Nitrogen balance studies with the milk-fed lamb

7*. Effect of age of the lamb

By B. W. NORTON† and D. M. WALKER

Department of Animal Husbandry, University of Sydney, Sydney, NSW 2006, Australia

(*Received* 20 *January* 1970—*Accepted* 19 *November* 1970)

1. Eighteen male cross-bred lambs, aged between 2 and 5 d, were allotted to two equal groups and given artificial milk diets of either low protein (diet A) or high protein (diet B) content for an experimental period of 6 weeks. Live-weight gain, diet digestibility, wool growth and the utilization of nitrogen and sulphur were measured.

2. There was a significant decrease with age in wool growth and in the apparent digestibility of dry matter, energy and N by lambs given diet A. There was no significant effect of age on the apparent digestibility of the nutrients in diet B. Live-weight gain and N balance were unaffected by age when expressed in relation to metabolic body size ($kg^{0.73}$).

The purpose of this experiment was to determine whether the pre-ruminant lamb utilizes the nutrients in its diet with constant efficiency during the first 6 weeks of life. In the normal lamb suckling the ewe, this is a period of active biochemical and physiological change as the lamb begins to eat solid food and the rumen develops (cf. Huber, 1969). In previous experiments with the pre-ruminant lamb (Walker & Cook, 1967; Walker & Faichney, 1964*b*), it has been assumed that the digestion, absorption and utilization of a given diet remain constant for 6 weeks or even longer, and that any apparent differences are due to the difficulties of equating animals of different body-weights and rapidly changing body composition (cf. Walker, Cook & Jagusch, 1967).

EXPERIMENTAL

Animals and their management

Eighteen male cross-bred lambs, (Border Leicester ♂ × Merino ♀) × Dorset Horn ♂, were used. The lambs were born at pasture and were taken from the ewe at between 2 and 5 d of age. The housing and management of the lambs, and the collection and storage of urine and faeces, were as described by Walker & Faichney (1964*a*). The mean daily maximum and minimum temperatures in the animal house during the experimental period were 24 and 12° respectively.

Experimental design

Two dietary treatments were used. The experimental period of 6 weeks was divided into six 7 d periods (periods 1–6). Two groups of nine lambs were given either a low-protein (A) or a high-protein (B) diet, and groups of three lambs were slaughtered

* Paper no. 6: *Br. J. Nutr.* (1967), **21**, 289.

† Present address: Department of Biochemistry and Nutrition, University of New England, Armidale, NSW 2351, Australia.

after 2, 4 or 6 weeks. Nitrogen balances of each lamb were determined at weekly intervals. Wool was collected from tattooed areas on each lamb following a preliminary feeding period of 1 week (Walker & Cook, 1967). The wool present on the patch at the end of the 1st week was discarded. Wool was collected from growth over periods of 1 (period 2), 3 (periods 2–4) and 5 (periods 2–6) weeks duration. It was assumed that the growth of wool in any one week reflected the nutrient intake in the preceding week. Sulphur balances were determined over periods of 1 (period 1), 3 (periods 1–3) and 5 (periods 1–5) weeks duration, corresponding to the wool-growth periods. Tissue S was calculated as the difference between S balance and wool S. The significance of the effect of age on the performance of the lambs was determined by an analysis of variance.

Diets

The compositions of the experimental diets are given in Table 1. The methods of preparation were as described previously (Walker & Cook, 1967). Supplements of vitamins and minerals were added to diet A so that the final composition was similar to that of ewe's milk (Walker & Faichney, 1964*a*). All lambs were bottle-fed twice daily at 07.00 and 18.00 hours after the diets had been warmed to about 37° by immersion in a constant-temperature bath. Lambs were given sufficient milk to provide 210 kcal (879 kJ) gross energy/$kg^{0.73}$ per d. The milk intake was adjusted every 2 d to allow for an increase in live weight, but was maintained constant when a loss of live weight occurred.

Table 1. *Constituents and composition of the diets (values expressed per 100 g dry matter); as fed to the lambs, each diet contained 15 % dry matter**

Constituent	Diet A†	Diet B‡
Dried whole milk (g)	21·3	100·0
Glucose (g)	23·8	—
Butter oil (g)	50·7	—
Minerals (g)	4·2	—
Crude protein§ (g)	6·1	28·5
Ether extractives (g)	56·6	27·6
Ash (g)	5·5	5·9
Nitrogen-free extractives (by difference) (g)	31·8	38·0
Sulphur (mg)	57	269
Energy (kcal)	675	556
Protein calories as % of total calories	5·0	28·7

* All lambs were dosed with 100000 i.u. retinyl acetate and 10000 i.u. ergocalciferol at 7 and 35 d of age, and were given daily, dissolved in the milk, 0·45 g Aureomycin soluble (Cyanamid of Great Britain Ltd), which contained 25 mg chlortetracycline hydrochloride.

