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# PROCEEDINGS OF THE NUTRITION SOCIETY

## ABSTRACTS OF COMMUNICATIONS

*The Four Hundred and Fourth Meeting of the Nutrition Society (One Hundred and Fifty-eighth of the Scottish Group) was held in the Cowan House, Pollock Halls, Holyrood Park Road, Edinburgh on Tuesday and Wednesday,* 25/26 *September* 1984, *when the following papers were read:*

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**Intake and digestibility of foods by Ayrshire cattle and Asiatic buffaloes maintained at moderate and high temperatures.** By R. P. BABER* and J. C. MATHERS†, *Centre for Tropical Veterinary Medicine, University of Edinburgh, Easter Bush, Roslin, Midlothian EH25 9RG*

The domesticated water buffalo (*Bubalus bubalis*) is an important multi-purpose animal especially in the Indian subcontinent and Southeast Asia. The present experiment is part of a continuing research project on the nutrition of the swamp buffalo which is used primarily for draught.

Four adult Ayrshire cattle and four adult swamp buffaloes were housed in climate chambers at approximately 20 and 33° (relative humidity 68–96%) and given *ad lib.* access to two pelleted diets: (1) a medium quality complete nutrient diet (AA6; Wainman *et al.* 1975) and (2) commercially-prepared alkali-treated straw pellets supplemented with urea, sodium sulphate, minerals and vitamins (ATS). All animals received all treatments in periods lasting 20 d with measurements made during the last 7 d.

| | Cattle | | | | Buffaloes | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Diet . . . | AA6 | | ATS | | AA6 | | ATS | | |
| Temperature (°) . . . | 20 | 33 | 20 | 33 | 20 | 33 | 20 | 33 | SE of mean |
| Respiration rate (breaths/min) | 40 | 85 | 30 | 71 | 17 | 32 | 18 | 22 | 2·9 |
| DM intake (g/kg body-weight$^{0.75}$ per d) | 145 | 113 | 127 | 122 | 84 | 83 | 108 | 99 | 7·0 |
| Apparent digestibility: | | | | | | | | | |
| DM | 0·69 | 0·67 | 0·54 | 0·57 | 0·66 | 0·72 | 0·60 | 0·64 | 0·024 |
| NDF | 0·53 | 0·52 | 0·59 | 0·61 | 0·50 | 0·59 | 0·62 | 0·68 | 0·032 |

The cattle ate significantly ($P<0·01$) more than the buffaloes. The large increases in the cattle's respiration rates at 33° indicated that they were more severely heat stressed than the buffaloes, probably because their greater food intake promoted greater metabolic heat production. At both temperatures, the buffaloes responded to the poorer diet (ATS) by eating significantly ($P<0·05$) more, whilst diet had no significant effect on food intake of cattle when averaged over both temperatures. Differences in digestibility of dry matter (DM) and neutral-detergent fibre (NDF) between species and between environmental temperatures were not significant although for the buffaloes digestibilities tended to be higher at the higher temperature. It will be important to compare the responses of the species to poorer quality diets more typical of those used in southern Asia.

Wainman, F. W., Smith, J. C. & Dewey, P. J. S. (1975). *Journal of Agricultural Science, Cambridge* **84**, 109–111.

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**The effects of casein supplements given by abomasal infusion on the nitrogen and energy metabolism of lactating cows.** By F. G. WHITELAW, J. S. MILNE, E. R. ØRSKOV and J. S. SMITH, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

The ability of lactating cows to increase milk and protein yield in response to post-ruminal infusion of casein appears to be enhanced in early lactation when cows are in negative energy balance (Clark, 1975; Ørskov *et al.* 1977) but little information is available regarding the separate components of nitrogen and energy metabolism which contribute to this effect.

Four mature Ayrshire cows were given abomasal infusions of either water alone or solutions containing 200, 400 or 600 g lactic casein/d, according to a Latin-square design. The basal diet contained 21·8 g N/kg dry matter and was restricted to a level which provided energy for maintenance + 10 kg milk/d. Treatments were started 20 d post-partum and measurements of digestibility and N-balance were made over 6 d and of respiratory exchanges over 5 d in each 14-d period. Blood samples were taken over 24 h on the last day. The effects on milk yields and on N and energy balance are shown in the table.

| Casein infused (g/d) | Milk yield (kg/d) | N (g/d) | | | | | Energy (MJ/d) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Intake | Faeces | Urine | Milk | Retained | Metabolized | Milk | Heat | Retained |
| 0 | 12·97 | 203 | 71·8 | 90·7 | 60·8 | −20·3 | 98·0 | 45·1 | 59·2 | −6·3 |
| 200 | 15·32 | 230 | 73·2 | 97·4 | 73·5 | −14·3 | 101·9 | 52·9 | 61·8 | −12·8 |
| 400 | 16·50 | 255 | 74·7 | 100·3 | 80·7 | ·1·0 | 110·3 | 56·6 | 65·2 | −11·4 |
| 600 | 17·18 | 285 | 75·7 | 117·2 | 85·6 | 6·8 | 112·7 | 56·2 | 64·4 | −7·9 |
| SE of differences | 0·76 | 6·60 | 1·56 | 6·71 | 3·80 | 7·28 | 3·40 | 2·97 | 1·44 | 5·20 |
| Significance: *P* | <0·01 | — | NS | <0·05 | <0·01 | <0·05 | <0·025 | <0·05 | <0·025 | NS |

NS, not significant.

