Bali and crossbred cows in gestation and lactation conditions, and they were kept intensively in barns. The variable measurements on the existing condition (unmodified barns) involved 90 cows, consisting of 33 pregnant and 19 lactating Balinese, and 22 pregnant and 16 lactating crossbred cows. While the modified barns involved 34 cows, consisting of 10 pregnant and 8 lactating Balinese, and 9 pregnant and 7 lactating crossbred cows. All cattle barns used were individual barns with a floor area of 3-4 m2/cow. The number of cows in each barn varied between 3-8 cows/barn for both the existing and treatment barns.

The equipment used in this research includes barn modification equipment, a 5-meter roll meter, a Beurer HM16 thermo-hygrometer, a digital anemometer, an Omron rectal thermometer model MC-245, an ABN classic stethoscope, a stopwatch, and a hand tally counter.

Methods

Barn modifications are carried out based on the availability of materials, economic considerations, and the social conditions of the local community. Alterations to the enclosure are made to the roof's material, type, and height. The treatment barns used an asbestos roof, a gable type, and a height of ≥3.5 meters. Modification of the environment around the barn is carried out by removing vegetation other than trees that have the potential to block airflow around the barn, as well as maintaining vegetation in the form of tree plants that can potentially block sunlight from entering the barn. All vegetation other than trees <5 meters from the barn is cleared. All trees with a height of ≥10 meters and a branch height of ≥5 meters around the barn are maintained; if tree branches are parallel to the barn's height, they are also cleaned. Determining the distance of vegetation from the barn and the height of the trees was done by considering the effectiveness of the tree's function in reducing environmental temperature. According to Lin *et al*. (2017) and Rogan *et al*. (2013), the essential factors influencing trees' function in reducing environmental temperatures are tree height, canopy distribution, and leaf size and arrangement. Tall and large trees with large canopy volumes significantly contribute to the environment's cooling effect and increase humidity (Rogan *et al*. 2013).

Microclimatic data and physiological responses were collected every month during the research. Microclimate conditions were measured at several points in the barn on the left, middle, and right sides. Measurements were also taken outside the barn for comparison. Data is collected three times a day, namely in the morning (06.30–07.30), noonday (11.30–12.30), and afternoon (16.30–17.30). Ambient temperature data is measured using a thermometer, air humidity using a hygrometer, wind speed using an anemometer. Microclimate variables measured include ambient temperature, relative humidity (RH), wind speed, and THI (Temperature Humidity Index). THI is calculated using the formula (Mader *et al*. 2006), namely: THI = [0.8 × ambient temperature] + [(% relative humidity ÷ 100) × (ambient temperature 128 − 14.4)] + 46.4.

Physiological response measurements are performed simultaneously with measurements of the microclimate environment. The data collected includes rectal temperature, heart rate, respiratory rate, and heat tolerance coefficient (HTC). Rectal temperature is measured by inserting a rectal thermometer into the rectum to a depth of ± 10 cm for three minutes (until the thermometer beeps). Heart rate is calculated using a stethoscope and stopwatch by holding the stethoscope near the left axillary bone for one minute. Respiratory rate is expressed in the number of breaths per minute, measured using a stethoscope and stopwatch on the auscultation of respiratory movements by attaching a stethoscope to the chest to count respiratory inspiration and expiration for one minute. The heat tolerance coefficient (HTC) is used as an index that combines respiratory frequency and rectal temperature; the value is calculated according to Benezra (1954) with the formula HTC = (Tb / 38.3) + (Rr / 23.0), with the information that Tb is the average body temperature (ºC), Rr is the average respiratory frequency for 1 minute, the value 38.3 is the standard number for average body temperature for cattle, and the value 23.0 is the standard number for respiratory frequency for 1 minute.

Statistical Analysis

Differences in microclimatic conditions and physiological responses before and after treatment were analyzed using the Student's t-test.

RESULTS AND DISCUSSION

Unmodified Barn Ambient Condition

Pulang Pisau Regency has a hot, humid climate. It is located in the lowlands as well. In areas like this, the role of barn buildings in protecting livestock from harmful environmental influences is vast. The existing conditions of beef cattle barns in the peatlands of Pulang Pisau Regency are shown in Table 1.

