Research Article

Effect of Heat Stress on the Physiological and Hematological Profiles of Horned and Polled Bali Cattle

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Abstract | Bali cattle are local cattle owned by Indonesia that play a role in meeting the lack of meat demand in the country. In its development, both horned and hornless Bali cattle were found. This study aims to determine the influence of heat stress on the physiological and hematological profiles of horned and polled Bali cattle. Eight male Bali cattle (four horned and four polled) with an age range of 2.5–4.5 years were used. Parameters observed were the body's physiological response (rectal temperature, skin surface temperature, respiration rate, and pulse rate) and hematological profile (erythrocytes, hemoglobin, hematocrit, and leukocytes). Body physiological and hematological data were analyzed using factorial analysis to compare Bali cattle (horned and polled) and the time factor of measurement (morning and afternoon), followed by Duncan's test. The results showed that horned and polled Bali cattle were significantly ($P<0.05$) different in rectal temperature, erythrocytic counts, hemoglobin levels, and hematocrit values but not in skin surface temperature, respiration rate, pulse rate, and leukocyte counts. The time factor of measurement (morning and afternoon) showed significant ($P<0.05$) differences in rectal temperature, skin surface temperature, respiration rate, pulse rate, erythrocyte counts, and hemoglobin levels, but not in hematocrit values and leukocytic counts. Compared to horned Bali cattle, polled Bali cattle showed higher increases in rectal temperature, skin surface temperature, and respiration rate caused by the absence of horns. A higher hematological profile supports higher metabolic processes.

Keywords | Bali Cattle, Heat Stress, Hematological, Physiological, Polled

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INTRODUCTION

Bali cattle (*Bos sondaicus, Bos javanicus*, or *Bos/Bibos banteng*) are one of Indonesia's indigenous livestock genetic resources. According to Minister of Agriculture Decree No. 325/Kpts/OT.140/1/2010, Bali cattle are characterized by a brick red coat on females and a blackish brown on adult males, with white on the lower legs, back of the pelvis (rump), and upper and lower lips. On the back, there is a black eel line (elongated) and also a black color at the tip of the tail (MOA, 2010). Bali cattle are beef cattle that contribute significantly to the development of the livestock industry in Indonesia by meeting the country's meat demand. Bali cattle have a higher carcass yield compared to the other native Indonesian cattle (Purwantara et al., 2012; Nuraini et al., 2019) because they are non-selective, can eat low-quality feed, adapt well to their environment, and can even live and produce well on critical land (Leo et al., 2012; Purwantara et al., 2012; Baco et al., 2020a).

Bali cattle are a breed that has horns, both on males and females. However, in its development, it was found that there are Bali cattle that are naturally hornless, also known as polled (Zulkharnaim et al., 2017; 2020a; Baco et al., 2020b; Hasbi et al., 2021). Polled cattle are inherited through an autosomal dominant pattern (Medugorac et al., 2012; Glatzer et al., 2013; Gehrke et al., 2020), where PP (polled), pp (horned), with heterozygous (Pp) cattle usually polled but commonly scurred (Wiedemar et al., 2014; Grobler et al., 2018; Randhawa et al., 2020; Aldersey et al., 2020). Polled cattle are usually easier to handle, safer for workers, and less aggressive towards each other (Glatzer et al., 2013), so polled cattle have their advantages in the maintenance process, and the risk of injuring their bodies and the other cattle can be minimized. However, Parés-Casanova and Caballero (2014) assumed that horns in animals influence thermoregulation.

Increased ambient temperature causes stress and affects the adaptive mechanisms of livestock (Nussa et al., 2018). Bali cattle have good physiological performances and can adapt to climatic conditions in Indonesia (Aritonang et al., 2017a, b), but polled Bali cattle that appear in this development are not yet known for their physiological responses to climatic changes (IPCC, 2014), which is one of the threats to the livestock industry (Nardone et al., 2010; Ganaie et al., 2013; Herbut et al., 2019), including Bali cattle farming. Several physiological indicators of heat stress include body temperature, pulse rate, respiration rate, and hematological profiles (Induk and Pareek, 2015; Berian et al., 2019). Therefore, this study was conducted to determine the physiological and hematological profiles of horned and polled Bali cattle during heat stress exposure.