Casein infusions increased milk yield ($P<0·01$), fat-corrected milk yield (FCM; $P<0·05$), milk protein yield ($P<0·01$) and milk energy yield ($P<0·05$) but both FCM and milk energy showed maximum response at 400 g casein/d. There were no significant differences between treatments in the losses of energy in faeces, urine or methane but energy retention tended to decrease in response to casein infusions. The evidence suggests that the primary response to casein is the correction of an amino-acid(s) deficit and that mobilization of body fat is secondary and occurs in response to the high ratio of protein:energy in the infused casein (6·7 g N/MJ). This effect persists until N equilibrium is achieved above 400 g casein/d, after which tissue N deposition appears to be favoured at the expense of further milk energy secretion. Increases ($P<0·05$) in plasma urea and insulin at the highest level of casein support this interpretation. There was no evidence that the efficiency of utilization of either N or energy was influenced by the addition of casein.

Clark, J. H. (1975). *Journal of Dairy Science* **58**, 1178–1197.
Ørskov, E. R., Grubb, D. A. & Kay, R. N. B. (1977). *British Journal of Nutrition* **38**, 397–405.

**The effect of ruminal infusions of propionic acid or abomasal infusion of glucose on plasma insulin secretion in non-lactating cows.** By L. ISTASSE, E. D. GOODALL and E. R. ØRSKOV, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

Glucose and propionic acid are potent stimuli of insulin secretion in ruminants. The mode of action is not fully understood. There are various published works in which intravenous infusions of glucose or propionic acid have produced a rise in plasma insulin concentration. When using a more physiological route however, such as intraruminal infusion of volatile fatty acids, most workers, with the exception of de Jong (1982), were unsuccessful in reproducing the effects observed using the intravenous route.

Three non-lactating cows were nourished entirely by intragastric infusion according to the technique of MacLeod *et al.* (1982). Propionic acid or glucose (10·4 MJ), corresponding to 68% of the total daily amount of propionic acid, was infused in two pulses each of 3 h duration. Blood was withdrawn from the jugular vein during the last 2 d of each period.

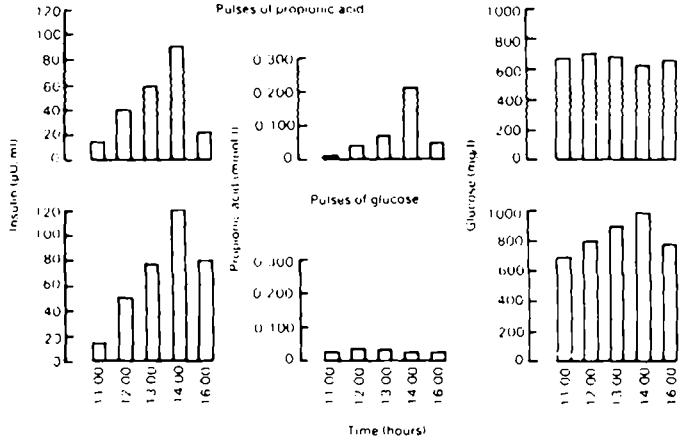



Fig. 1. Blood plasma concentrations of insulin, glucose and propionic acid during and 2 h after pulses of propionic acid or glucose. The pulses started at 11.00 hours and ended at 14.00 hours.

The effects of the pulse infusions on plasma insulin, glucose and propionic acid concentrations are given in Fig. 1. The differences observed between the concentrations of glucose and propionic acid in the plasma suggest that two different mechanisms were involved. The increasing concentration of plasma propionic acid observed during the pulses was postulated to have been caused by an excess of propionic acid passing from the rumen to the liver. A proportion may have escaped metabolism in the liver, entered the peripheral blood and would appear to have stimulated the pancreas to produce insulin. Glucose did not appear to be involved since the levels of plasma glucose did not change to any large extent. By contrast, the response in insulin to pulses of glucose may possibly be attributed to a direct effect of glucose on the pancreas with an associated increase in insulin. The increasing concentrations in glucose or propionic acid observed during the pulses were associated with the time involved for equilibration of pools.

de Jong, A. (1982). *Journal of Endocrinology* **92**, 357–370.
MacLeod, N. A., Corrigall, W., Stirton, R. A. & Ørskov, E. R. (1982). *British Journal of Nutrition* **47**, 547–552.

**The effect of supplements of fish meal and organic acids on silage intake by young cattle.** By M. GILL and P. ENGLAND, *Grassland Research Institute, Hurley, Maidenhead, Berks SL6 5LR*

McLeod *et al.* (1970) reported negative correlations between acid content of silage and dry matter (DM) intake, while Thomas *et al.* (1980) observed that the decrease in intake when lactic acid was added to silage was not apparent when fish meal was given as a supplement with the silage.

The present study was designed to measure the effect on silage intake of adding acetic and propionic acids (50 g acid/kg silage DM) to silage alone (U), or mixed with fish meal at 50 (F1) or 100 (F2) g/kg silage DM. The silage was prepared from primary growth Italian ryegrass and was offered *ad lib.* to sixty-three 4-month-old Friesian steers. Voluntary intake was measured daily over 30 d and live weight (LW) determined weekly. Total intakes are also presented as g DM/kg LW. Digestibility was measured over 10 d for treatments U, UF1 and UF2.

