FASTING HEAT PRODUCTION OF SHEEP AT PASTURE BEFORE AND AFTER SHEARING

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Summary

Sheep kept at pasture were taken indoors for periods of up to four days for determination in respiration chambers of fasting heat production. Before shearing, values after a 64 h fast were similar to those after an 88 h fast and the general mean, with SD, was 58.7 ± 1.9 $kcal.kgw^{-0.75}.24h^{-1}$. Mean daily minimum and maximum temperatures over four months during and after shearing were 1.5 and 11.6°C. After shearing, fasting heat production increased; at chamber temperatures of 21 to 26°C return to pre-shearing values was not observed until day 135 and the maximum increase observed was 44 per cent on day 13. At about five weeks, the increase, as for measurements made at 30 to 33°C, was 21 to 23 per cent. It is suggested that sheep at pasture may have an increased energy requirement for maintenance for a considerable period after shearing.

I. INTRODUCTION

Increases after shearing have been observed in the heat production of fed sheep (Graham ***et al.*** 1959; Ewy and Kuhl 1961), in heart rate (Webster and Lynch 1966; Wodzicka-Tomaszewska and Walmsley 1966) and in feed intake in pens (Wodzicka-Tomaszewska 1963, 1964, 1966) and at pasture (Wheeler, Reardon and Lambourne 1963). There may be high mortality, especially among sheep declining in body condition (Hutchinson 1968; Hutchinson and McRae 1969), often involving impairment of adrenocortical function (Panaretto and Ferguson 1969) apparently due to climatic stress.

The object of the present experiment was to determine the extent to which the fasting heat production of sheep maintained at pasture was increased after shearing. An increase can be taken to indicate an increased energy requirement for maintenance.

II. EXPERIMENTAL

(a) ***Pasture and Environment***

The adult Merino sheep used grazed pastures of *Phalaris tuberosa/Trifolium repens* providing amounts of herbage that kept them in moderate to good body condition; rates of change in liveweight were generally small.

During the four months from the start of the experiment in June, mean daily minimum and maximum temperatures in a Stevenson screen were 1.5 and 11.6°C respectively. Actual minimum night temperatures were often several degrees below freezing.

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(b) *Animals*

Four ewes and three wethers kept at pasture were accustomed over a period of several months to handling, and to confinement in respiration chambers. When required for the determination of fasting heat production, they were taken from pasture and, to standardize experimental conditions, were held in a room at the controlled temperature of 20 ± 2°C for about ***48*** h before being placed in the chambers.

(c) *Respiration Chambers*

The three chambers used were made of fibreglass about 6 mm thick moulded on a rigid steel framework. Each was approximately 160 cm long, 81 cm wide and 155 cm high and of about 2000 1. capacity. All animals were in view of one another through plate glass windows set in the chamber walls. The temperature in one chamber, insulated with polystyrene foam, could be controlled to within ± 1 °C over the range of 0 to 40°C; the temperature in the other two chambers was that of the room which could be increased by electric heaters from the usual 20 ± 2°C to about 26°C. The integrated electrical output of eight copper-constantan thermo couples sited at various points in each chamber was used to measure dry bulb temperature; an additional thermocouple measured wet bulb temperature.

The initial charge of air in each chamber, about 2000 1., was circulated continuously at a rate of up to 120 1 $\cdot$min^{-1} through a calcium chloride drying train. The change in oxygen concentration was measured by paramagnetic analyser* and in carbon dioxide and methane by infra-red analyser.? Heat production was calculated from the changes in gas composition over 4 h periods using the equation of Brouwer (1965) but no account was taken of urinary nitrogen excretion. Each determination of the fasting heat production of a sheep normally comprised two such 4 h periods.

(d) *Length* of *Fast*

The heat production of the four ewes was measured before they were shorn, 64 and 88 h after removal from pasture, to determine whether the grazing sheep should be fasted for a longer time than housed sheep in order to obtain minimal measurements of heat production, that is fasting metabolic rate (FMR) (Blaxter 1962). The heat production of fasted newly shorn sheep may not represent FMR because the critical temperature (Graham *et al.* 1959) of such animals is not precisely known.

(e) *Plan* of *Experiment*

All measurements on the wethers were made in the two uninsulated chambers at ambient temperatures in the range 21 to 26°C. For ewes in the insulated chamber, temperatures were in the range 30 to 33°C.

The fasting heat production of two of the wethers was determined on three occasions before shearing in June; measurements were made at intervals after shearing until values returned to pre-shearing levels. A similar series of observations was made on the third wether but shearing was delayed for two months while it was used as an unshorn control.

