The Effects of Seasons (Hot/Dry and Cool/Humid) on Thermoregulatory Responses of Male and Female Bali-Cattle Working in the Field

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ABSTRACT : A study was conducted on the effects of ploughing on physiological responses of male and female Bali-cattle. A 2 × 2 × 6 × 8 factorial design (2 seasons, 2 sexes, 6 days and 8 consecutive time of measurements every 30 minutes) was employed. Responses during the cool/humid season were lower than hot/dry; respiration rate (RR) was 52 vs 75/min, rectal temperature (RT) was 39.1 vs 39.5℃ and skin temperature (ST) was 37.1 vs 37.6℃. Within sexes, males were less tolerant than females in that their RR (66 vs 61 breath/min), RT (39.4 vs 39.2℃) and ST (37.6 vs 37.1℃) were each higher than females during work. With increasing time, during the average 2.5 h working period gradual increases in RR, RT and ST were recorded and the overall increases of 84 breath/min, 1.9℃ and 13.8℃ respectively ($p < 0.001$).

Packed cell volume (PCV) data indicated significant difference between sexes, time and season ($p < 0.001$, $p < 0.05$ and $p < 0.001$ respectively). Within time (before and after 2.5 h working) the PCV decreased from 27.4 to 25.6%.

(**Key Words** : Seasons, Bali-cattle, Sexes, Work, Thermoregulation)

INTRODUCTION

Male and female Bali cattle are used for ploughing in Bali in both irrigated paddy fields and dryland areas during both major climatic seasons, the hot/day (March-September) and the cool/humid (or "rainy"; October till February). Temperatures (dry bulb) during the hot/dry are higher by 5-10℃, with a relative humidity of 20-25% less (at about 70%) than during the cool/humid one.

In European cattle, Murray and Yeates (1967) reported that heifers were more heat tolerant than bulls when walked at either 2.7 or 4.3 km/h under hot, sunny, subhumid conditions in Australia. As yet no experiments have been conducted on male and female Bali-cattle working in the field.

MATERIALS AND METHODS

Three males (bull) and three females (cow) Bali cattle, with body weights of 333.3 ± 62.4 and 270.0 ± 14.1 kg respectively and similar body condition scores of 3.0 (Jefferies, 1966) were employed.

The experiment was carried out at Sangsit village about 80 km from Denpasar (the capital city of Bali), northern part of Bali island, and 5-10 m above the sea level. Three tenant farmers were actively involved in this project. The animals were fed *ad libitum* with local native grass as explained by Nitis et al. (1985). Experiments were carried-out in the months of January and July during rainy and hot seasons respectively, with 2 replicates per season, 3 days each replicate and 3 days rest in between those 2 replicates. Observations were made during 2.5 h ploughing and another 1 h at recovery within 30 minutes interval. The experiment was carried out at 6.30 in the morning and finished by 12.00 o'clock in the afternoon.

A 2 × 2 × 6 × 8 factorial design (2 seasons, 2 sexes, 6 days and 8 consecutive time of measurements every 30 minutes) was used. All results were analysed by analysis of variance (Steel and Torrie, 1980), and the "BMDP 2V" (Dixon et al., 1983) statistical packages for repeated measurement in the DEC-20 and GARA computer systems at the University of New England.

RT was routinely measured using a clinical thermometer inserted 10 cm for 1 minute. At regular intervals the accuracy of the various thermometers was checked by calibration against a standard mercury-in-glass thermometer in stirred water.

RR was measured by counting flank movements for 1 minute using a stop watch (TM-104 model).

During field work STs were routinely measured using a thermistor thermometer with digital read-out ("Digi-Thermo") and a 20 cm-long probe of 0.3 cm external

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Received April 29, 1996; Accepted August 30, 1996

diameter. The end of the probe (the location of the thermistor) was pressed lightly against the skin until a steady reading was achieved (approx. 1 minute).