Table 1. *Daily DM intake of silage and supplements*

| Level of fish meal (g/kg silage DM) | Silage | | Silage + acetic acid | | Silage + propionic acid | |
|---|---|---|---|---|---|---|
| | kg | g/kg LW | kg | g/kg LW | kg | g/kg LW |
| 0 | 2·64[a] | 21·48[a] | 2·73 | 22·11 | 2·73 | 22·20 |
| 50 | 2·72[ab] | 23·27[b] | 3·02 | 23·68 | 2·62 | 21·53 |
| 100 | 2·99[b] | 24·13[b] | 2·83 | 22·91 | 2·75 | 22·47 |
| SE | 0·100 | 0·567 | 0·145 | 0·783 | 0·092 | 0·469 |
| df | 18 | 18 | 18 | 18 | 18 | 18 |

[a,b]Values in the same column with different superscript letters are significantly different ($P<0·05$).

The silage had a pH of 3·8 and a DM content of 237 g/kg. Lactic acid, acetic acid and total-nitrogen constituted 157·7, 19·1 and 18·9 g/kg DM respectively. Organic matter digestibility of the silage alone was 0·647 and this was increased to 0·663 for UF1 and 0·672 for UF2. N digestibility was 0·522 for silage alone, 0·571 for UF1 and 0·623 for UF2.

Voluntary intake was not significantly affected by the addition of acetic or propionic acids to the silage. However, intake was increased by addition of fish meal to silage alone. Fish meal had no significant effect when either acetic or propionic acids were added to the silage.

McLeod, D. S., Wilkins, R. J. & Raymond, W. F. (1970). *Journal of Agricultural Science, Cambridge* **75**, 311–319.
Thomas, C., Gill, M. & Austin, A. R. (1980). *Grass and Forage Science* **35**, 275–279.

**Voluntary food intake and growth responses in store lambs given protein supplements to grass silage.** By SUSAN M. MARCHMENT and E. L. MILLER, *Department of Applied Biology, University of Cambridge, Pembroke Street, Cambridge CB2 3DX*

Protein supplementation of silage-based diets has lead to increases in voluntary food intake (VFI) and live-weight gain (LWG) in cattle, which would not be predicted from Agricultural Research Council (1980) energy or protein systems.

The objective of the present study was to measure VFI and LWG responses in thirty-six lambs of Suffolk × Mule breeding (mean initial live weight 29·6 (SD 3·71)) to protein supplementation of a grass silage-based diet. Grass silage (composition: modified acid-detergent fibre (MADF) 315·4 g/kg dry matter (DM), crude protein (N × 6·25; CP) 156·6 g/kg DM, toluene DM 219·3 g/kg; pH 3·98) was offered *ad lib.* with one of six pelleted supplements given twice daily. Supplements supplied 150 (L) or 300 (H) g barley DM/d, with either 0 or 66 g CP provided by rapeseed meal (RM) or selected fish meal (FM), together with urea, minerals and vitamins.

Digestibility of MADF of the silage alone or with the same amount of supplement used in the feeding trial was determined using seven mature wethers in a balanced incomplete block design.

FM tended to increase, while RM tended to decrease silage DM intake such that silage DM intake differed significantly ($P<0.05$) between the two supplements. A similar pattern was observed for MADF digestibility, the difference between RM and FM being significant ($P<0.01$). The contribution of indigestible fibre from RM may account for the lower MADF digestibility of the RM-supplemented diets. Increasing barley increased growth rate ($P<0.001$) and decreased MADF digestibility ($P<0.05$) without effecting silage DM intake. Protein supplements increased growth rate ($P<0.01$).

| Supplement . . . | None | L | L + RM | L + FM | H | H + RM | H + FM | SEM |
|---|---|---|---|---|---|---|---|---|
| Silage DM intake (g/d) | — | 644 | 637 | 727 | 663 | 613 | 677 | 33·2 |
| Silage DM intake (g/kg body-wt$^{0.75}$ per d) | — | 47·5 | 45·4 | 51·0 | 47·0 | 43·0 | 46·8 | 1·98 |
| Total DM intake (g/d) | — | 823 | 974 | 981 | 994 | 1103 | 1081 | 33·2 |
| LWG (g/d) | — | 84 | 127 | 149 | 145 | 187 | 185 | 14·1 |
| MADF digestibility | 0·831 | 0·811 | 0·779 | 0·832 | 0·809 | 0·732 | 0·798 | 0·0141 |

Protein supplementation gave growth responses which would not have been predicted from Agricultural Research Council (1980) energy values. Approximately half of the response can be attributed to increasing energy intake while the remainder appears to be an effect of protein *per se*.

S.M.M. acknowledges the support of a MAFF studentship.

Agricultural Research Council (1980). *The Nutrient Requirements of Ruminant Livestock.* Slough: Commonwealth Agricultural Bureau.

