Sweating Rates and Thermoregulation in Male and Female Bali Cattle

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ABSTRACT: An experiment has been conducted to compare the sweating rate between male and female Bali cattle under tropical conditions in Bali, Indonesia with dry bulb (DB) temperatures varying from 25 to 34.5℃ and relative humidity (RH) 70 to 98%.

Rectal temperature (Tr) was significantly different ($p < 0.05$) between males and females (39.7 vs 39.4℃ compared to 39.2 vs 38.8℃ on weeks 1 and 8 respectively). There were significant effects on RR associated with both week × sex ($p < 0.01$) and sex × time ($p < 0.01$) interactions, with values for males higher than females. Skin temperature (Ts) differed significantly between sexes ($p < 0.05$), weeks ($p < 0.05$) and times ($p < 0.01$); being lower in females (36 vs 36.4 ℃). With prolonged working, there were marked increase in RR were recorded after 30 minutes (the overall increase was 12.4℃). Sweating rate (SR) differed significantly between sexes ($p < 0.05$), weeks ($p < 0.01$) and times ($p < 0.01$) during exercise. Females had a lower mean SR (225.3g/m²/h) than males (238.8g/m²/h). With increasing time, the highest SR was achieved after 30 minutes of exercise of 313.3g/m²/h.

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

INTRODUCTION

It is well known that the sweat glands of cattle are functional means of heat loss (FERGUSON and DOWLING, 1955; TANEJA, 1959 and SCHELEGETR and BEAN, 1971). Most studies on sweat-gland activity, however, have been conducted in controlled tempeerature chambers where direct solar radiation and exercise have not been included as part of the thermal burden. Although several investigators, including RHOAD (1940) have proposed heat-tolerance tests based on rectal temperature of European cattle changed during exposure to direct sunlight, there is little information available on sweat gland activity under field conditions in Bali cattle. However, in Saanen goats KASA (1995) reported, males being more stressed than females to the extent of 25g/m²/h after 20 min of treadmill exercise ($p < 0.05$).

Therefore, the present experiment was designed to determine the influence of ploughing and direct solar radiation on sweat gland activity by measuring cutaneous evaporation under field work in male and fermale Bali cattle.

MATERIALS AND METHODS

General

The experiment was done at Sangsit village about 80 km from Denpasar (the capital city), on the northern part of Bali island, and 5-10m above sea level. Six tenant farmers were actively involved in this project. DB temperatures during the experiment varied from 25 to 34.5 ℃ and RH from 70 to 98%. Details of the climate condition can be seen in table 1.

Animals and management

Three pairs each of male (bull) and female (cow) Bali cattle, with body weight of 333.5 ± 62.4 and 270.0 ± 14.1 kg respectively and similar body condition scores of 3.0 (JEFFERIES, 1996) were used for the experiments. For one month prior to and also during the experiment the animals were kept in a small hut of 10 × 5 m².

During the pre-experimental period, the animals were accustomed to experimental procedures and techniques and the animals were fed *ad libitum* with native grass (NITIS et al., 1985; table 2) twice daily, in the morning and late afternoon. On days when experimental data were to be collected, the morning ration was offered at 6 a.m. before any observations were made. Experiments were carried-out from February 1st to April 1st, 1996. Observations were made at 30 minute intervals during 2 h of work. The "normal" experimental day started at 12:00 pm in the afternoon and finished by 14:00 pm, and corresponded to the usual time when ploughing was undertaken locally. Weights of the plough being used in this experiment was about 25kg. Walking speed of the animal was 2 to 2.5 km/h.

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Table 1. Environmental temperatures during field trials with Bali-cattle at Sangsit village, Bali, Indonesia in February and March 1996