† Vitamin and mineral supplements added (see above).

‡ Trace-element supplement containing $FeSO_4$, $CuSO_4$ and $CoCl_2$ was added to diet B to increase the concentration of these metals in the dry matter by 50 ppm Fe, 5 ppm Cu and 0·1 ppm Co.

§ Nitrogen × 6·38.

Table 2. *Mean values with their standard errors for the live weight, gross energy intake, nitrogen balance, live-weight gain and digestibility coefficients for three lambs per group given a low-protein (A) or a high-protein (B) diet for 6 weeks*

Diet	Period no.	Live wt (kg)	Energy intake (kcal/ $kg^{0.73}$ d)	N intake (g/week)	Faecal N (g/week)	N balance		ADN† retained (%)	Live-wt gain (g/ $kg^{0.73}$ d)	Apparent digestibility coefficient (%)			
						g/ week	g/ $kg^{0.73}$ d			Dry matter	Energy	Total N	Total S
A	1	4·07	215	7·1	1·3	0·2	0·01	7·4	14	93·8	93·8	82·1	—
	2	4·13	207	5·7	0·9	1·0	0·05	20·9	2	93·3	93·8	83·8	64·4
	3	4·26	207	5·9	0·9	1·5	0·07	30·1	7	93·5	93·0	84·2	—
	4	4·47	207	6·1	1·5	1·0	0·05	22·4	10	90·6	87·7	75·2	70·3
	5	4·68	207	6·3	1·4	1·1	0·05	22·2	13	90·7	87·8	74·2	—
	6	4·90	208	6·5	1·8	0·9	0·04	18·0	6	82·9	79·6	72·6	58·4
SE of period mean		0·02	0·3	0·04	0·14	0·3	0·01	4·6	2·3	1·6	1·7	2·3	6·7
Significance of effect of period		NS	*	NS	*	NS	*	*	*	*	*	*	NS
B	1	4·81	211	37·3	1·5	21·8	0·99	60·9	43	98·0	97·9	96·0	—
	2	5·57	205	40·1	1·1	27·8	1·14	71·4	34	98·7	98·7	97·2	87·0
	3	6·49	204	44·8	1·3	30·3	1·11	69·7	36	98·4	98·5	97·2	—
	4	7·61	205	50·4	1·4	32·5	1·06	66·6	41	98·3	98·6	97·2	86·8
	5	8·79	205	56·3	2·0	34·1	1·00	63·0	36	97·6	98·0	96·3	—
	6	10·10	206	62·3	2·5	35·8	0·95	59·9	35	97·1	97·6	95·9	92·4
SE of period mean		0·12	0·2	0·33	0·35	0·6	0·03	1·9	2·5	0·3	0·3	0·7	3·6
Significance of effect of:													
Period		*	*	*	*	*	*	*	*	NS	NS	NS	NS
Diet		*	*	*	NS	*	*	*	*	*	*	*	*
Diet × period		*	NS	*	NS	*	NS	NS	NS	*	*	*	NS

NS, not significant. * $P < 0.05$. † Apparently digested N.

Table 3. *Mean values with their standard errors for wool growth, and for retention of nitrogen and sulphur in the wool and tissues of three lambs per group given a low-protein (A) or a high-protein (B) diet*

