collection of rumen gas from intact animals has distinct advantages over the collection of gas from artificial rumens because gas production occurs under normal conditions and hence few assumptions are required and many possible errors are eliminated. Though the heritability of rumen gas composition was not determined, the animals differed significantly ($P = 0.01$) and gas composition rankings did not change when groups of animals were sampled at widely spaced intervals⁹. The large inherent errors in determining the efficiency of feed utilization^{5,6} and factors other than digestion which play an important part in the physiology of feed utilization undoubtedly reduced the correlations.

Rumen gas analyses could be used to replace traditional feed efficiency tests on breeding animals if a higher correlation could be obtained. This would permit screening of much larger populations than is feasible with the present expensive and inaccurate method. Because rumen gas can be readily collected from intact animals, and because it can be conveniently stored and inexpensively analysed with precision, it is anticipated that this measurement will be useful in conjunction with studies concerning the efficiency of feed utilization and the causes of differences between animals.

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Energy Expenditure of Grazing Sheep

THE results of several field experiments¹ have indicated that the energy expenditure of sheep at pasture in equable climates is 1.1–2.0 times larger than that of stall-fed animals. The distances travelled by grazing sheep and the energy cost of locomotion have been measured², and it appears that walking would increase the daily energy expenditure by 5–10 per cent. This leaves the energy cost of grazing *per se* and of the animal's reactions to its environment to be accounted for; the first measurements of the former can now be reported.

Two sheep were allowed to graze normally for a week. A patch of turf 1.0 × 1.5 m was then dug up and relaid on the floor of a respiration chamber. The sheep, which had both been trained for such work, were then, one at a time, placed in the respiration chamber (ambient temperature 22°C; water vapour pressure 10–15 mm mercury; still air) and their respiratory exchange measured by the confinement method³ during five successive 30-min periods. The sheep were restrained from grazing during the first

and third periods, usually rested voluntarily during the fifth period, and grazed during the second and fourth periods. Thus any changes of the metabolism due to time of day or to metabolism of ingested food would not affect the measurement at issue. Afterwards, the grass on a 1.0 × 1.5 m patch was cut and given to the sheep in the chamber over the course of an hour.

Five different types of pasture have been used. These ranged from one containing dry mature grass (*Paspalum dilatatum*) with a few small green clover plants (*Trifolium repens*), which was grazed slowly with an intake (estimated by clipping) of about 40 g dry matter per hour while in the respiration chamber, to one containing lush young grass (*Poa annua*), which was grazed avidly with an estimated intake of 130 g dry matter per hour.

The 'resting' metabolism of the sheep was not dependent on whether they were restrained or rested voluntarily, nor on the level of carbon dioxide in the apparatus (never more than 3 per cent). The energy cost of grazing was calculated⁴ from the mean increments of carbon dioxide production and of oxygen consumption between the 'resting' and grazing periods; methane production and nitrogen catabolism, which together contribute less than 2 per cent to the calculation of heat production, were ignored.

The energy expenditure of the sheep always increased during grazing and fell again during the subsequent rest period, but there was no significant change when the pre-cut grass was given to the sheep. The grazing increment did not vary significantly from sward to sward, and had a mean value of 0.62 ± 0.04 kcal/h/kg body-weight for a 29-kg Merino ewe and of 0.84 ± 0.12 for a 53-kg Merino wether. When considering the daily expenditure of a sheep at pasture these values must be reduced to allow for the fact that only one-third of the day is spent in grazing⁵. They then amount to 12 and 18 per cent of the heat produced by the small and large animal, respectively, when hand fed.

These experiments are being continued with other sheep and pastures, but it may be concluded tentatively that the energy expended by a sheep in walking and grazing is not likely to be more than one-quarter of its heat production when stall-fed. This expenditure would not wholly account for the apparent additional energy requirements of grazing sheep¹ mentioned here.

Laboratory experiments⁶ have shown that the metabolism of sheep can be increased two-fold when they are placed in an environment to which they are not accustomed. It remains to be determined whether climatic factors or the social environment can stimulate the metabolism of grazing sheep similarly and so increase their energy requirements substantially.

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