Haematocrit concentration was measured before and after exercise by the standard laboratory procedures with 3 replications (Jain, 1986).

This experiment was thus undertaken on mature *Bos banteng* or "Bali-cattle" in the superhumid zone of Bali (Indonesia). Performance was monitored outdoors under uncontrolled temperature conditions, using animals of the same age and body condition score, but differeing in body weight, during normal ploughing operations. The animal was trained for 3 days before the experiment trial to accustom working in the field.

RESULTS

DB temperatures during the cool/humid and hot/dry seasons varied from 24.5 to 34.5℃ and 20 to 43℃ respectively, RH from 60 to 98% and 70 to 85% respectivey. Details of the climate situation can be seen in table 3. Respiration rate (RR), rectal temperature (RT) and skin temperature (ST) differed significantly ($p < 0.001$) between seasons, sexes, days and times during exercise. Responses during the cool/humid season were lower than hot/dry season (table 1); RR (52 vs 75/min), RT (39.1 vs 39.5℃) and ST (37.1 vs 37.6℃). Within sexes, the males were less tolerant than the females in that their RR (66 vs 61/min), RT (39.4 vs 39.2℃) and ST (37.6 vs 37.1℃) were all higher during working than in females.

Table 1. Mean respiration rate (RR breaths / min), rectal (RT) and skin temperature (ST ℃) of male and female Bali cattle after 2.5 h working in the field during cool / humid and hot / dry seasons

Sea-sons:		cool / humid		hot / dry					SEM	Level of signifi-cance
RR :		52^a		75^b					0.040	***
RT :		39.1^a		39.5^b					0.002	***
ST :		37.1^a		37.6^b					0.002	***
Sex :		male		female					SEM	
RR :		66^a		61^b					0.040	***
RT :		39.4^a		39.2^b					0.002	***
ST :		37.6^a		37.1^b					0.002	***
Day :		D1	D2	D3	D4	D5	D6		SEM	
RR :		54^a	68^b	68^b	69^b	62^c	60^c		0.100	***
RT :		39.4^a	39.5^b	39.4^a	39.3^c	39.1^d	39.1^d		0.005	***
ST :		37.5^a	37.8^b	37.5^a	37.5^a	36.7^c	37.2^d		0.007	***
Times : (hours)	0	0.5	1	1.5	2	2.5	recovery 0.5	period: 1	SEM	
RR :	18^a	38^b	58^c	77^d	90^e	102^f	77^d	48^g	0.200	***
RT :	38.3^a	38.7^b	39.0^c	39.5^d	39.9^e	40.2^f	39.6^g	39.2^h	0.006	***
ST :	27.9^a	34.9^b	38.2^c	39.7^d	40.9^e	41.7^f	38.7^g	37.1^h	0.009	***

Values within line with dissimilar superscripts differ significantly (***$p < 0.001$).

On day 1, the animals did not show as high a level of stress as on day 2 (RR, RT and ST were lower than on day 2 by 14/min, 0.1 and 0.3℃ respectively), and then followed by an apparent pattern of acclimatisation when values in general showed a progressive decline. With increasing time, during the average 2.5 h working period, gradual increases in RR, RT and ST were recorded (overall increases of 84/min, 1.9℃ and 13.8℃ respectively; $p < 0.001$). After work, during the first and second 30 minutes intervals of the recovery period, significant and progressive reductions occured in all three parameters but 1 h after work all 3 remained significantly elevated above pre-work levels. For ST there were significant effects associated with both day x sex ($p < 0.001$) and sex x time ($p < 0.05$) interactions (figures 1 and 2), with values for males higher than females.