Based on Table 1, it is known that breeders use three roof types in barn buildings: shed roof, semi-gable, and gable roof. The shed roof type is a form of roof that uses one flat plane with one plane installed lower than the other parts. The roof slope is shallow in this type, so it looks more like a flat roof. A gable type is a roof form that uses two identical roof planes installed to form the letter "A" with a high slope so that both roof planes form the same inclined plane. The semi-gable type is a combination of a gable type roof with a shed roof, which has two roof planes, but one roof plane forms a flat plane and the other forms a sloping plane so that the area of the flat plane is twice as large as the sloping plane. Gable and semi-gable are the roof types most often chosen by breeders.

Table 1. Unmodified beef cattle barns in the peatlands of Pulang Pisau Regency

Physical barn condition	Sample (n=41)	Percentage (%)
Roof type		
Shed roof	8	19.51
Semi gable	11	26.83
Gable roof	22	53.66
Roof material		
Asbestos	29	70.73
Corrugated iron or tin	12	29.27
Roof height		
≤ 2.5 meter	18	43.9
>2.5 meter	23	56.1

Asbestos and corrugated iron roofs are the two primary materials cattle breeders use as roofing materials at research locations. Asbestos is the material most commonly used by breeders as a roofing material. The choice of asbestos as a roofing material is closely related to ease of installation, availability, relatively good strength, and extended durability. Corrugated iron or tin roofs are easily installed and widely available in building material stores. Nevertheless, this material rusts and breaks easily. Therefore, only a few farmers use the tin as a roofing material. In contrast to asbestos and tin, tile is rarely used as a roofing material in this region because it is relatively complex to obtain and installation costs are relatively expensive.

The roof height generally varies between barns, with a height range of 1.5–4.0 meters from the floor surface. Farmers' considerations in raising the height of the roof are only based on construction considerations (building area) and cost availability. Differences in the type of roof used also cause discrepancies in roof height. The roof height is generally much more significant on gable and semi-gable roofs than on shed roofs. This situation happened because the high roof allows rainwater to enter the enclosure and is not proportional to the area of the building, particularly on the shed roof.

Barn Modification Effect on the Ambient Microclimate

The microclimate environmental conditions in beef cattle barns on peatlands under existing conditions and after treatment are shown in Table 2. Table 2 shows that modifications to the barn and the surrounding environment significantly impact ($P<0.05$), reducing the microclimate in the barn during the noonday and afternoon. A drop in noonday and afternoon temperatures and a drop in afternoon humidity all point to this outcome. Based on the temperature and humidity index, it is known that the THI in the barn decreased from emergency to dangerous levels during the noonday and from dangerous to caution levels in the afternoon. During the day, the decrease in THI occurs due to a significant decrease in air temperature, even though the relative humidity remains constant. In the afternoon,

Table 2. The climatic conditions outside and inside in unmodified and modified beef cattle barns in the peatlands of Pulang Pisau Regency

Parameter	Barn outside ambient		Barn inside ambient			
	Unmodified (n=41)	Modified (n=5)	Unmodified (n=41)	Level*	Modified (n=5)	Level*
Morning						
T (oC)	27.06±1.32	26.53±0.14	27.52±1.39		26.64±0.13	
RH (%)	80.88±3.13b	85.71±1.27a	80.77±3.54b		84.63±1.17a	
Ws (ms-1)	0.50±0.50	0.32±0.04	0.19±0.24		0.18±0.03	
THI	78.26±1.90	78.02±0.28	78.99±1.96	caution	78.07±0.27	caution
Noonday						
T (oC)	37.23±1.91	36.74±0.13	36.07±1.90a		32.29±0.34b	
RH (%)	55.45±6.67	53.28±2.13	54.54±5.23		54.68±2.07	
Ws (ms-1)	1.13±0.66	0.83±0.13	0.45±0.36		0.65±0.13	
THI	88.77±2.08	87.68±0.32	87.04±2.39a	emergency	82.02±0.42b	danger
Afternoon						
T (oC)	32.26±1.33	32.72±0.17	31.63±1.65a		29.11±0.16b	
RH (%)	67.35±5.26a	59.17±2.25b	65.98±5.51a		56.80±2.80b	
Ws (ms-1)	1.22±0.76	0.87±0.12	0.59±0.57		0.67±0.09	
THI	84.06±1.64	83.42±0.56	83.08±2.64a	danger	78.04±0.5b	caution