**Additive effects of intraventricular injection of noradrenaline and intraruminal infusion of sodium acetate on food intake of sheep.** By S. AYDINTUG and J. M. FORBES, *Department of Animal Physiology and Nutrition, University of Leeds, Leeds LS2 9JT*

Intraventricular injections of 542 nmol noradrenaline (NA) induces feeding for about 30 min (Baile *et al.* 1972). It is also well-established that infusion of products of digestion into several sites can depress food intake in ruminants; for example, Adams & Forbes (1981) have shown that intraruminal infusion of sodium acetate solution (AC) at 4 mmol/min depresses intake in sheep and that this effect is additive with the depressions caused by (a) propionate infusion into the hepatic portal vein or (b) rumen distension. The present experiment was designed to see whether a stimulatory and an inhibitory factor have additive effects.

Five castrated male sheep weighing 50–60 kg, prepared with rumen fistulas and lateral ventricular guides, were penned individually and fed *ad lib.* on a complete pelleted diet. Fresh food was offered each day at 09·30 hours. AC infusion (0 or 4 mmol/min) lasted from 12·30 to 15·30 hours while NA injections (0 or 542 nmol) were made at 13·30 hours.

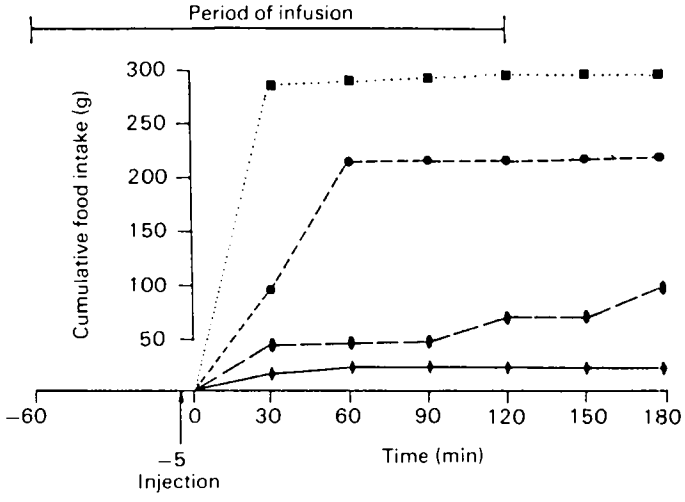



Fig. Food intakes of control sheep (●– – –●) and sheep given NA injection (■ . . . . ■) into the cerebroventricles, or AC infusion ( ●——◆ ) into the rumen, or both ( ●——◆ ).

Compared with controls (0 AC, 0 NA), where the intake during the 3 h was 217 g, 542 nmol NA significantly stimulated intake (292 g/3 h) while 4 mmol AC significantly depressed intake (18 g/3 h; SE of treatment mean 6·6). In combination the two treatments had almost exactly additive effects (98 g/3 h) thus extending the evidence that different factors involved in the control of food intake act in an additive manner.

Adams, G. B. & Forbes, J. M. (1981). *Proceedings of the Nutrition Society* **40**, 44A.
Baile, C. A., Simpson, C. W., Krabill, L. F. & Martin, F. H. (1972). *Life Sciences* **11**, 661.

**The absorption and faecal losses of phosphorus by mature sheep.** By J. H. TERNOUTH and H. M. S. DAVIES, *Department of Animal Production, University of Queensland, St Lucia, Queensland* 4067, *Australia*

Four mature Merino wethers (38–43 kg), accustomed to animal house procedures, were fed *ad lib.* a phosphorus-deficient (0·72 g P/kg dry matter (DM)) diet for 8 weeks and then repleted for 5 weeks by supplementing the diet (4·50 g P/kg DM) with $NaH_2PO_4$. The diet consisted (g/kg) of 600 barley straw, 310 refined sugar, 64 gluten, 17 urea and 9 mineral–vitamin supplement. The diet of two sheep contained 1·41 calcium/kg DM and that of the other two 10·86 g Ca/kg DM.

The P balance of the sheep was monitored continuously throughout the experiment and the results of the depletion and repletion balance periods are shown in the table. The results for the high- and low-Ca diets were similar and have been pooled.

| Treatment period . . . | Depletion | | Repletion | |
|---|---|---|---|---|
| | Mean | SE | Mean | SE |
| DM intake (g/d) | 633 | 54 | 752 | 23 |
| Faecal P (mg/d) | 587 | 54 | 1036 | 115 |
| Urinary P (mg/d) | 21·9 | 11·5 | 583 | 116 |
| Apparent absorption | −0·29 | 0·06 | 0·69 | 0·03 |
| Apparent retention | −0·34 | 0·07 | 0·55 | 0·06 |

During the depletion period the sheep were calculated to have lost 8·72 (SE 1·7) g P and their faecal P loss (FP, mg/d) was related to DM intake (DMI, kg/d):

$$FP = 84{\cdot}6 + 793 \text{ (SE } 106) \text{ DMI (RSD } 135, r\ 0{\cdot}81, n\ 32),$$

a mean faecal loss of 14·7 mg P/kg live weight. This value is within the minimum endogenous faecal P range quoted by the Agricultural Research Council (1980).

During the first week of the repletion period, the sheep had apparent absorption and retention coefficients of 0·82 (SE 0·03) and 0·79 (SE 0·03) respectively. Faecal P losses were higher during repletion than depletion and were not related to DMI. As the sheep regained P the absorption and retention coefficients decreased progressively. Although the sheep were calculated to have regained more P than was lost during depletion, absorption and retention remained substantial.