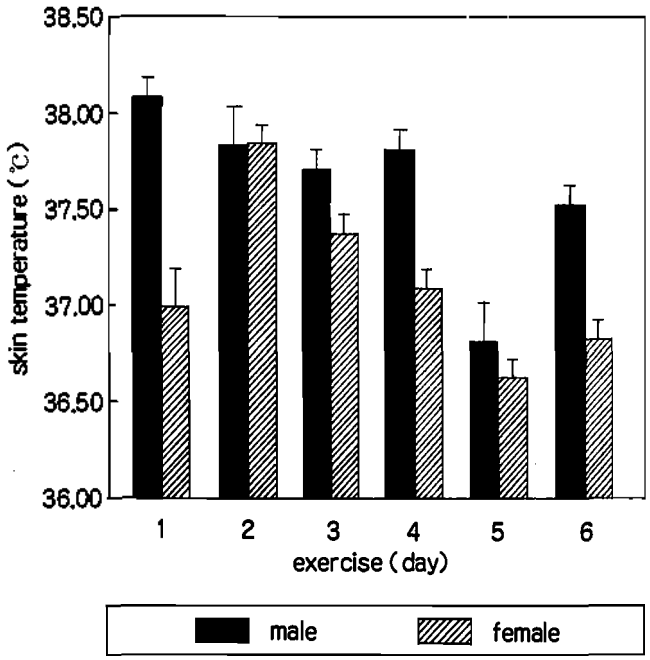

Figure 1. Mean skin temperature (ST) of male and female Bali-cattle working in the field for 6 days on Bali.

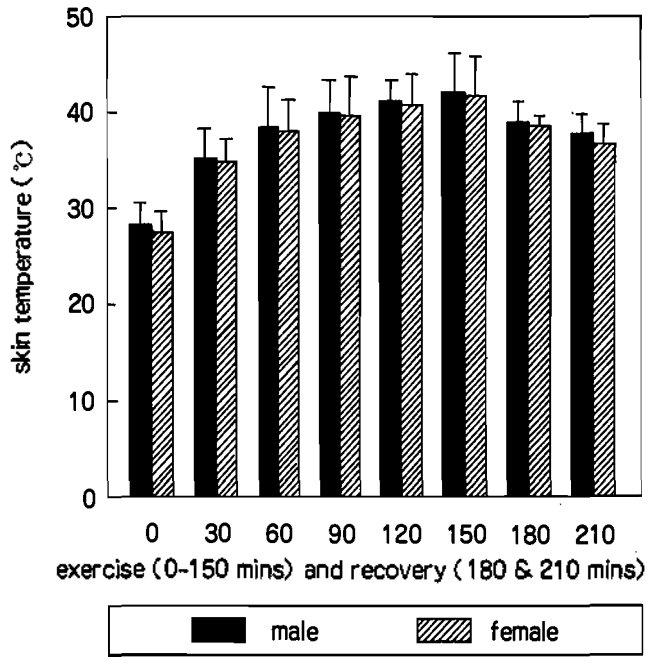

Figure 2. Mean skin temperature (ST) of male and female Bali-cattle working in the field for 150 minutes on Bali and during a subsequent 60 minutes recovery period.

PCV data are presented in table 2, which indicated significant differences between sexes, time and season ($p < 0.001$, $p < 0.05$ and $p < 0.001$ respectively). For example, within time (before and after 2.5 h working) the PCV decreased from 27.4 to 25.6%. Male having higher PCV and PCV was higher in hot/dry season.

Table 2. Mean PCV (%) of male and female Bali-cattle working in the field during cool / humid and hot / dry

	PCV (%)		SEM	Level of significance
sex	male	female		
	28.2[a]	24.7[b]	0.6	***
time	0	2.5[h]		
	27.4[a]	25.6[b]	0.6	*
season	cool/humid	hot/dry		
	21.6[a]	31.3[b]	0.6	***

Values within line with dissimilar superscripts differ significantly (***$p < 0.001$; *$p < 0.05$).