MATERIALS AND METHODS

Period and place of research

The study was carried out between July and November of 2022. Evaluation of physiological parameters (rectal temperature, skin surface temperature, respiration rate, and pulse rate) and blood sampling were conducted at one of the farms in Tanete Riaja District, Barru Regency, South Sulawesi, Indonesia (4°29'17" south latitude and 119°38'50" east longitude; 10 msal). The dry season lasts 6 months, from May to November, and the month with the fewest wet days is August. Hematological parameters were examined using a Prokan Hematology Analyzer Model PE-6800 Vet (Shenzhen Prokan Electronics Inc., China) at the Laboratory of Pathology and Toxicology, Maros Veterinary Center, Maros, Indonesia.

Research animals

This study used eight male Bali cattle aged 2.5–4.5 years, 4 horned and 4 polled, respectively. The cattle were kept in a barn with 1x1.5 m individual stalls equipped with feed and drink container. Cattle were fed concentrate (20%) and elephant grass (80%) twice a day, in the morning and evening, while drinking water was given *ad libitum*. All cattle have been vaccinated against foot and mouth disease (FMD).

Implementation procedure

Each animal was measured twice: in the morning, from 6:30 to 7:30 am (before eating and engaging in other activities), and in the afternoon, from 12:30 to 2:00 pm (given an exercise to walk in the hot sun for 5 min before measurement). Physiological measurements, including rectal temperature, skin surface temperature, respiration rate, and pulse rate were conducted on the study animals.

Blood was drawn from the jugular vein and placed in a 3 mL Vaculab® EDTA-K3 vial (One Med, Indonesia). The collected samples were transferred in a cooler box to the laboratory and kept 4°C.

Measured parameters

Environmental parameters

The environmental parameters measured in this study were temperature, humidity, and temperature-humidity index (THI).

Temperature and humidity

The ambient temperature and humidity were measured using a thermohygrometer (Thermohygrometer Clock HTC-2), which was placed on the location to be measured and then left for 3–5min before taking the readings.

Temperature-humidity index (THI)

The relationship between air temperature and humidity was calculated using the THI (Temperature Humidity Index) to measure the comfort level of the livestock environment after Thompson and Dahl (2012), namely:

$$THI = (1{,}8 \times Ta + 32) - [(0{,}55 - 0{,}0055 \times RH) \times (1{,}8 \times Ta - 26)]$$

Where; Ta = Ambient Temperature (°C) and RH = Relative Humidity (%).

Body physiological parameters

Parameters measured for the physiological body of horned and polled Bali cattle in this study include rectal temperature, skin temperature, respiration rate, and pulse rate.

Rectal temperature

Measured using an Omron digital thermometer model MC-343F (Omron Healthcare Co. Ltd., Japan) by inserting the thermometer 6-7 cm into the rectum at an angle toward the rectal wall (Rashamol et al., 2018).

Skin surface temperature

Measured with an Omron infrared thermometer model MC 720 (Omron Healthcare Co. Ltd., Japan) 1–5 cm from the skin surface at four measurement points: the back (A), chest (B), upper legs (C), and lower legs (D). The average skin surface temperature was calculated after McLean et al. (1983) in Pamungkas et al. (2020) as follows:

$$Skin\ Surface\ Temperature = 0.25\ (A + B) + 0.32\ C + 0.18\ D$$

Respiration rate

Measured visually after Shilja et al. (2016) by counting flank movements with a stopwatch.

Pulse rate

measured by attaching a Littmann Classic III™ stethoscope (3M Healthcare, USA) to the left chest of the cattle. When this was not possible, it was palpated on the coccygeal artery under the middle of the tail, about 10 cm from the anus (Nugraha et al., 2020).