Means in the same row with different superscript differ significantly (P<0.05)

T is temperature; rH is the relative humidity; Ws is the wind speed; THI is the temperature humidity index;

*THI ≤74. normal; 74 < THI < 79; caution. 79 ≤ THI < 84; danger. THI ≥84; emergency (Mader *et al.* 2006)

a significant (P<0.05) drop in ambient temperature and relative humidity impacted the barn's THI.

Given that there was no discernible difference in THI outside the barn under the current conditions or following treatment, the study's findings suggested that the reduction in THI inside the barn resulted from changes made to the microclimatic environment. Even though it has experienced a significant reduction compared to existing conditions, the microclimatic conditions of the barn as a result of this research are not yet under the thermal neutral zone required by beef cattle, with a THI level of alertness to danger. Even though modifications have been made to the barn microclimate, the still-high THI is closely related to the climate outside the barn, which also shows high temperatures, humidity, and very low wind speeds.

The results of this study show that microclimate modification through the use of asbestos with a gable roof type and a roof height of ≥3.5 meters, accompanied by arranging vegetation around the barn, can significantly reduce the THI in the barn during the day and evening. A significant decrease in air temperature caused a decrease in THI in the afternoon and evening. The relatively high drop in air temperature in the barn indicates that the roof is functioning well in retaining and blocking the sun's heat from entering the barn. Using asbestos as a roofing material is quite capable of retaining and reflecting solar heat because asbestos does not readily absorb heat and has low conductivity. Material properties with low conductivity and a low ability to absorb heat will isolate the solar heat received, thereby preventing heat from entering the enclosure (Nuriyasa *et al*. 2015).

Using a gable-type roof also plays a role in retaining and blocking the sun's heat from entering the barn. This type of roof has two sloping planes, which can block sunlight from entering the barn directly. Two identical inclined planes likewise contribute to the angle of incidence of sunlight hitting the sloping surface. This inclined plane can reflect most of the sunlight, and only a tiny amount is absorbed (Wald 2018). Apart from that, the high inclination angle at the meeting point of the two roof planes also provides ample space for air circulation so that airflow can enter and prevent heat under the roof from entering the barn. According to Kholiq and Syarif Hidayat (2016), a sloping roof with a broader cavity underneath will show a lower room temperature because the roof cavity can reduce the heat from the roof surface.

Elevating the roof height to ≥3.5 meters prevents solar heat from entering the barn. Increasing the height of the roof will increase the space between the bottom of the roof and the building space so that this space can function optimally in reducing heat from the roof surface. This more expansive space will cause the airflow to run optimally, so heat reduction through the airflow will also be maximized. According to Kholiq and Syarif Hidayat (2016), the air cavity below the roof surface plays a vital role in reducing heat flow from the roof surface. If this air cavity functions optimally, the heat below the roof surface will be isolated from the room below.

The vegetation around the barn also reduces the temperature and humidity in the barn, especially in the afternoon. In existing conditions, afternoon sunlight generally enters the barn directly because the roof area can no longer block the angle of incidence of sunlight. The presence of a tree to the west of the barn is quite helpful in blocking direct sunlight from entering the barn so that the temperature is not too high. Monteiro *et al*. (2019) state that tree plants are crucial for lowering ambient temperature because they retain and reflect solar radiation, allowing the environment to absorb very little. Arranging vegetation close to the barn, although it does not significantly impact increasing wind speed in the barn, is quite helpful in reducing air humidity. The sunlight can shine on the soil's surface around the barn, so it will help reduce humidity outside the barn, especially in the morning and evening. Also, airflow outside the barn is not blocked, so it can be maximized to reduce humidity inside the barn. According to Sathiameena *et al*. (2020), areas with dense vegetation have better temperature mitigation capabilities compared to sparse vegetation; however, in densely vegetated environments, air humidity will also be high due to the high water vapor produced during the cooling process by the leaf pores and the blocking of incoming sunlight to illuminate the ground surface.