DISCUSSION

The results showed, that rises in environmental temperature during work are followed by increases in RR, RT and ST. These findings are similar to that of Murray and Yeates (1967) who observed gradual increased of RR and RT in bulls, steers and cows when walking under environmental temperatures of 24.4-31.1°C. However, according to Murray and Yeates that ST decreased with time as compensation patterns, but on the whole the ST in Herefords was higher than in Bali-cattle. It can be concluded, therefore, that the Herefords observed by Murray and Yeates (1967) were more stressed than the current Bali-cattle, even though the Bali-cattle were working in a tropical country under 21.2-40.1°C environmental temperature (ET) and 65-95% relative humidity (RH). Obviously, the greater effect observed in the European Hereford breed than in Bali-cattle could have been due to the fact that the Herefords have thinner skin.

From the current results it can be concluded that the high ET during working the more stressed the animal was. This finding is in general agreement with Quinlan and Riemerschmid (1941), who found that the mean ST of Sussex cattle was 37.0 ± 0.4°C in the sun (from 9 am to 3 pm) but 36.0 ± 0.4°C in the shade. Beakley and Findlay (1955) in their studies showed that when Ayrshire calves were exposed to 30 to 40°C ET, ST increased from approximately 37 to 39°C. A similar pattern occurred in sheep, Brown (1971), for example, found that ST increased from 36.5 to 37.5°C at about 7.30 am to a

maximum of approximately 44℃ by about 10 am. Additionally, on theoretical grounds, differences in cost colour, coat depth, fibre diameter and medullation could also contribute to the observed differences in ST between Herefords and Bali-cattle.

Table 3. Environmental temperature during field trials with Bali-cattle at sangsit village, Bali, Indonesia in the cool / humid and hot / dry seasons

		A. Cool /humid season :				B. Hot /dry season :			
		D.B. (℃)	W.B. (℃)	max. (℃)	min. (℃)	D.B. (℃)	W.B. (℃)	max. (℃)	min. (℃)
day 1 :	07:00	28.5	26.5			21.0	20.0		
	09:00	29.5	27.0			32.0	24.0		
	11:00	33.5	29.5	35.0	25.5	39.5	30.0	37.0	22.0
day 2 :	07:00	26.5	25.5			20.0	19.0		
	09:00	32.5	29.0			29.0	25.0		
	11:00	34.5	30.5	39.5	24.0	37.0	29.0	37.0	22.0
day 3 :	07:00	25.0	24.0			21.0	19.0		
	09:00	30.5	28.5			32.0	27.0		
	11:00	32.5	29.0	35.0	25.0	36.0	28.0	32.0	22.0
day 4 :	07:00	25.0	24.0			22.0	20.0		
	09:00	27.0	26.5			32.0	26.0		
	11:00	27.5	27.0	29.0	24.5	42.0	32.0	42.0	19.0
day 5 :	07:00	24.5	24.0			21.0	19.0		
	09:00	26.5	26.0			31.0	27.0		
	11:00	31.5	29.5	32.5	24.0	43.0	33.0	43.0	20.0
day 6 :	07:00	27.0	26.0			22.0	21.0		
	09:00	28.5	27.0			37.0	30.0		
	11:00	31.0	28.5	34.0	27.0	43.0	32.0	41.0	21.0
mean :	07:00	26.1	25.0			21.2	19.7		
	09:00	29.1	27.3			32.2	26.5		
	11:00	31.8	29.0	39.5	24.0	40.1	30.4	43.0	19.0

Differences in the physiological responses (RR, RT and ST) between sexes may also be associated with a larger mass of muscle in the males, which could be expected to produce more heat. It is naturally recognized that the male farm animals are heavier than females, as Saho and Mishra (1990) reported that in Binjharpuri cattle the birth weights of male and female calves were 18.2 ± 0.36 and 14.7 ± 0.34 kg, respectively. Similarly, Taylor et al. (1989) reported that mature carcass weights of male sheep were higher than females (16.3 ± 4.2 and 13.1 ± 3.2 kg respectiely). Similar results were also reported by Saho and Mishra (1989) and Panda and Mishra (1990). The reflection of these phenomena have also been shown in the experiment conducted by Pearson (1989) who concluded that heavier-mature animals, whether expressed as a result of either sex or live body weight differences, react more in comparison to lighter-young ones.