The fasting heat production of two of the ewes was determined on three occasions before shearing, and on four occasions during the six weeks after shearing, at the times when measurements were made on the other two unshorn ewes.

*Beckman E_2 Oxygen analyser.
†Grubb Parsons 'Poly-Irga'.

TABLE 1

Effect of length of fast on the fasting heat production of unshorn Merino ewes taken from pasture

Sheep No.	Length of fast (h)	Live-* weight (kg)	Respiratory† quotient	CH_4 ($1 \cdot 24h^{-1}$)	Heat production‡ $kcal \cdot 24h^{-1}$	$kcal \cdot kgw^{-0.75} \cdot 24h^{-1}$
8A	64	38.5	0.68	1.04	897	58.0
	88	37.5	0.67	0.92	885	58.4
7A	64	40.5	0.69	1.30	901	56.1
	88	39.8	0.67	1.29	904	57.2
6A	64	44.0	0.72	1.56	985	57.6
	88	44.0	0.69	1.19	1018	59.5
5A	64	32.5	0.69	1.22	846	61.9
	88	32.0	0.68	0.97	826	60.7
Mean and standard Deviation		38.6 ± 4.6	0.69 ± 0.15	1.19 ± 0.21	908 ± 65	58.7 ± 1.9

*Excludes weight of fleece.
†Not corrected for urinary nitrogen excretion.
‡Each value the mean of two 4 h measurements.

III. RESULTS

The heat production of the unshorn ewes fasted for 64 and 88 h after removal from pasture is shown in Table 1; the results are expressed as $kcal \cdot kgW^{-0.75} \cdot 24h^{-1}$ to allow comparison with other estimates of FMR. Heat production did not change significantly between 64 and 88 h and all subsequent measurements were made after a 64 h fast.

Values obtained after shearing for fasting heat production per kg of liveweight (W) are expressed in Table 2 as the per cent increases above the corresponding pre-shearing values; W before shearing excluded wool weight, but included any fleece carried afterwards. The fasting heat production of the control wether and

TABLE 2

Increases after shearing in fasting heat production of Merino sheep taken from pasture expressed as percentage changes from values before shearing

	Mean chamber temperature (°C)	No. of Measurements	Days after shearing	Percent increase in heat production Mean	± S.D.
Wethers	26	5	1	22	8
	23	4	13	44	6
	22	3	24	32	4
	21	2	36	23	3
	22	4	49	22	8
	24	4	68	10	4
	24	6	92	12	5
	21	4	110	12	3
	24	4	135	0	4
	23	4	160	–4	7
Ewes	30	1	4	33	–
	33	4	9	26	3
	32	2	34	23	3
	33	3	40	21	3

*Each of 4 h duration, made 64 h after removal from pasture.

ewes did not vary significantly during the time that they remained unshorn (coefficients of variation 2.6 and 3.4 per cent respectively) even though one animal was handled as in shearing but without removal of the fleece.

Results for the wethers (Table 2) show that the maximum increase probably occurred later than the first day after shearing. At about the 35th day, the increases for wethers and ewes were similar though chamber temperatures differed by 11 °C.

IV. DISCUSSION

Feed intakes of housed sheep are usually standardized at about the maintenance level for at least seven days before determining FMR. With the grazing sheep, the conditions of fasting were standardized but grazing intake could not be closely controlled. However, gains or losses in liveweight during the experiment were generally small and the values in Table 1 are similar to the FMR of adult sheep of similar liveweight reported by Blaxter (1962), Blaxter, Clapperton and Wainman (1966), and Graham (1967).

No detailed report on the critical temperature of newly shorn and fasted sheep has been published. Blaxter (1962) indicated that 30°C was well above critical for such sheep; Graham (1964) indicated that 35 °C was thermoneutral for Merinos with about 2 mm wool, in "store to emaciated" condition and fasted for up to four days. It appears from observations on sheep not acclimated to temperatures below 15°C reported by Armstrong *et al.* (1960) that for our wethers the chamber temperatures were thermoneutral when their fleece had grown to a length of 15 to 20 mm, but the increased thermogenesis persisted for many weeks. At five weeks it was still about 23 per cent for the ewes, measured at 32°C, as well as for the wethers although fleece lengths were then more than 15 mm, and it is unlikely that chamber temperatures were below critical throughout the experiment.

