Physiological conditions of Bali cattle based on daily temperature-humidity index (THI) in oil palm plantation

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Abstract. Oil palm plantations (OPP) have a temperature-humidity index (THI) higher than the surrounding environment, which affects the physiological conditions of cattle. The study aims to measure the body temperature (BT), respiration rate (RR), and pulse rate (PR) as a comfort indicator of cattle to the environment. Fourteen Bali cattle were used to study the physiological condition of cattle in an OPP based on THI. The THI in the morning, day, and night were tested using a Completely Randomized Design followed by Duncan's multiple range test. The results showed that the OPP had a different THI (P<0.05): 77.36±1.22, 82.91±1.40, and 79.49±2.63 in the morning, day and night respectively. The BT, RR, and heat tolerance coefficient (HTC) during the day higher (P<0.05) than morning and the night, while the PR was not different. It is concluded that OPP has THI potential to give moderate stress, but the cattle still overcome them through physiological efforts, so it was suitable for Bali cattle grazing area.

1. Introduction

Oil palm plantations (OPP) in Indonesia reached 14.03 million hectares in 2018, with annual growth reaching 10.31% per year [1]. An OPP has potential feed resources for the development of ruminants, especially cattle [2], and it is proven to be able to meet the forage requirement of cattle [3] [4]. Beside the availability of forages for cattle grazing areas, suitability of temperature and humidity of the environment for comfortable of livestock should be considered so that the productivity could be optimal; one of the indicators to measure the comfortable environment is the temperature-humidity index (THI).

The air temperature in Indonesia is generally high, between 24 to 35˚C, with humidity between 60 to 90% [5] [6]. The environment influences the body temperature of cattle; cattle must maintain temperature by 38.8˚C [7]. The optimum of the environment temperature for cattle in the tropics is 25-37˚C [8]. Temperature-humidity index (THI) value as well as an indicator of the physiological status of cattle [9] [10] It must be ≤74 to be in reasonable condition, 75-78 means mild stress, and 79-83 is moderate stress, and ≥84 is in stress category [11] [12].
The study aims to measure the body temperature (BT), respiration rate (RR), and pulse rate (PR) as physiological conditions based on THI as a comfort indicator of cattle to the environment, as a consideration for OPP-cattle integrated system.

2. Material and methods
Fourteen Bali cattle, 10-15 months of age were raised in an OPP in Pelepat Ilir Subdistrict, Bungo Regency, Jambi Province, Indonesia and used to observe their adaptability, indicated by: body temperature, respiration frequency, pulse, and HTC [13] [10]. Each observation was repeated three times. Temperature and humidity were observed for nine days using a 1080p CCTV camera that was directed to a digital thermohygrometer [14]. Three HTC-1 thermohygrometers were installed in a barn with a maximum distance of 6 meters [6] used to determine the temperature in the morning (05.00 to 09.00), during the day (12.00 to 16.00) and in the night (20.00 to 24.00) and used as a basis for physiological measurements [9].

Measurement of THI was calculated using a formula [9]: 0.8 x temperature ambient + [(% relative humidity /100) x (temperature ambient -14.4)] +46.4.

Rectal temperature was measured using a digital body thermometer for ± 1 minute [17] [18]. The respiration rate was measured by observing thoracic movements in the flank section in a timed interval [19] [17]. Pulse rate was measured by putting fingers on the coccygeal artery below the middle of the tail. HTC values were used for determination of adaptability of the cattle, which calculated using Benezra formula 1954 [20] (HTC = TB / 38.3 + Fr/23). The environmental and physiological data were analyzed by Complete Randomized Design (CRD) followed by Duncan's multiple range test (DMRT) [21].

3. Result and discussion
The temperature, humidity, and THI of OPP environment are presented in Table 1.

Table 1. Average temperature (T), humidity (H), and THI Environment

| Treatment | Period   | Morning | Day       | Night     |
|-----------|----------|---------|-----------|-----------|
| T (˚C)    | 25.66 ± 0.90a | 31.82 ± 2.30b | 26.94 ± 0.62a |
| H (%)     | 92.87 ± 3.41b | 65.00 ± 14.25a | 91.96 ± 2.63b |
| THI       | 77.36 ± 1.22a | 82.91 ± 1.40a | 79.49 ± 2.63b |

a, b, c: different superscripts in the same row showed significant differences (P<0.05)

There was no difference between temperature in the morning and the night (P>0.05) while the temperature during the day was the much higher compared that in the morning and night (P<0.05). The temperature in that area is considered as normal as in tropical situation, but it possibly influenced the cattle. Therefore, improved management is needed [5].

Humidity in the morning and evening also was not different (P>0.05), while the humidity during the day was much lower compared to that in morning and night (P<0.05). The humidity was still slightly larger at maximum humidity [6], so in the morning, cattle may have difficulty releasing heat through evaporation. During the day, the humidity is ideal and perfect for high ambient temperatures to increase the rate of water evaporation from the skin surface, which can help cattle release heat excess from the body [14].

There was a difference THI between morning, during the day, and the night (P<0.05) (Table 1). Based on the potential hazards, THI in the morning was in mild stress conditions, while during the day and the night were in moderate stress [22] [19]. It means that proper management is needed to reduce maintenance risks caused by the environment.

Table 2 described that the BT of Bali cattle in the morning was not different from the night (P>0.05), but during the day, it reached the highest (P<0.05).
Table 2. Physiological response of Bali cattle in the OPP environment

| Treatment                      | Morning       | Day           | Night         | Average       |
|--------------------------------|---------------|---------------|---------------|---------------|
| Body temperature (°C)          | 37.51 ± 0.35  | 38.70 ± 0.24  | 37.57 ± 0.68  | 37.92 ± 0.71  |
| Respiration rate (times/minute)| 22.64 ± 5.33  | 37.36 ± 4.43  | 17.64 ± 2.02  | 25.88 ± 9.39  |
| Pulse rate (times/minute)      | 55.50 ± 10.63 | 64.50 ± 11.26 | 59.14 ± 8.75  | 59.71 ± 10.69 |
| HTC                            | 1.97 ± 0.24   | 2.63 ± 0.19   | 1.75 ± 0.09   | 2.12 ± 0.42   |

a, b, c: different superscripts within the same rows showed significant differences (P<0.05)

The temperature, humidity, and THI were slightly changed in 24 hours, from morning till the next morning and influencing the BT. Nevertheless, the BT of Bali cattle were still in the normal condition [14]. The RR was not different between morning and night, while during the day it increased higher (P<0.05). It means that cattle were under normal conditions for respiration [23] [18].

The PR was not different between morning and night, yet, was significantly higher during the day (P<0.05). However, it was still in a normal range (40-70 times per minute) [24]. HTC value described the difference between morning, day and night (P<0.05). HTC during the night was the lowest and during the day was the highest [25]. HTC was equal and the best condition in adaptability, while HTC > 2 is in a weak condition. The results showed that during the day, Bali cattle were in heat stress and needs improved treatment to reduce the level of stress suffered from the environment [26] [27].

4. Conclusion

It is concluded that OPP environment tends to influence on cattle stress level at the moderate level, although body temperature, respiration and pulse rates are still in the normal range. The heat tolerance level indicates that cattle in the OPP condition experiencing a heat stress. It implies that management needs to be improved to reduce the environmental heat impact.

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