From the results of the two seasons it could also be seen that RR, RT and ST were all lower during the rainy compared to the hot season (table 1). These present findings are in general agreement with Badreldin et al. (1951) who reported that during winter (5 to 26℃) animals (cattle and buffalo) had a lower RR and RT, and that both parameters reached high levels during the summer months (15 to 36℃) when ploughing in the field. The differences between these two experiments clearly revealed that the animals in the current experiment were more affected since it was conducted in tropical region (mean ET in rainy and hot are 30.2-31.8℃ and 33.6-40.1 ℃ respectively) rather than in a subtropical area which had a lower mean ET. This results is in general agreement with Siqueira et al. (1993) who found that in unshorn sheep kept in the sun or the shade (at a temperature of 45.8℃ or 31.0℃) that ewes exposed to sunlight had a

significantly higher RT (40.6 vs 40.1℃) and RR (191/min vs 129.5/min) than those kept in the shade when grazing.

Results on PCV (table 2) showed a significant decreases with time (after working). These findings support those of Arave et al. (1978) who found that mean PCV decreased from 37.8 to 37.7% after exercise in Holstein dry cows at treadmill speed of 3.5-5.5 km/h. Similar results are also reported by Hays et al. (1978) and Igbokwe et al. (1992). Various reasons could explain this phenomenon such as the possible destruction of numbers of red blood cell during exercise in hot weather as well as changes in splenic function. For example, Singh et al. (1968) showed that the Zebu cattle showed similar response and the explanation for the such decreases lay in the destruction of some erythrocytes due to the stress of exercise in these animals. Moreover, Igbokwe et al. (1992) found that in Sokoto Red goats, the mean PCV values decreased significantly from 32.1 ± 3.0 to 29.2 ± 1.6% when environmental temperature increased at 08.00 to 16.00, and suggested that this might be due to sequestration of red blood cell in the capillaries following peripheral vasodialtation induced by enviromental heat stress in the afterneen. Similar patterns were also reported by Upadhyay and Madan (1985). Pearson and Archibald (1989). In addition, Chen et al. (1993) pointed out that both red blood cells and haemoglobin decreased after exercise in rats by 4 and 1% respectively, probably due to an increase plasma volume such as that which has been observed during training for a week in man and which can increase the baseline plasma volume by almost 500 ml (Convertino et al., 1980).

The rule of splenic function proposed by Dooley (1973) is another possible explanation. According to this theory, since the spleen is a blood reservoir, that organ is able to release blood cells when the animal becomes stressed and take those cells back after the animal has acclimatised. This has clearly been shown to follow an insulin injection that increased the hematocrit in sheep by 43% in 110 min. It is concluded that, when the PCV reaches a steady state level or decreases after working, it meant that acclimatisation occurred in those animal. Conversely, when the PCV increases after exercise, the animal can be considered to be stressed. In the case of a decreased PCV after exercise, the response is known as "rebound phenomenon".

Overall results from these field trials indicated the effects of different ploughman, which seemed likely to be expressed as different increases in RR. For examples, it was observed that the highest RR was achieved on day 4 of 69/minute. On this day the ploughman was replaced due to his other social commitments. These findings were in general agreement with Pearson et al. (1989), who found that an incompatible team (different ploughman) was sometimes difficult to steer and to manoeuvre at the end of furrows, and so used more energy per day for work (674-781 kJ/h) than a lazy one of similar ploughman (595-716 kJ/h). To confirm such cases, further detailed experiments are needed in the future to examine the effects of different ploughmen.

ACKNOWLEDGEMENTS

The work was supported by the AIDAB and by the grant from the University of New England. We thank G. Chisholm for technical assistance.

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