All the sheep were observed at hourly intervals while in the chambers and none was seen to be shivering at any time. Although they were held in a room at higher than outdoor temperature for periods of about two days before entering the chambers, observations made by Sykes and Slee (1969) indicate that more than two days in a thermoneutral environment are required before effects of cold exposure are dispelled. Consequently, it appears that the increased thermogenesis stemmed from a metabolic adjustment to prolonged exposure to low ambient temperatures in the field. This conclusion is supported by observations of Webster, Hicks and Hays (1969) on metabolic responses by sheep during acclimatization to cold; a persistent elevation in resting heat production was induced, and critical temperature fell. In addition, the maximum observed increase in heat production by our wethers was on the 13th, not 1 st, day after shearing. It is unlikely that this was because chamber temperature was 3°C lower on day 13, for fleece length was then about 10 mm, providing greater insulation than the 3 to 5 mm on day 1. The apparently delayed response is consistent with the observations of Wodzicka-Tomaszewska (1963, 1964, 1966) that the maximum increase in feed intake occurred 10 to 15 days after shearing; maximum heart rates were observed 8 to 15 days after shearing by Webster and Lynch (1966) and Wodzicka-Tomaszewska and Walmsley (1966). Schwabe, Emery and Griffith (1938) found for the rate that exposure to temperatures of 7 to 12°C for 16 h daily for periods of up to 60 days increased basal metabolic rate, measured at 29°C (thermoneutrality), by 11 to 16 per cent above the mean for control animals not cold acclimated; values did not reach a maximum until between the 15th and 30th day and were sustained for at least 60 days.

Although Peirce (1934) found that the "standard metabolism" (48 h fast) of sheep 20 days after shearing was similar to the pre-shearing values, it is possible that high ambient temperatures prevailed from the time of shearing (October, South Australia) so that a thermogenic response was not initiated. After sheep in good condition were shorn in January (mean minimum 11°C) at Armidale (Farrell, unpublished data) an increase of 20 per cent in fasting heat production above the pre-shearing values did not persist for more than seven weeks although sheep in poor body condition showed a similar increase in heat production for a considerably longer period.

The results of this experiment indicate that newly shorn sheep at pasture may have a higher energy requirement for maintenance than before shearing and that this persists for a considerable time.

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VI. REFERENCES

ARMSTRONG, D. G., BLAXTER, K. L., CLAPPERTON, J. L., GRAHAM, N. McC., and WAINMAN, F. W. (1960). *J. agric. Sci., Camb.* 55: 395.

BLAXTER, K. L. (1962). *Br. J. Nutr.* 61: 615.

BLAXTER, K. L., CLAPPERTON, J. L., and WAINMAN, F. W. (1966). *Br. J. Nutr. 20:* 103.

BROUWER, E. (1965). In: "Energy Metabolism." (Ed. K. L. Blaxter.) p. 441. (Academic Press: London).

EWY, Z., and KUHL, W. (1961). *Acta physiol. Pol.* 12: 731.

GRAHAM. N. McC. (1964). *Aust. J. agric. Res.* 15: 113.

GRAHAM, N. McC. (1967). *Aust. J. agric. Res.* 18: 127.

GRAHAM, N. McC., WAINMAN, F. W., BLAXTER, K. L., and ARMSTRONG, D. G. (1959). *J. agric. Sci., Camb. 52:* 13.

HUTCHINSON, J. C. D. *(1.968). Aust. J. exp. Agric. Anim. Husb. 8: 393.*

HUTCHINSON, K. J., and McRAE, B. H. (1969). *Aust. J. agric. Res. 20:* 513.

PANARETTO, B. A., and FERGUSON, K. A. (1969). *Aust. J. agric. Res. 20: 99.*

PEIRCE, A. W. (1934). *Bull. Coun. scient. ind. Res., Melb. No.* 84.

SCHWABE, E. L., EMERY, F. E., and GRIFFITH, F. R. (1938). *J. Nutr. 15: 199.*

SYKES, A. R., and SLEE, J. (1969). *Anim. Prod.* 11: 77.

WEBSTER, A. J. F., HICKS, A. M., and HAYS, F. L. (1969). *Can. J. Physiol. Pharmac. 47: 553.*

WEBSTER, M. E. D., and LYNCH, J. J. (1966). *Proc. Aust. Soc. Anim. Prod. 6: 234.*

WHEELER, J. L., REARDON, T. F., and LAMBOURNE, L. J. (1963). *Aust. J. agric. Res. 14: 364.*

WODZICKA-TOMASZEWSKA M. (1963). N.Z. *Jl agric. Res. 6: 44.*

WODZICKA-TOMASZEWSKA M. (1964). *N.Z. Jl agric. Res. 7: 654.*

WODZICKA-TOMASZEWSKA M. (1966). *N.Z. Jl agric. Res. 9: 909.*

WODZICKA-TOMASZEWSKA M., and WALMSLEY, R. R. (1966). N.Z. *J. agric. Res. 9: 455.*