Resting heat production in *Bos indicus* and their F_1 crosses with exotic breeds at a thermoneutral environment

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(*Received 8 August 1983 – Accepted 19 September 1984*)

1. Resting heat production, 18 h post-feeding, was studied in Hariana cattle (*Bos indicus*; Zebu) and in their F_1 crosses with Jersey, Brown Swiss and Holstein Friesian, at 18·5° ambient temperature in a psychrometric chamber at different ages.

2. There was no significant change in the resting heat production on a per kg body-weight $(W)^{0.75}$ per 24 h basis from 16–19 to 37–40 months of age in any of the genetic groups. The daily resting heat production, however, increased with increases in body-weight and age.

3. The resting heat production in all three F_1 crosses was higher than that in Hariana cattle. Among the crosses, the resting heat production was highest in the Holstein Friesian × Hariana and lowest in the Jersey × Hariana.

4. Metabolizable energy (ME) intake per 24 h was significantly different between genetic groups and in different age groups. However, ME intake per kg $W^{0.75}$ was not significantly different between genetic groups.

The lower metabolic heat production in *Bos indicus* (Zebu) cattle in comparison with *Bos taurus* has been observed by several workers (Kibler & Brody, 1950, 1951; Worstell & Brody, 1953; Johnston *et al.* 1958). Mullick (1959*a*) had similar findings from studies in the natural geoclimate of northern India. However, information on heat production in F_1 crosses of *Bos indicus* with Jersey, Holstein Friesian and Brown Swiss breeds, which have been used in the All India Coordinated Research Project on Cattle for production of different genetic groups, is meagre. We, therefore, studied the resting heat production in cattle of different ages and genetic groups, within the zone of thermoneutrality.

EXPERIMENTAL

Experimental animals

Sixteen bull calves, four of Hariana breed (*Bos indicus*; Zebu) and four each of their F_1 crosses with Jersey, Brown Swiss and Holstein Friesian (JH, BH and FH respectively) were used as experimental animals.

Feeding

The animals were offered a weighed quantity of concentrate mixture (1·5–2 kg/d) and green roughage (5 kg/d) and *ad lib.* wheat straw at fixed times (Table 1) according to revised (US) National Research Council (1971) standards. Metabolizable energy (ME) intake was calculated using tables (Ranjhan, 1980).

Exposure schedule

The animals at 16–19, 21–24, 26–29, 31–34 and 37–40 months of age were exposed to 18·5° ambient temperature, with a fixed vapour pressure of 10–12 mmHg, for 6 d in the psychrometric chamber. All the experiments were of 11 d duration: the first 5 d acted as a 'dummy' run (with only an 'air blower') to make the animals familiar with the 'machine' noises, continuous artificial light and management procedures related to the experiment, followed by 6 d at 18·5°.

Table 1. *Daily feeding and watering schedule and composition of concentrate mixture*

Feeding and watering schedule	Time of day (hours) (Indian standard time)
Concentrate mixture* offered	10.30
First watering *ad lib.*	11.00
Roughage offered	11.30
Second watering *ad lib.*	15.00
Food residue removed	08.00† next day

* Contained (g/kg): maize 250, groundnut cake, 300, wheat bran, 420, mineral mixture 25, common salts 5.
† At 16.00 hours on the eve of the day of measurement of resting heat production.

Table 2. *Mean values for resting heat production in different ages and genetic groups of cattle within the zone of thermoneutrality*

	Age (months)	Hariana*	Jersey† × Hariana	Brown Swiss† × Hariana	Holstein Friesian† × Hariana
			(a) MJ/24 h		
	16–19	13·6	16·1	17·8	21·7
	21–24	16·2	19·7	22·3	25·2
	26–29	19·6	21·8	23·8	30·1
	31–34	20·0	24·2	27·7	32·6
	37–40	22·1	26·3	31·2	34·2
SED 1 = 1·56					
SED 2 = 2·18					
			(b) kJ/kg body-wt$^{0·75}$ per 24 h		
	16–19	258	283	315	324
	21–24	262	303	313	323
	26–29	270	297	316	329
	31–34	267	294	304	333
	37–40	273	299	329	339
SED 1 = 17					
SED 2 = 21					

SED 1, comparisons between ages for a given breed based on the interaction between ages and animals within genetic groups (48 df).
SED 2, comparisons between breeds at a given age based on a pool of the variation between animals within genetic groups (12 df) and the interaction between ages and animals within genetic groups (48 df).
* *Bos indicus.*
† *Bos taurus.*

Measurement of resting heat production

The animals were trained to wear face masks. Measurements of resting heat production by open-circuit indirect calorimetry (Brody, 1945) were made for the different groups of animals at 18 h post-feeding after they had been placed in a psychrometric chamber for 6 d at 18·5° with a fixed vapour pressure of 10–12 mmHg.