These results support the conclusion of Schneider *et al.* (1984) that the absorption of P by sheep is not precisely regulated. As endogenous P is largely of salivary origin and salivary flow rate is related to food intake (Doyle *et al.* 1982), we consider that minimum endogenous P should be estimated in sheep given P-deficient diets and related to DMI, a method previously used for nitrogen (Agricultural Research Council, 1965).

Agricultural Research Council (1965). *The Nutrient Requirements of Farm Livestock,* No. 2 *Ruminants.* London: H.M. Stationery Office.

Agricultural Research Council (1980). *The Nutrient Requirements of Ruminant Livestock.* Farnham Royal: Commonwealth Agricultural Bureau.

Doyle, P. T., Egan, J. K. & Thalen, A. J. (1982). *Australian Journal of Agricultural Research* **33**, 573–584.

Schneider, K. M., Sevilla, C. C. & Ternouth, J. H. (1984). *Australian Journal of Agricultural Research* (In the Press).

**Effect of unmolassed sugar beet pulp on the rate of straw degradation in the rumens of sheep given barley straw.** By AYONA T. SILVA and E. R. ØRSKOV, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

In a previous trial it was shown that the rate of disappearance of straw dry matter (DM) was greater from the rumens of sheep given ammonia-treated rather than untreated straw (Silva & Ørskov, 1984). The differences in rate occurred when the concentrations of rumen $NH_3$ and rumen pH were similar. Since $NH_3$ treatment of straw increases the amount of β-glucans available for degradation, these results suggested that improvement of the rumen environment of animals given untreated straw might be achieved by supplementation with degradable β-glucans. Unmolassed sugar beet pulp was used as a supplement in the experiment described here.

Eight Suffolk cross sheep fitted with permanent rumen cannulas were used. Untreated straw, or a diet containing 150 g unmolassed sugar beet pulp and 850 g untreated straw/kg, was given to each of four sheep for a period of 21 d. All the diets were supplemented with urea, vitamins and minerals. During the last week of the 21-d period, untreated straw was incubated in nylon bags in the rumens of the sheep. Rumen fluid samples were withdrawn during the last 2 d for the determination $NH_3$ and pH. At the end of the first 21-d period animals were randomly re-allocated to the two diets and the experiment was repeated.

Table 1. *Rumen pH, rumen $NH_3$ concentrations and DM disappearance from nylon bags of straw incubated in the rumens of sheep fed on either untreated straw or on a diet containing 150 g sugar beet pulp and 850 g untreated straw/kg*

| Sugar beet pulp in the diet (g/kg) | Rumen pH | Rumen $NH_3$ (mg/l) | DM disappearance of incubated untreated straw (mg/g) after (h): 8 | 16 | 24 | 48 | 72 |
|---|---|---|---|---|---|---|---|
| 0 | 7·0 | 151 | 166 | 293 | 386 | 463 | 515 |
| 150 | 6·9 | 129 | 179 | 308 | 407 | 503 | 547 |
| SE of difference | 0·09 | 29·5 | 5·8 | 8·7 | 6·9 | 8·9 | 9·8 |

The inclusion of sugar beet pulp significantly increased the rate of disappearance of straw DM ($P<0·01$ at 24, 48 and 72 h). A subsequent experiment in which higher proportions of sugar beet pulp were used showed no further improvement. Since cellulolysis was increased an improvement in voluntary intake of straw was predicted.

This was confirmed in a feeding experiment in which the inclusion of 150 g unmolassed sugar beet pulp/kg increased the voluntary intake of the straw by sheep from 414 to 505 g DM/d ($P<0·01$). The extent of improvement of cellulolysis to be expected will probably depend on the quality of the straw and 150 g unmolassed sugar beet pulp/kg is unlikely to be optimal in all cases.

Silva, A. T. & Ørskov, E. R. (1984). *Proceedings of the Nutrition Society* **43**, 11A.

**The effect of level of feeding and inclusion of a maize starch supplement on rumen digesta pool size and turnover.** By ELISABETH M. AITCHISON, M. S. DHANOA, M. GILL and D. F. OSBOURN, *Grassland Research Institute, Hurley, Maidenhead, Berks SL6 5LR*

The removal of digesta from the rumen can have an important effect on the voluntary intake of fibrous diets by ruminants, and is brought about by the combined mechanisms of digestion and passage. The present study measured these factors to determine the extent to which changes in the level of feeding and addition of a maize starch supplement influence the kinetics of digestion in the rumen.