From the results of this study, it was obtained that modification of the roof of the cattle barn using asbestos, gable roof type and roof height ≥3.5 meters, accompanied by the arrangement of vegetation around the barn was able to reduce THI in the cattle barn, especially during the day and evening. However, the impact of these modifications in creating a microclimate environment below the thermo-neutral zone for beef cattle is still not optimal, so more efforts are needed to create comfortable micro-environmental conditions for beef cattle on peatlands. Modification efforts that can be made include using monitor-type roofs, roofing materials such as shingles, leaves, roof tiles, uPVC, THI modifications using fans, ceiling additions, and others. However, the modifications made must still consider economic considerations and the social conditions of the local community so that the resulting technology can be accepted and applied in society.

Modified Microclimate Effect on Beef Cow Physiological Responses

The physiological response of beef cattle on peatlands under existing conditions and after improving the barn microclimate is shown in Tables 3 and 4. Improving the barn microclimatic conditions significantly ($P<0.05$) reduces the physiological response of beef cattle kept on peatlands in gestation and lactation cows. Significant reductions in heart rate, breathing frequency, and rectal temperature compared to current affairs suggest this predicament. However, in general, cows still show symptoms of mild stress.

Based on Table 3, it is known that improving the microclimatic conditions of the barn has a significant impact ($P<0.05$) on reducing the physiological response of gestation cows, both in Bali cattle and cross cattle. Gestation cross cattle, the group most susceptible to microclimatic stress, show a significant decrease in rectal temperature, heart rate, respiratory frequency, and heat tolerance coefficient in the morning, afternoon, and evening. In contrast, Bali cattle show significantly decreased rectal temperature, heart rate, and respiratory frequency. The heat tolerance coefficient was significant only during the afternoon and evening. Gestation cows' physiological response also decreased as the THI in the barn decreased from emergency to danger level throughout the day and from danger to warning level in the afternoon. In general, the cows' rectal temperature,

Table 3. The physiological responses of gestating Bali and crossbred cattle under unmodified and modified barns

Physiological responses	Bali cattle		Crossbreed cattle	
	Unmodified (n=33)	Modified (n=10)	Unmodified (n=22)	Modified (n=9)
Morning				
RT (^{o}C)	38.46±0.23	38.37±0.10	38.55±0.09a	38.48±0.08b
HR (bits/min)	82.79±6.89	79.03±3.17	89.36±3.97a	80.70±3.20b
RF (breath/min)	31.00±5.29	27.60±1.98	36.00±4.09a	28.54±1.47b
HTC	2.35±0.23	2.20±0.09	2.57±0.18a	2.24±0.06b
Noonday				
RT (^{o}C)	38.75±0.21a	38.55±0.08b	38.97±0.21a	38.71±012b
HR (bits/min)	95.39±7.27a	87.37±2.24b	101.91±6.22a	92.70±3.52b
RF (breath/min)	46.54±5.44a	38.74±0.85b	53.18±4.81a	39.08±0.84b
HTC	3.03±0.24a	2.69±0.04b	3.33±0.21a	2.71±0.04b
Afternoon				
RT (^{o}C)	38.67±0.15a	38.51±0.07b	38.85±0.20a	38.64±0.08b
HR (bits/min)	91.58±7.74a	85.23±2.26b	97.73±6.99a	90.00±3.11b
RF (breath/min)	42.73±4.55a	37.14±0.66b	47.91±5.18a	37.62±0.78b
HTC	2.87±0.20a	2.62±0.03b	3.10±0.23a	2.64±0.03b

Means in the same row with different superscript differ significantly ($P<0.05$)

RT: rectal temperature. HR: heart rate. RF: respiratory frequency. HTC: heat tolerance coefficient

Table 4. The physiological response of lactation Bali and crossbred cattle under modified and unmodified barns