Hematological parameters

Samples were tested using a Prokan hematology analyzer model PE-6100 Vet for the erythrocytic count, hemoglobin level, hematocrit value, and leukocytic count. The examination was conducted following the procedures of the Prokan model PE-6100 vet hematology analyzer.

Data analysis

Data on environmental parameters were analyzed using independent sample T-test to compare difference between morning and afternoon. Physiological and hematological data obtained were analyzed using factorial analysis to determine the effect of Bali cattle type (horned and polled) and the time factor of measurement (morning and afternoon), followed by Duncan's test. The p-value had to be less than 0.05 for the parameter to be considered significant. All analysis was performed using SPSS version 25.

RESULTS

Microclimatic conditions of the research site

The climate is one of the external factors that has a significant impact on livestock productivity and physiology. The average microclimatic conditions during the study are presented in Table 1.

Table 1 showed that morning and afternoon were significantly ($P<0.05$) different in averages ambient temperature, humidity, and THI.

Body's physiological response

Table 2 displayed physiological parameters including rectal temperature, skin temperature, respiration rate, and pulse rate.

Horned and polled Bali cattle were significantly ($P<0.05$) different in rectal temperature but not in skin surface temperature, respiration rate, and pulse rate.

The time factor of measurement (morning and afternoon) had significant ($P<0.05$) differences in rectal temperature, skin surface temperature, respiration rate, and pulse rate.

Hematological profile

Blood profile (hematological) parameters in the form of the erythrocytic count, hemoglobin level, hematocrit value, and leukocytic count are presented in Table 3.

The erythrocytic count, hemoglobin level, and hematocrit value of horned and polled Bali cattle were significantly ($P<0.05$) different rather than the leukocytic count.

The time factor of measurement (morning and afternoon) had significant ($P<0.05$) differences in erythrocytic count and hemoglobin level but not in hematocrit values and leukocytic count.

Table 1: Average temperature, humidity, and THI at the research site.

Time factor of measurement	Ta (°C)	RH (%)	THI	Environmental comfort categories*
Morning	24.20 ± 0.52^{a}	93.25 ± 1.76^{a}	74.86 ± 0.74^{a}	Normal
Afternoon	32.90 ± 1.08^{b}	67.50 ± 8.50^{b}	85.19 ± 0.71^{b}	Severe heat stress

Description: Ta: ambient temperature; RH: relative humidity; THI: temperature humidity index. [a,b] Significant differences ($P<0.05$) are indicated by different superscripts in the same column. *Bulitta *et al.*, 2015.

Table 2: Average values of physiological parameters of horned and polled Bali cattle.

Parameters	Bali cattle	Time factor of measurement		Average
		Morning	Afternoon	
Rectal temperature (°C)	Horned	37.35±0.24[a]	38.30±0.22[b]	37.83±0.55[p]
	Polled	37.66±0.26[a]	38.73±0.24[c]	38.20±0.61[q]
	Average	37.51±0.29[x]	38.51±0.31[y]	
Skin surface temperature (°C)	Horned	35.63±0.42[a]	36.80±0.08[b]	36.21±0.69
	Polled	35.68±0.34[a]	37.30±0.20[c]	36.49±0.91
	Average	35.65±0.35[x]	37.05±0.30[y]	
Respiration rate (breath/min)	Horned	21.25±1.71[a]	35.25±0.96[b]	28.25±7.59
	Polled	21.50±1.73[a]	37.50±1.30[c]	29.50±8.67
	Average	23.38±1.60[x]	36.38±1.60[y]	
Pulse rate (beats/min)	Horned	54.75±8.66[a]	93.50±1.91[b]	74.13±21.51
	Polled	55.00±5.01[a]	97.50±5.07[b]	76.25±23.20
	Average	54.88±6.58[x]	95.50±4.14[y]	

Notes: [a, b, c] Different superscripts in rows and columns within the same parameter indicate significant differences (P<0.05). [x, y] Different superscripts in the same row indicate significant differences (P<0.05). [p, q] Different superscripts in the same column indicate significant differences (P<0.05).

Table 3: Average values of hematological parameters of horned and polled Bali cattle.