Eight wether sheep, weighing 48–60 kg and fitted with large rumen cannulas, were given perennial ryegrass hay (digestible organic matter in dry matter 0·62) once daily at two levels of feeding (11 g/kg live weight (LW), L; 16·5 g/kg LW, H), with (S) or without maize starch being given as a supplement at 0·175 of the hay dry matter (DM). Rates of digestion ($k$) of the hay were obtained using dacron bags (Ørskov & McDonald, 1979), and passage from the rumen was measured using chromium-mordanted hay (Uden *et al.* 1980) to obtain rates of outflow of mordant from the rumen ($k_1$). The rumen digesta content at intervals after feeding was measured by emptying and sampling of the whole rumen contents.

| Treatment . . . | L | LS | H | HS | SE |
|---|---|---|---|---|---|
| Rate of digestion $k$ (/h) | 0·0295 | 0·0320 | 0·0279 | 0·0228 | 0·00358 (30 df) |
| Rumen removal rate $k_1$ (/h) | 0·0317 | 0·0234 | 0·0331 | 0·0333 | 0·00257 (30 df) |
| Rumen DM pool size (g) (time after feeding, h) | | | | | |
| 5 | 890 | 959 | 1121 | 1290 | |
| 10 | 719 | 815 | 1056 | 1016 | 46·9 (82 df) |
| 15 | 634 | 690 | 872 | 886 | |
| 24 | 483 | 466 | 578 | 561 | |

Increasing the level of feeding resulted in an increase in the rate of passage of digesta from the rumen, with a corresponding decrease in the digestion rate of the feed, although this value was not significant at the 5% level. The higher level of feeding resulted in significantly higher rumen digesta contents, although there was no effect of the starch on the pool sizes within the same levels of feeding at the same sampling times. However, addition of starch resulted in initially larger pool sizes, but smaller pool sizes 24 h after feeding, giving a decrease in rumen digesta content that was more rapid when starch was given than when the hay was given alone.

Ørskov, E. R. & McDonald, I. (1979). *Journal of Agricultural Science, Cambridge* **92**, 499–503.

Uden, P., Colucci, P. E. & Van Soest, P. J. (1980). *Journal of the Science of Food and Agriculture* **31**, 625–632.

**Particle breakdown and chewing activity in sheep fed on fresh perennial ryegrass and white clover.** By GWYN MOSELEY, *Welsh Plant Breeding Station, Plas Gogerddan, Aberystwyth SY23 3EB* and D. W. DELLOW, *DSIR, Applied Biochemistry Division, Palmerston North, New Zealand*

The extent and efficiency of breakdown of forage particles depends mainly on the physical characteristics of the forage, particularly those which affect its resistance to the shearing forces employed in chewing during eating and rumination (Moseley & Jones, 1984). Differences in voluntary intake between forages may therefore be directly related to their physical characteristics.

Ten 1-year-old Romney wethers fitted with large, removable rumen cannulas (≃ 100 mm diameter) were housed in metabolism crates. Animals were given either freshly cut perennial ryegrass (var. Ruanui) or white clover (var. Huia) hourly, at five levels ranging from 400 g dry matter (DM)/d to *ad lib.* supply. Food intake and faecal output were measured and jaw activity recorded using a jaw balloon and pressure transducer. Total rumen contents were weighed and sampled on at least five occasions for each animal and analysed for DM and particle size distribution using a wet sieving technique.

Sheep fed on perennial ryegrass spent 40% more time eating and 90% longer ruminating than those fed on white clover. Although there was little change in time spent eating over the range of intakes there was a highly significant increase in ruminating time with increasing intake. The time spent eating per 100 g DM intake decreased significantly with intake for both feeds but the mean for perennial ryegrass was twice that of white clover. There was also a highly significant decrease with increasing intake in the time spent ruminating per 100 g DM intake for perennial ryegrass, but not for white clover.

A particle breakdown index (PBI) was calculated from the wet sieving results and is given as (weight of particles <1 mm/weight of total particles) + (weight of soluble DM/weight of total DM).

| | Perennial ryegrass | | | | White clover | | | |
|---|---|---|---|---|---|---|---|---|
| | Range | Mean | *b* | *r* | Range | Mean | *b* | *r* |
| DM intake | 400–1300 | 850 | — | — | 400–1800 | 1100 | — | — |
| DM digestibility | 0·74–0·71 | 0·72 | −0·00361 | −0·221 | 0·80–0·80 | 0·8 | −0·00033 | −0·201 |
| Time eating (min/d) | 106–183 | 144 | 0·085 | 0·479* | 82–124 | 103 | 0·030 | 0·339 |
| Time ruminating (min/d) | 217–316 | 266 | 0·110 | 0·590** | 66–214 | 140 | 0·106 | 0·817*** |
| Time eating (min/100 g) | 24·4–11·8 | 18·1 | −0·014 | −0·531* | 13·9–5·9 | 9·9 | −0·00570 | −0·666** |
| Time ruminating (min/100 g) | 47·7–18·9 | 33·3 | −0·032 | −0·764*** | 14·1–11·7 | 12·9 | −0·00172 | −0·265 |
| Particle breakdown index | 1·099–0·891 | 0·995 | −0·0002 | −0·754*** | 1·166–1·128 | 1·147 | −0·00003 | −0·243 |
| Efficiency of breakdown | 3·25–1·66 | 2·46 | −0·0018 | −0·964*** | 7·20–2·72 | 4·96 | −0·0032 | −0·974*** |

*$P<0.05$, **$P<0.01$, ***$P<0.001$. *b*, Regression on intake.

The PBI of perennial ryegrass decreased significantly with increasing intake whereas that of white clover did not, and the mean PBI for the grass was lower than that of the clover ($P<0.01$). Efficiency of particle breakdown (PBI × 100/total time chewing) decreased with increasing intake but the mean for clover was twice that for grass, showing the importance of physical characteristics in controlling the intake of forage.

Moseley, G. & Jones, J. R. (1984). *British Journal of Nutrition* **52**, 381–390.