Physiological responses	Bali cattle		Crossbred cattle	
	Unmodified (n=19)	Modified (n=8)	Unmodified (n=16)	Modified (n=7)
Morning				
RT (^{o}C)	38.30±0.18	38.30±0.14	38.41±0.21	38.41±0.10
HR (bits/min)	78.95±6.37	76.54±3.61	82.00±6.85	80.37±2.56
RF (breath/min)	28.21±4.10	25.93±2.47	32.25±5.16	28.49±1.93
HTC	2.23±0.18	2.13±1.11	2.40±0.22	2.24±0.08
Noonday				
RT (^{o}C)	38.65±0.23a	38.44±0.06b	38.84±0.25a	38.50±0.06b
HR (bits/min)	91.16±4.07a	85.25±3.21b	93.62±5.17a	86.84±2.90b
RF (breath/min)	42.32±6.57a	36.29±1.30b	46.50±5.39a	37.27±0.70b
HTC	2.85±0.29a	2.58±0.06b	3.04±0.24a	2.63±0.03b
Afternoon				
RT (^{o}C)	38.57±0.16a	38.39±0.04b	38.67±0.17a	38.46±0.05b
HR (bits/min)	88.95±3.79a	80.75±1.40b	89.50±4.16a	84.21±1.06b
RF (breath/min)	38.42±3.80a	34.32±1.19b	41.75±3.86a	36.12±0.59b
HTC	2.68±0.17a	2.49±0.05b	2.82±0.17a	2.57±0.03b

Means in the same row with different superscript differ significantly (P<0.05)

RT: rectal temperature. HR: heart rate. RF: respiratory frequency. HTC: heat tolerance coefficient

heart rate, and respiratory frequency due to this study were close to customary conditions, except for crossbred cattles, which were still indicated to be experiencing mild stress.

The rectal temperature, heart rate, and respiratory rate of gestation Bali cattle are close to normal levels throughout the day, even though they are kept in a barn with a high THI (alert to danger level), further strengthening evidence of the high adaptability of Bali cattle to heat stress. In contrast to Bali cattle, gestation cross cattle, as a result of this study, still showed rectal temperatures, heart rate, and respiratory frequency above normal levels during the day and evening, indicating that the cattles were still experiencing heat stress. Nonetheless, environmental heat stress is not the only factor influencing a gestation cow's rectal temperature to rise above the ordinary. Gestation cows also produce high metabolic heat due to high biological activity during pregnancy (Beatty *et al*. 2006; West 2003). The heart rate and respiratory frequency of gestate crossbred cows above the normal range during the day and evening also indicate that the cow is experiencing heat stress. Although the pregnancy process also affects the rapid heart rate and frequent breathing of gestation cows, the fetal activity in the womb can cause a 15–40% increase in heart rate in gestation cattle (Kelly 1984).

Based on Table 4, it is known that improving microclimatic conditions through barn modifications has a significant impact (P<0.05) on reducing the physiological response of lactating cows, especially in the afternoon and evening, for both Bali and crossbred cattle. Changes in microclimate conditions in the barn did not significantly impact the cow's physiological response in the morning regarding rectal temperature, heart rate, or respiratory frequency. In the afternoon and evening, all physiological parameters showed significant differences (P<0.05). After improving microclimatic conditions, lactating cows' rectal temperature, heart rate, respiratory frequency, and heat tolerance coefficient were much lower than in existing conditions in Bali and crossbred cattle.

After improving microclimatic conditions, Bali cattle and the crosses in the lactation period showed a reasonably good physiological response and were close to normal levels. A rectal temperature within the normal range indicates a response. Although still above average, heart rate and respiratory frequency are ideal for lactation cows. The explanation is that livestock's physical and biological activities, including the lactation period, besides external stress, can significantly alter their heart rate and respiration rate (Alam *et al*. 2011).

CONCLUSION

Modifying the microclimatic environment through improved barn by using asbestos with a gable roof type and a roof height of ≥3.5 meters, accompanied by the arrangement of vegetation around the barn had a positive impact on reducing THI and the physiological response of gestating and lactation beef cows.

ACKNOWLEDGEMENT

Big thanks to everyone and every organization that assisted with the research.

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