Parameter	Bali cattle	Time factor of measurement		Average
		Morning	Afternoon	
Erythrocytic count (x10^6/mm^3)	Horned	5.47±0.30[a]	5.29±0.40[a]	5.38±0.34[p]
	Polled	7.11±0.39[c]	6.06±0.34[b]	6.59±0.65[q]
	Average	6.29±0.93[x]	5.68±0.54[y]	
Hemoglobin level (g/dl)	Horned	11.63±0.54[a]	11.25±1.06[a]	11.44±0.81[p]
	Polled	17.23±0.40[c]	14.33±1.09[b]	15.78±1.72[q]
	Average	14.43±3.03[x]	12.79±1.92[y]	
Hematocrit (%) value	Horned	33.93±1.30[a]	32.83±2.42[a]	33.38±1.89[p]
	Polled	43.83±3.21[b]	40.95±3.86[b]	42.39±3.63[q]
	Average	38.88±5.76	36.89±5.27	
Leukocytic Count (10^3/mm^3)	Horned	12.65±3.81	11.73±3.35	12.19±3.36
	Polled	13.55±2.05	13.25±2.93	13.40±2.35
	Average	13.10±2.87	12.49±3.03	

Notes: [a, b, c] Different superscripts in rows and columns within the same parameter indicate significant differences (P<0.05). [x, y] Different superscripts in the same row indicate significant differences (P<0.05). [p, q] Different superscripts in the same column indicate significant differences (P<0.05).

DISCUSSION

The temperature rises throughout the day until it reaches a peak when the sun shines perpendicular to the earth's surface. The humidity decreases during the day, indicating that when the ambient temperature is high, the humidity will decrease. According to Yani et al. (2007), the ambient temperature in Indonesia tends to be high, ranging from 24-34°C and the humidity is also high, at 60–90% annually. The temperature and humidity are considered normal for the tropics (Putra et al., 2019), but may affect livestock and therefore require improved management.

The temperature-humidity index (THI) is a simple combination of temperature and humidity that is often used to estimate livestock comfort based on environmental conditions. The higher the THI value, the more severe the heat stress that can be inflicted on cattle. A THI value of <74 is ideal for beef cattle, 75–78 is mild heat stress, 79–83 is moderate heat stress, and >84 is severe heat stress (Bulitta et al., 2015). The results showed that THI values during the day can put cattle under severe stress, making it difficult to maintain thermoregulatory mechanisms and normal temperatures (Habeeb et al., 2018), which can have an impact on livestock productivity. Although the threshold value of THI concerning stress is unknown due to limited information, it may affect behavioral changes, the ability to maintain body homeostasis by increasing respiration rate and heart rate, and changes in hematological profile.

The results showed that both horned and polled Bali cattle experienced an increase in physiological parameters after being exercised under direct sunlight, but polled Bali cattle tended to experience a higher increase (rectal temperature, skin temperature, and respiration rate) than horned Bali cattle. Although horns are not one of the factors that influence the process of thermoregulation, the presence of horns is thought to have a contribution. Parés-Casanova and Caballero (2014) explained that heat exchange works by pumping blood around the horn core (the part containing blood vessels). When this blood passes through the outside of the horn, heat is lost to the environment, and cooled blood is returned to the cattle's body.

Rectal temperature is considered an optimal parameter for representing body temperature (Rashamol et al., 2018; Reuter et al., 2010) because it reflects the heat produced and heat released (Hermawansyah et al., 2020). In hot weather, an increase in body temperature is a function of heat accumulation and heat dissipation with the environment (Lees et al., 2019). Heat absorption on the animal's body surface during hot weather contributes to raising the animal's body temperature. This condition forces animals to maintain a constant body temperature (homeostasis) with thermoregulation mechanisms (Terrien et al., 2011; Mota-Rojas et al., 2021; Renaudeau et al., 2012) to remove excess heat from the body.