Diet	Wool collection period (weeks)	Wool growth mg/cm² week	Wool growth g/week	N in clean wool (%)	S in clean wool (%)	ADN† intake (g/week)	Wool N‡ (g/week)	Tissue N‡ (g/week)	ADS§ intake (g/week)	Wool S‡ (g/week)	Tissue S‡ (g/week)	Wool N (% of ADN)	Wool S (% of ADS)	N retained in wool (% of N balance)	S retained in wool (% of S balance)
A	1–2	3·5	9·5	16·33	2·83	6·8	1·5	−2·0	0·35	0·27	−0·13	22·6	84·5	> 100	> 100
	1–4	2·4	5·9	16·18	3·02	5·2	0·9	0·2	0·27	0·16	−0·01	18·0	60·9	83·9	> 100
	1–6	2·1	5·4	16·28	2·69	5·0	0·9	0·1	0·23	0·15	−0·01	17·3	63·6	90·3	> 100
SE of period mean		0·2	0·7	0·07	0·22	0·6	0·1	0·5	0·05	0·02	0·04	1·8	15·4	—	—
Significance of effect of period		*	*	NS	NS	*	*	*	NS	*	NS	NS	NS	—	—
B	1–2	10·2	33·9	16·32	2·75	38·0	5·4	18·5	2·15	0·90	0·88	13·8	41·6	22·4	50·2
	1–4	10·7	31·7	16·41	2·80	42·0	5·1	17·9	2·32	0·86	1·22	12·1	37·2	22·1	41·8
	1–6	9·7	30·5	16·35	2·65	44·3	4·9	24·4	2·60	0·81	1·44	10·9	30·9	16·5	35·6
SE of period mean		1·0	5·4	0·09	0·13	3·5	0·9	1·1	0·22	0·01	0·05	1·0	2·1	1·7	2·6
Significance of effect of:															
Period		NS	NS	NS	NS	NS	NS	*	*	NS	*	NS	*	NS	*
Diet		*	*	NS	NS	*	*	*	*	*	*	*	*	—	—
Diet × period		NS	NS	NS	NS	NS	NS	*	NS	NS	*	NS	NS	—	—

NS, not significant. * $P < 0.05$. † Apparently digested N. ‡ See p. 2. § Apparently digested S.

Analytical methods

Total N, fat, ash, dry matter and energy in the dietary constituents and faeces, and N in the urine, were determined by the methods of Walker & Faichney (1964*a*). Total S in the dietary constituents, faeces and urine was determined by the methods of Walker (1967). The N and S contents of clean wool were determined by the methods of Walker & Cook (1967). Dirt and suint were removed by the method of Reis & Schinckel (1961).

Wool growth was estimated on tattooed areas on the shoulder of each lamb. The area of patch was measured at the beginning and end of the collection periods. Tracings of the patch area were made on polyethylene film, then cut out and weighed, and the weights were compared with that of a known area of polyethylene film. Total wool growth was estimated by the method of Ferguson, Carter & Hardy (1949).

RESULTS AND DISCUSSION

Digestibility, live-weight gain and N balance

The results for this experiment are summarized in Tables 2 and 3. An analysis of variance showed that there was a significant decrease with age in the apparent digestibility of dry matter, energy and N by lambs given diet A. This diet provided sufficient N to balance the endogenous urinary N losses (Walker & Faichney, 1964*a*), but insufficient to permit appreciable growth. It seems likely that the low intake of N was limiting the production of certain digestive enzymes (Waterlow, Cravioto & Stephen, 1960), so that the digestibility of the dietary constituents was reduced. Since the digestibility of diet B was unaffected by the age of the lamb, it seems likely that this diet provided adequate amounts of N for growth and for normal metabolic functions. When live-weight gain and N balance were expressed in relation to metabolic body size ($kg^{0.73}$), the period effects were significant, but there were no significant linear trends with age with either dietary treatment.

Wool growth

Values are given in Table 3 for the wool growth and for the N and S retentions in the wool and wool-free tissues during the corresponding collection periods. There was a significant decrease with age in the growth rate of wool (mg/cm^2 week or g/week) by lambs given diet A, but not by lambs given diet B. The reduction in wool growth in lambs given diet A was a reflection of the very limited amounts of N and S available to these lambs so that, as the period of protein depletion continued, the initial rate of wool growth could not be maintained.

It seems clear from the results of this experiment that, between birth and 6 weeks, the age of the lamb has only a minor effect on the utilization of a diet of medium to high protein content; on the other hand, a diet of low protein content adversely affects the metabolism of the lamb and performance is reduced.

REFERENCES

Ferguson, K. A., Carter, H. B. & Hardy, M. H. (1949). *Aust. J. scient. Res.* **B2**, 42.
Huber, J. T. (1969). *J. Dairy Sci.* **52**, 1303.
Reis, P. J. & Schinckel, P. G. (1961). *Aust. J. agric. Res.* **12**, 335.
Walker, D. M. (1967). *Br. J. Nutr.* **21**, 289.
Walker, D. M. & Cook, L. J. (1967). *Br. J. Nutr.* **21**, 237.
Walker, D. M., Cook, L. J. & Jagusch, K. T. (1967). *Br. J. Nutr.* **21**, 275.
Walker, D. M. & Faichney, G. J. (1964*a*). *Br. J. Nutr.* **18**, 187.
Walker, D. M. & Faichney, G. J. (1964*b*). *Br. J. Nutr.* **18**, 295.
Waterlow, J. C., Cravioto, J. & Stephen, J. M. L. (1960). *Adv. Protein Chem.* **15**, 131.

Printed in Great Britain