On day 6 of exposure, expired air was collected in a Douglas bag at 10.00 hours for 6 min. The samples of expired air from the Douglas bag were analysed, in duplicate, for oxygen and carbon dioxide using a Lloyd gas analyser (Lloyd, 1960). Total expired air

Table 3. *Mean values for metabolizable energy intake in different ages and genetic groups of cattle within the zone of thermoneutrality*

	Age (months)	Hariana*	Jersey† × Hariana	Brown Swiss† × Hariana	Holstein Friesian† × Hariana
			(a) MJ/24 h		
	16–19	48·6	53·0	54·5	57·9
	21–24	58·4	60·3	65·0	71·9
	26–29	63·2	66·5	70·2	85·5
	31–34	60·4	63·4	67·7	76·6
	37–40	63·6	68·1	72·9	76·3
SED 1 = 2·54					
SED 2 = 3·22					
			(b) kJ/kg body-wt$^{0.75}$ per 24 h		
	16–19	960	937	976	859
	21–24	956	928	913	921
	26–29	886	878	879	917
	31–34	800	790	791	779
	37–40	780	770	766	757
SED 1 = 39					
SED 2 = 48					

SED 1, comparisons between ages for a given breed based on the interaction between ages and animals within genetic groups (48 df).
SED 2, comparisons between breeds of a given age based on a pool of the variation between animals within genetic groups (12 df) and the interaction between ages within genetic groups (48 df).
* *Bos indicus*.
† *Bos taurus*.

collected in the Douglas bag was passed through a gas meter fitted with a thermometer to measure the volume and temperature of the air. From these measurements O_2 consumption, CO_2 production and respiratory quotient (RQ) were calculated.

The data for each variate was analysed as a whole using analysis of variance (Snedecor & Cochran, 1967). Fixed effect model was followed in analysis of data. Pooled standard error was used for all comparisons between genetic groups and between ages using Duncan's Multiple Range Test. Regression between resting heat production per day and body-weight were calculated for each genetic group and compared.

RESULTS

Resting heat production on a 24 h basis showed the expected increase with the increase in body-weight and age in all genetic groups. The absolute increase in resting heat production per 24 h from 16–19 months of age to 37–40 months of age was 8·5, 10·2, 13·4 and 12·5 MJ/24 h in Hariana, JH, BH and FH respectively. However, there was no significant change ($P > 0.05$) in the metabolic rate on a unit metabolic body-weight (kg body-weight $(W)^{0.75}$) basis from 16–19 to 37–40 months of age in any of the genetic groups (Table 2). The corresponding increase in body-weight was 166·3, 171·1, 220·3 and 196·5 kg in Hariana, JH, BH and FH respectively. The regression of daily resting heat production *v.* body-weight was significant ($P < 0.01$) in all genetic groups. This regression was, however, not significant ($P > 0.05$) between the genetic groups. At a body-weight of 328·5 kg (mean of all genetic groups) the resting heat production was 20·5, 22·8, 24·2 and 25·1 MJ/24 h in Hariana, JH, BH and FH respectively.

The resting heat production per kg $W^{0.75}$ (Table 2) in BH and FH was significantly ($P < 0.01$) higher than that in Hariana cattle. Among the crosses, resting heat production was highest in the FH cross and lowest in the JH cross.

ME intake expressed per 24 h was significantly different ($P < 0.01$) between the genetic groups. It was maximum in the FH (heaviest) group and minimum in the Hariana (lightest) group (Table 3). ME intake on a per kg $W^{0.75}$ basis, however, was not significantly ($P > 0.05$) different between the genetic groups (Table 3). ME intake per 24 h in general increased significantly ($P < 0.01$) with increase in age but ME intake per kg $W^{0.75}$ decreased with increase in age (Table 3).

DISCUSSION

The inherent difference in the metabolic rates of *Bos taurus* and *Bos indicus* and within breeds of *Bos taurus* is well known (Kibler & Brody, 1950; Johnston *et al.* 1958). The values for resting heat production in Hariana animals are in congruence with those reported by Mullick (1959*a*, *b*) from experiments conducted during the cool months of the year. The values for resting heat production in different F_1 crosses are apparently intermediate between those of European and Zebu cattle.

Vercoe (1970) reported significantly higher values for fasting metabolism in Africander and Shorthorn × Hereford cattle in comparison with those for Brahman cattle. Similarly, Frisch & Vercoe (1977) reported that the fasting metabolic rate per kg live weight was highest for Hereford × Shorthorn (HS) and lowest for Brahman × HS and intermediate for Africander × HS.

The observed differences in the resting heat production on a per kg $W^{0.75}$ basis between genetic groups cannot be attributed to variation in the ME intake since there was no significant difference in ME intake per kg $W^{0.75}$ between the genetic groups. The influence of previous dietary treatment, as observed by Frisch & Vercoe (1977), and level of feeding, as observed by Holmes & Davey (1976), was achieved by keeping the feed consumption constant in relation to metabolic body size during the whole period of study. The value for RQ was also not significantly different between the genetic groups.

Frisch & Vercoe (1977) concluded that the differences in the fasting metabolism were higher at low growth rates. The impetus of growth, as reflected in higher growth rates in F_1 crosses in comparison with the Hariana breed, seems to be one of the possible reasons for differences in resting heat production in different genetic groups (Webster *et al.* 1977). The existence of differences in resting heat production even in the mature animals at 37–40 months of age indicates the inherent difference in the basal metabolic rate in Hariana cattle and different F_1 crosses. The measured resting heat production on a per kg $W^{0.75}$ per 24 h basis in all the genetic groups was lower than the predicted basal metabolism reported by Webster *et al.* (1974), as the body-weight of our animals was about 200 kg at the start of the study.

The higher rate of heat production in F_1 crosses probably renders these animals more prone to heat load in comparison with indigenous Hariana. The lower heat production in Brahman × *Bos taurus* animals in comparison with *Bos taurus* cattle (Frisch & Vercoe, 1977), however, might allow these animals to endure the impact of heat more efficiently (Johnston *et al.* 1958; Holmes *et al.* 1980).

The authors wish to thank Dr C. M. Singh, formerly Director, Indian Veterinary Research Institute, Izatnagar, for providing the necessary facilities, and to Dr P. N. Bhat, formerly Project Coordinator, All India Coordinated Research Project on Cattle, for provision of the experimental animals and for constant encouragement.

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Printed in Great Britain