**The effect of shearing on body tissue mobilization in pregnant sheep.** By M. E. SYMONDS[1], M. J. BRYANT[2] and M. A. LOMAX[1], *Departments of [1]Physiology & Biochemistry and [2]Agriculture, University of Reading, Whiteknights, Reading RG6 2AJ*

Shearing ewes during the final 10 weeks of gestation increases lamb birth weight (LBW), while food intake is unchanged. Thompson *et al.* (1982) have proposed that shearing induces cold stress which results in an increased mobilization of body tissue and partition of nutrients to the fetus. However, there have been no studies which quantify the contribution of body tissue to energy supply.

Thirty-two pregnant Bluefaced Leicester cross Swaledale ewes were paired with respect to body-weight and one animal from each pair was shorn at approximately 8 weeks prior to lambing. All ewes were housed individually and fed on a diet comprising barley concentrate and ammonia-treated straw. Nine pairs of ewes were then sequentially placed in an indirect open circuit respiration chamber for a 5-d period, during which time metabolizable energy (ME) intake and heat production (H) were measured. The mean temperature inside the calorimeter chamber was $11{\cdot}9 \pm 0{\cdot}3°$.

| | ME intake | | H | | Energy balance | | Body tissue mobilization† | | Gravid uterus accretion‡ (MJ/d) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MJ/kg body-wt$^{0.75}$ per d | | | | | | | | | |
| | Mean | SEM | Mean | SEM | Mean | SEM | Mean | SEM | Mean | SEM |
| Shorn | 0·44 | 0·04 | 0·58$^{\bullet\bullet\bullet}$ | 0·02 | −0·14$^{\bullet}$ | 0·04 | 0·15$^{\bullet}$ | 0·04 | 0·25 | 0·09 |
| Unshorn | 0·42 | 0·02 | 0·47 | 0·02 | −0·05 | 0·02 | 0·05 | 0·02 | 0·24 | 0·05 |

Significances assessed by a paired *t* test: $^{\bullet}P<0{\cdot}05$, $^{\bullet\bullet\bullet}P<0{\cdot}001$.
†Body tissue mobilization = (H + gravid uterus accretion) − ME intake.
‡Calculated from Tissier *et al.* (1980).

Shearing resulted in a significant increase in LBW in sheep bearing either twins or triplets (shorn 4·25 (SE 0·15) kg, unshorn 3·79 (SE 0·16) kg; $P<0{\cdot}05$, *n* 26). ME intake was similar in both groups of animals but ewes responded to shearing by increased H and body tissue mobilization. There was no difference in calculated gravid uterus accretion between the two groups which may have been due to the early stage of pregnancy at which the sheep were placed in the calorimeter (mean 112 (SEM 5·7) d), and the fact that some were carrying single fetuses.

It is concluded that the increased H in the shorn pregnant ewe results in an additional requirement for energy which is met by mobilizing body tissue. Therefore, these results confirm the hypothesis of Thompson *et al.* (1982).

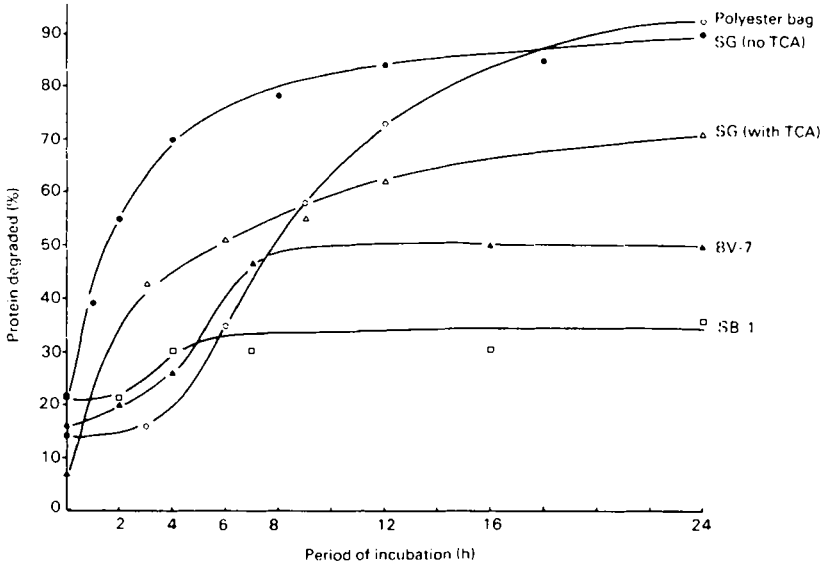
M.E.S. acknowledges the support of a MAFF studentship.

Tissier, M., Theriez, M., Purroy, A. & Brelurut, A. (1980). In *Energy Metabolism*, pp. 329–333 [L. E. Mount, editor]. London: Butterworths.
Thompson, G. E., Bassett, J. M., Samson, D. E. & Slee, J. (1982). *British Journal of Nutrition* **48**, 59–64.