The rectal temperature of Bali cattle in this study is still in the normal category. Beef cattle have a normal rectal temperature range of 36.7-39.1°C (average 38.3°C) (Reece, 2015) or 37.8-39.2°C (Abdisa, 2017). The rectal temperature of polled Bali cattle increased more than that of horned Bali cattle during the day. Rectal temperatures in both Bali cattle are not very different from those reported by Aritonang et al. (2017a), who researched in the same district (Barru Regency) and reported that Bali cattle have rectal temperatures in the range of 37.6-38.6°C. Putra et al. (2021) also reported that the rectal temperature of Bali cattle increased from 37.5±0.3°C in the morning to 38.7±0.2°C in the afternoon. Contrary to Prahesti et al. (2021), who reported that exercised Bali cattle had higher rectal temperatures between 39.16-40.06°C. Prasanna et al. (2022) reported Sahiwal and Sahiwal cross cattle had higher average rectal temperatures during summer than other seasons, which could be due to the excessive heat production due to the increased metabolic rate.

Animals try to maintain their body temperature by releasing heat through various efforts. The respiration rate is the first thermoregulatory mechanism used by the animal to maintain body temperature (Seixas et al., 2017). Polled Bali cattle during the daytime showed a higher increase in respiration rate. Putra et al. (2021) reported an average respiration rate of 22.6±5.3 breaths/min in the morning, which increased to 37.4±4.4 breaths/min during the day. When exposed to high environmental heat, peripheral receptor activation sends nerve impulses to the hypothalamic thermal center, which then stimulates the cardio-respiratory center to send impulses to the diaphragm and intercostal muscles to accelerate breathing (Ganaie et al., 2013; Atkins et al., 2018), so that body heat can be lost through evaporative breathing. Animals that have increased respiration rates do not necessarily indicate that they have been able to maintain a stable body temperature, but rather that the animal has overheated and is trying to restore its body heat balance (Ganaie et al., 2013). Low respiration rates in hot environments indicate a greater tolerance (Prasanna et al., 2022). The normal respiration rate for beef cattle, according to Abdisa (2017) is 25–30 breaths/min.

The skin acts as a heat radiator, allowing heat to radiate from the body surface to the environment (Collier et al., 2019). Animals release heat through vasodilation and sweating. Vasodilation begins when the heart increases blood flow in the capillaries to the upper periphery of the skin to facilitate the transfer of body heat to the environment (Habeeb et al., 2018; Shilja et al., 2016; Wang et al., 2020). When this mechanism is unable to reduce body temperature or the external environment is higher, the brain responds by releasing sweat on the skin to carry additional heat from the body from the liquid to vapor phase (Habeeb et al., 2018).

The increase in skin surface temperature in this study is similar to the report of Putra et al. (2021), where the skin surface temperature in Bali cattle increased from 32.6±1.0°C in the morning to 37.0±1.6 °C during the day. Berian et al. (2019) also reported that crossbred dairy cows that experienced heat stress had a higher skin surface temperature (38.69±0.09°C) than those kept at a comfortable ambient temperature (37.31±0.04°C). The skin surface temperature of horned and polled Bali cattle in this study did not differ much from Nuriyasa et al. (2015), who reported that Bali cattle have a skin temperature range of 36.66-37.89°C. The skin surface is the part of the body that is directly exposed to sunlight. The skin color of these cattle is thought to have a correlation with skin surface temperature. Brown-Brandl et al. (2006) explained that cattle breeds with dark skin (Angus and MARC III) have higher surface temperatures than cattle breeds with light-colored skin (Charolais and Gelbvieh). Male polled Bali cattle have a color that tends to be slightly darker than horned Bali cattle (Zulkharnaim et al., 2020b) so during the day they have a higher skin surface temperature.

Bali cattle had a higher pulse rate in the afternoon after exercise under sun exposure compared to that in the morning. Exposure of animals to heat stress induces changes in circadian rhythms in the heart of the animal (Rashamol et al., 2018). Putra et al. (2021) showed an increase in the pulse rate of Bali cattle from 55.5±10.6 beats/min to 64.5±11.3 beats/min when the ambient temperature increased. Prahesti et al. (2021) also reported an increase in pulse rate from 70.00±5.00 beats/min to 96.66±6.00 beats/min after Bali cattle were given exercise. Under normal conditions, the pulse rate of cattle generally ranges from 40 to 70 beats/min (Kubkomawa et al., 2015) or 60 to 90 beats/min (Abdisa, 2017).