		D. B. (℃)	W. B. (℃)	Maximum (℃)	Minimum (℃)
Week 1:	12:00	28.5	26.5		
	14:00	33.5	29.5		
	16:00	29.5	27.0	35.0	25.5
Week 2:	12:00	26.5	25.5		
	14:00	34.5	30.5		
	16:00	32.5	29.0	39.5	24.0
Week 3:	12:00	25.0	24.0		
	14:00	32.5	29.0		
	16:00	27.5	27.0	35.0	25.0
Week 4:	12:00	25.0	24.0		
	14:00	27.5	27.0		
	16:00	27.0	26.5	29.0	24.5
Week 5:	12:00	24.5	24.0		
	14:00	31.5	29.5		
	16:00	26.5	26.0	32.5	24.0
Week 6:	12:00	27.0	26.0		
	14:00	31.0	28.5		
	16:00	28.5	27.0	34.0	27.0
Week 7:	12:00	24.5	24.0		
	14:00	31.5	29.5		
	16:00	26.5	26.5	32.5	24.0
Week 8:	12:00	27.0	26.0		
	14:00	31.0	28.5		
	16:00	28.5	27.0	34.0	27.0

Table 2. Species and chemical compositions (% DM) of the roughages fed to cattle used in the field trials in Bali

Biological name	Ca	P	K	Na	Mg	Cl
Axonopus compressus	0.41	0.42	1.85	0.010	0.43	0.05
Bothriochloa	0.29	0.48	2.05	0.015	0.35	0.65
Cynodon	0.30	0.35	2.33	0.016	0.10	0.69
Cyperus	0.30	0.47	3.22	0.061	0.32	0.95
Digitaria ciliaris	0.24	0.95	3.31	0.017	0.22	0.38
Digitaria	0.22	0.56	3.05	0.014	0.31	0.36
Eleusine	0.70	0.37	2.71	0.010	0.22	0.50
Imperata	0.10	0.29	2.60	0.012	0.17	0.38
Isachne	0.26	0.50	2.59	0.025	0.30	0.84
Leersia	0.25	0.28	2.56	0.026	0.20	0.65
Oplismenus	0.47	0.36	3.14	0.033	0.41	1.31
Panicum	0.27	0.43	2.37	0.045	0.20	0.63
Polytrias	0.40	0.47	2.06	0.021	0.18	0.38
Themeda	0.22	0.32	1.96	0.005	0.11	0.20

After NITIS et al. (1985).

MEASUREMENTS

Rectal temperature

Rectal temperature is used as a measure of "core" or "deep body" temperature, and was routinely measured using a thermister thermometer with digital read-out ("Digi-Thermo"). At regular intervals (every 7 days) the accuracy of this equipment was checked by callibration over the full range of temperatures being studied against a standard mercury-in-glass thermometer in a thermostatically controlled and constantly stirred water bath (TE-7 TEMPETTE). Rectal temperature was measured by inserting the 4 mm diameter thermister probe to a depth of 10 centimetres for 1 minute. Observations were made at 30 minute intervals during 2 h of work.

Respiration rate

Respiration rate was measured by counting the flank movements for 1 minute using a stop watch. Measurements were undertaken at 30 minute intervals during 2 h of work.

Skin temperatures

Skin temperatures were measured using a thermistor thermometer with digital readout ("Digi-Thermo") and a 20 cm-long probe of 0.3 cm external diameter. The end of the probe (the location of the thermistor) was pressed lightly against the skin at the loin area until a steady reading was achieved (approx. 1 minute).

Sweating rate

Sweating rate measured in loin area using the dessicating capsule method (BROOK and SHORT, 1960). The capsules used were 7 cm in diameter and 5 cm in depth and contained 80 g of silica gel which was regenerated for 12 h at 80℃ after every second sweating rate estimate. The capsule was attached to the skin for 3 minutes on a 10×10 cm clipped patch and all figures were extrapolated to g/m^2/h. The capsules were weighed before and after weighing to 3 decimal points on a digital electronic balance, and when not in use were stored in a desiccator. Measurements were done at 30 minute intervals during 2 h of work.

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

A $2 \times 3 \times 5 \times 8$ factorial design (2 sexes, 3 replicates each sex, 5 consecutive times of measurement every 30 minutes and 8 weeks of exercise with 7 day resting in between) was used. The major statistical procedure used

was analysis of variance. Factorial design and analyses were generally carried out using statistical formulas from STEEL and TORRIE, (1980), and the "NEVA" (BURR, 1982) statistical packages for the DEC-20 and GARA computer systems at the University of New England.

RESULTS

Rectal temperature (Tr):

The week × sex interaction for Tr was significantly different ($p < 0.05$), with males being more stressed than females throughout the eight week experiments (39.7 vs 39.4℃ compared to 39.2 vs 38.8℃ in weeks 1 and 8 respectively; figure 1). Rectal temperature differed significantly ($p < 0.01$) with time during exercise, it increased gradually within 1h and decreased thereafter to 39.4℃ (table 3).