The increase in pulse rate in hot environmental conditions is due to sympathetic activity. Heart rate is controlled by the activity of the autonomic nervous system, namely the sympathetic nervous system, which increases heart rate, and the parasympathetic nervous system, which decreases heart rate (Kasahara et al., 2021). When the environment is hot, animals try to control their body temperatures by releasing heat from their bodies into the environment. Sarangi (2018) explained that the increase in heart rate is caused by two things, namely: (1) increased muscle activity involved in regulating respiration rate, and (2) decreased vascular and arterial peripheral resistance. Heat release can be achieved through water diffusion from the skin by increasing blood flow from the core to the surface (Gupta et al., 2013), where the heart will be more active in pumping blood.

The results revealed that polled Bali cattle have higher erythrocytic counts, hemoglobin levels, and hematocrit values than horned Bali cattle. During the day after exercise, polled cattle had decreased erythrocytic counts and hemoglobin levels, while horned Bali cattle showed no significant disturbances in their hematological profile. High hematological values indicated that polled Bali cattle have a high metabolic rate.

Red blood cells, also known as erythrocytes, are blood cells that function as oxygen transportation from the lungs to body tissues and provide the oxygen needed by body cells (Mohanty et al., 2014). The average erythrocytic counts in horned Bali cattle were not much different from the research of Adam *et al.* (2015), which was 5.49±0.88 x10^6/mm^3 (male); 4.89±0.53 x10^6/mm^3 (female), Siswanto (2011), which was 5.2 x10^6/mm^3 and Suharti et al. (2017), which was 5.18±0.41 x10^6/mm^3. Meanwhile, polled Bali cattle have a higher erythrocyte count but are still within the normal range when referring to the erythrocytic count of Roland et al. (2014). The erythrocytic count of horned Bali cattle did not change, while that of polled Bali cattle decreased after morning exercise.

The decrease in the erythrocytic count in polled Bali cattle indicates that sun exposure and exercise during the day can interfere with erythrocytes, as explained by Tamzil et al. (2014) that heat stress can affect the erythropoietin hormone in the spinal cord so that the production and development of erythrocytes are inhibited. Abduch et al. (2022) reported that daytime sun exposure and exercise had a negative impact on the number of erythrocytes in Caracu beef cattle. Ondruska et al. (2011) also reported that rabbits exposed to 36°C daily, for 12 h, within 4 weeks were able to reduce the erythrocytic count. Another report by Perumal et al. (2022) reported lower erythrocytic counts in local Andamanese cattle during the dry season than during the wet season. Piemontese cattle reared in a hotter environment showed lower erythrocyte counts (Mazzullo et al., 2014).

Hemoglobin is the main component of erythrocytes and functions as the carrier of oxygen and carbon dioxide. The average hemoglobin levels of horned and polled Bali cattle were higher than the hemoglobin levels reported by Siswanto (2011) and Diparayoga et al. (2014) but still within the range of reports by Septiarini et al. (2020) and Suharti et al. (2017) which had hemoglobin levels of 12.53-14.53 g/dl and 10.62±1.21 g/dl, respectively, and in general similar to the result reported by Roland et al. (2014).

According to Srikandakumar and Johnson (2004), heat stress can result in erythrocyte lysis because of an increase in free radicals in the erythrocyte membrane, which is rich in fat. This can lower hemoglobin levels or lead to a lack of nutrients for the synthesis of hemoglobin because the animal consumes less feed. Lawrence et al. (2017) explain that hemoglobin correlates with the number of erythrocytes; when the number of erythrocytes decreases, hemoglobin levels also decrease. Hemoglobin synthesis occurs at the beginning of erythrocyte formation. When erythrocyte formation is disrupted, hemoglobin synthesis is also disrupted. Perumal et al. (2022) reported that local Andamanese cattle during the dry season were significantly had lower erythrocytic count and hemoglobin than cattle reared during the wet season.