Table 3. Mean respiration rate (RR breaths/min), rectal an skin temperature (Tr and Ts ℃) and sweating rate (SR g/m²/h) of male and female Bali-cattle working in the field

Sex		male		female					SEM	Level of significance
RR:		82a		63b					0.09	**
Tr:		39.5a		39.3b					0.003	*
Ts:		36.4a		36.0b					0.009	*
SR:		238.8a		225.3b					0.2	*
Week:	W1	W2	W3	W4	W5	W6	W7	W8	SEM	
RR:	81a	74b	86c	76b	76b	70b	66e	54f	0.4	**
Tr:	39.5a	39.5a	40.3b	39.6a	39.3c	39.1d	39.0d	39.0	0.009	**
Ts:	37.0a	37.0a	38.1b	34.2c	35.3d	37.9e	35.7f	34.6g	0.04	**
SR:	229.9a	223.8a	250.3b	239.4c	225.6a	247.6b	225.0a	214.8d	0.8	**
Times: (hours)		0	0.5	1	1.5	2			SEM	
RR:		15a	91b	94b	86c	78c			0.2	**
Tr:		38.4a	39.7bc	39.8b	39.6c	39.4d			0.006	**
Ts:		27.6a	40.0b	38.7c	38.2d	36.7e			0.03	**
SR:		0.0a	313.3b	303.0b	281.3c	262.7c			0.5	**

Values within line with dissimilar superscripts differ significantly (** $p < 0.01$; * $p < 0.5$).
Values in different sexes are the mean of 3 replicates, each with 5 different time of measurement and 8 day experiments. Values in different weeks are the mean of 3 replicates, each with 2 sexes and 5 different time of measurements. Values in different time of measurements are the mean of 3 replicates, each with 2 sexes and 8 week experiments.

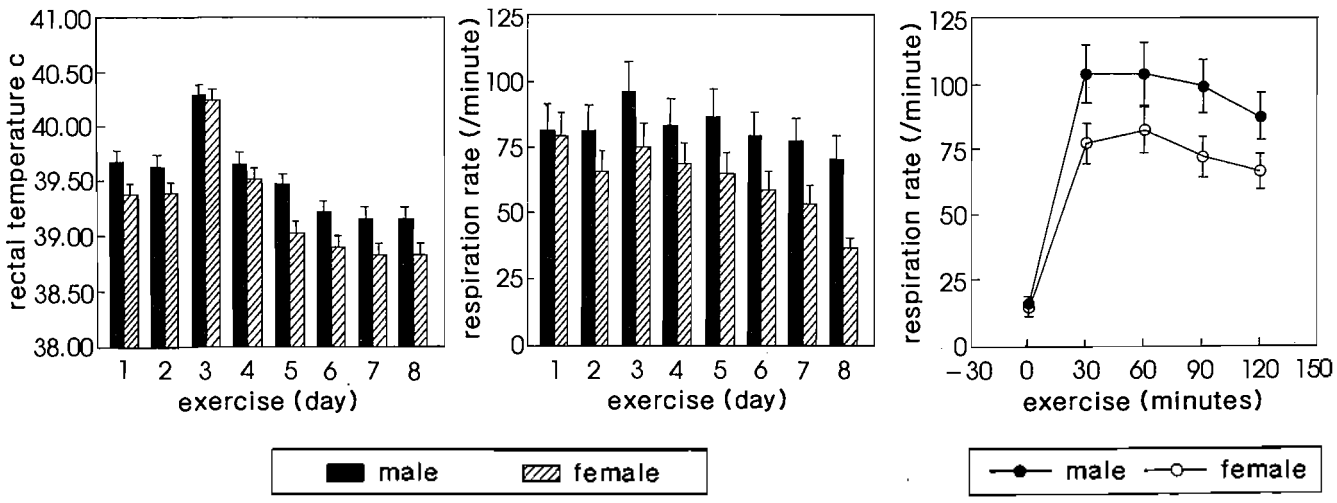

Figure 1. Mean Tr and RR of male and female Bali-cattle working for 120 minutes in the field on Bali.

Respiration rate (RR):

For RR there were significant effects associated with both week × sex ($p < 0.01$) and sex × time ($p < 0.01$) interactions (figure 1), with values for males higher than females. Over weeks, males had significantly higher RR than females. With increasing time during the working period, steep increases in RR were recorded after 30 minutes, and then followed by gradual decreases afterward. The males had significantly higher values than females, at all intervals after 0.5 h exercise. Overall, the RR values are much higher than those previous result (KASA et al., unpublished), could be due to this experiment was conducted during midday (from 12:00 to 14:00 pm), meanwhile, the previous one was carried-out at 7:00 to 11:00 am. Therefore, mean environmental temperature during midday was higher and the animal becoming more stress.

Skin temperature (Ts):

In the absence of significant interactions, mean Ts differed significantly between sexes ($p < 0.05$), weeks ($p < 0.01$) and times ($p < 0.01$) during exercise (table 3). Responses were lower in females (36 vs 36.4℃). The highest and lowest Ts of 38.1 and 34.2℃ were achieved on weeks 3 and 4 respectively. With increasing time during work, a marked increases in Ts were recorded after 30 minutes (the overall increase was 12.4℃), and then patterns of acclimation occured thereafter.

Sweating rate (SR):

SR differed significantly between sexes ($p < 0.05$), weeks ($p < 0.01$) and times ($p < 0.01$) during exercise, and no significant interactions were recorded. Females had a lower mean SR (225.3 g/m²/h) than males (238.8 g/m²/h). On week 1, SR was lower by 17.7 g/m²/h than on week 6, and the lowest was achieved in week 8 of 214.8 g/m²/h as acclimation pattern (table 3).

With time during work, a marked increase in SR was recorded (the increase was 313.3/g/m²/h after 30 minutes). After the third 30-minute interval of work period, significant reductions occured in SR, and the final value recorded at 262.7 g/m²/h.

DISCUSSION

From the overall result it can be concluded that, in Bali cattle the males were less tolerant than females. This confirms with the previous results in goat, Bali cattle and swamp buffalo (KASA, 1995). This result is in general agreement with MURRAY and YEATES (1967) who reported that during walking trials with unclipped cattle under the sun at 24 to 31℃ at 4.3 km/h, bulls displayed a higher mean Tr of 40.7℃ compared to only 40.1℃ in heifers. Evan at the slower speed of 2.7km/h, bulls still showed higher Tr than heifers (40.3° vs 39.6℃). With respect to sex differences in SR, it was found that male Bali cattle produced more sweat compared to female. This is also in general agreement with those of DMI' EL et al. (1979) who reported that when exposed to solar radiation the male Black Bedouin goat has a mean sweating rate higher than female from the thorax of 145.5 ± 42.5 and 130 ± 41ml/m²/h respectively. This difference could have been due to the male having a higher sweat gland density (2.5 ± 0.6 glands/mm²) than the female (1.8 ± 0.6 glands/mm²).

The inferior thermoregulatory performance of males could have been due to their longer stride, as well as a possibly greater heat production associated with walking as the mass of muscle involved in locomotion is greater in males than in females. In the current experiments mean stride lengths of male and female Bali-cattle were 76 ± 8 vs 71 ± 9 cm respectively. As a result of their longer stride, males tended to walk faster during work and thus tended to pull along the female to which they were yoked together for comparative purposes. The exact extent of this effect is unknown, but it would undoubtedly have added somewhat to the work performed by males. The current investigations revealed the opposite pattern of response as reported by YEATES and MURRAY (1966) who found that Herefords, which walked with smaller steps than Santa Gertrudis, displayed greater increases in Tr and RR. Therefore, further researh need to be undertaken in the future, particularly during individual work (not yoked together).

It is has long been known (e.g. BRODY, 1945) that males produce more heat than females of the same body weight. In part, therefore, the higher heat production of males who have larger mass of muscle could be associated with their larger sweating rate. Unfortunately, no informations have been found on such phenomenon yet. Once again, further detail experiment is required later. It is also widely recognized that male farm animals are heavier than females throughout life (SAHOO and MISHRA, 1989; SAHOO and MISHRA, 1990; TAYLOR et al., 1989; PANDA and MISHRA, 1990; and PEARSON, 1989).

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