Hematocrit, also known as packed cell volume (PCV), is a term used to describe the proportion of erythrocytes in 100 mL of blood (Reece, 2015). The hematocrit value of horned Bali cattle is not significantly different from those reported by Diparayoga et al. (2014) and Suharti et al. (2017), but the hematocrit values of horned and polled Bali cattle was still higher than the reports of Siswanto (2011) and Adam et al. (2015), but still in the normal category when referring to result reported by Roland et al. (2014).

Providing exercise under sunlight did not impair hematocrit values. In contrast, Iranian cattle reported by Mirzadeh et al. (2010) and local Andamanese cattle reported by Perumal et al. (2022) showed lower hematocrit values when reared in summer compared to colder seasons. An increase or decrease in hematocrit value is related to erythrocytic counts (Merdana et al., 2020), which affects the viscosity of the blood, with high or low values having an impact on increasing or slowing blood flow and heart (Merdana et al., 2020).

White blood cells, also known as leukocytes, are blood cells that play a role in protecting the body from disease-causing infections. Horned and polled Bali cattle have similar leukocytic counts. The leukocytic count in this study is not much different from the results of Novanty et al. (2022), who reported the leukocytic count of Bali cattle at 12.26±2.85 x10^3/mm^3 although the contrast was higher than Suharti et al. (2017), who reported 7.13±0.80 x10^3/mm^3.

Exercise under sunlight did not affect the leucocytic count of horned and polled Bali cattle. This indicates that the immunity of both Bali cattle was not impaired during heat stress. Pandey et al. (2017) reported leukocyte counts of Tharparkar and Karan Fries cattle that showed no difference in cattle exposed to heat stress and oxygen levels compared to controls. In contrast, Perumal et al. (2022) reported that local Andamanese cattle have lower leukocytic counts during the dry season than during the rainy season.

The absence of horns in polled Bali cattle is expressed by a higher rectal temperature, skin surface temperature, and respiration rate. This condition was supported by the hematological profile of polled Bali cattle, which has higher erythrocytic counts, hemoglobin levels, and hematocrit values to compensate for higher metabolic processes. During the day after exercise under the hot sun, horned Bali cattle did not experience significant changes, while polled Bali cattle experienced significant decreases in several hematological parameters. This circumstance does not imply that polled Bali cattle are less resilient to heat stress than horned Bali cattle. Polled Bali cattle may be able to adapt and survive at high altitudes with low oxygen levels (Pathak et al., 2022). Low oxygen availability at high altitudes requires physiological adjustments that allow adequate tissue oxygenation (Gassmann et al., 2019). High erythrocytic counts and hemoglobin levels are the most important hematological indicators for high-altitude acclimatization.

CONCLUSIONS AND RECOMMENDATIONS

Horned and polled Bali cattle both experience an increase in physiological parameters during the day after being given exercise in the sun, but polled Bali cattle tend to experience a higher increase (rectal temperature, skin surface temperature, and respiration rate) compared to horned Bali cattle. Higher rectal temperature, skin surface temperature, and respiration rate compensate for the absence of horns in polled Bali cattle. These conditions are balanced by the higher hematological profile of polled cattle to compensate for the faster metabolic processes.

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NOVELTY STATEMENT

The physiological and hematological profiles of Bali cattle are only found in horned Bali cattle, not in polled Bali cattle. This study is preliminary research that discusses the differences in physiological and hematological profiles of horned and polled Bali cattle.

AUTHOR'S CONTRIBUTION

SS and DPR conception and design of the study, data collection, data analysis, initial writing drafts, writing-review and editing. HS conception and design of the study; data analysis; correcting and editing a draft. HH data collection; data analysis. SB data analysis. SG data collection. KDDA; data collection, data analysis.

Ethical approval

The Animal Ethics Committee of Hasanuddin University, Makassar, Indonesia, approved all procedures in the present study.

Conflict of interest

The authors have declared no conflict of interest.

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