**Potential use of proteolytic rumen bacteria for assessing feed protein degradability in vitro.** By KATHRYN A. LAYCOCK[1], G. P. HAZLEWOOD[2] and E. L. MILLER[1], [1]*Department of Applied Biology, University of Cambridge, Pembroke Street, Cambridge CB2 3DX* and [2]*Department of Biochemistry, AFRC Institute of Animal Physiology, Babraham, Cambridge*

The rate of degradation of soya-bean meal was determined using polyester bags, *Streptomyces griseus* protease (SG), and proteolytic rumen bacteria *Butyrivibrio* sp. strain 7 (BV-7) and *Streptococcus bovis* strain 1 (SB-1) (Hazlewood *et al.* 1983). The incubations were terminated by either filtration or TCA precipitation.

Degradation with SG was determined by the method of Krishnamoorthy *et al.* (1982) with modifications to determine nitrogen soluble in TCA (100 g/l final concentration). For studies with bacterial cells the soya-bean meal was ground through a 1 mm screen and sterilized by gamma irradiation (1 Mrad). Inoculum cells were grown for 16 h in medium 2 (Hazlewood *et al.* 1983), centrifuged, washed and resuspended in a low-N basal medium. 5 ml low-N medium and 0·5 ml inoculum were added to 2·5 mg sterilized soya-bean meal and samples incubated at 39° for up to 24 h with rotation at 3·5 r.p.m. Protein degradation was calculated as the increase in bacterial N, separated by filtration and centrifugation, plus the increase in TCA-soluble N.




Compared with polyester bags the initial rate of degradation was greatest with SG with no sign of a lag phase. Terminating with TCA reduced the apparent rate and extent of degradation. BV-7 and SB-1 gave similar lag phases and initial rates of degradation to those of the polyester bag, but the extent of breakdown was less.

Factors limiting degradation by BV-7 and SB-1 require further investigation.

Hazlewood, G. P., Orpin, C. G., Greenwood, Y. & Black, M. E. (1983). *Applied and Environmental Microbiology* **45**, 1780–1784.

Krishnamoorthy, U., Sniffen, K. J. & Van Soest, P. J. (1982). *Cornell Nutrition Conference* 95–102.

**Prediction of the energy value of diets for pigs.** By C. A. MORGAN[1], C. T. WHITTEMORE[1], P. PHILLIPS[2] and P. CROOKS[1], [1]*Edinburgh School of Agriculture, West Mains Road, Edinburgh* and [2]*AFRC Unit of Statistics, The Kings Buildings, Edinburgh*

Equations for predicting the energy values of compound foods from a variety of laboratory-based indices, have been put forward for ruminant animals (Wainman *et al.* 1981) and poultry (Fisher, 1982). The present paper describes the work carried out at Edinburgh to produce similar equations for pig foods.

Thirty-six diets were formulated to the following specifications: 140 or 200 g crude protein (nitrogen × 6·25)/kg; 20, 40 or 80 g oil/kg; 25, 50 or 100 g crude fibre/kg; low or high levels of starch. The digestibility of the energy (DE) of each diet was measured by total faecal collection, over a period of 7 d, using four pigs per diet. Samples of diet were distributed to collaborating laboratories for analysis for dry matter (DM), crude protein (CP), oil (OIL), ash (ASH), crude fibre (CF), neutral-detergent fibre (NDF), acid-detergent fibre, Christian lignin, starch, sugar, oil following acid hydrolysis, and gross energy (GE). Equations were derived for predicting DE from combinations of the chemical indices. As in the previous studies the effectiveness of the equations in predicting DE was judged according to residual standard deviation (s) and after allowing for between-laboratory variance (s'). GE and NDF were particularly effective in two or three factor equations. NDF was always superior to the other measurements of fibre.

The most effective two, three or four factor linear equations were:

$$DE = 3{\cdot}770 - 0{\cdot}0186\ NDF + 0{\cdot}7582\ GE\ (s = 0{\cdot}381,\ s' = 0{\cdot}470), \quad (1)$$

$$DE = 17{\cdot}009 + 0{\cdot}0159\ OIL - 0{\cdot}0182\ NDF\ (s = 0{\cdot}438,\ s' = 0{\cdot}502), \quad (2)$$

$$DE = 5{\cdot}012 - 0{\cdot}0136\ ASH - 0{\cdot}0173\ NDF + 0{\cdot}7380\ GE\ (s = 0{\cdot}360,\ s' = 0{\cdot}446), \quad (3)$$

$$DE = 17{\cdot}493 + 0{\cdot}0157\ OIL + 0{\cdot}0078\ CP - 0{\cdot}0325\ ASH - 0{\cdot}0149\ NDF\ (s = 0{\cdot}322,\ s' = 0{\cdot}399), \quad (4)$$

where components are expressed as MJ/kg DM or g/kg DM. The equation using the components of the statutory declaration (i.e. CF in place of NDF in eqn (4)) was:

$$DE = 17{\cdot}375 + 0{\cdot}0114\ OIL + 0{\cdot}0105\ CP - 0{\cdot}0402\ ASH - 0{\cdot}0317\ CF\ (s = 0{\cdot}543,\ s' = 0{\cdot}593), \quad (5)$$

Inclusion of in vivo variance (s"; L. Aspinall, personal communication) decreased precision slightly, e.g. s" for eqn (4) was 0·438.

The project was funded by MAFF and received technical support from ADAS, UKASTA and the AFRC Poultry Research Centre.

Fisher, C. (1982). *Energy Values of Poultry Feeds.* Occasional Publication no. 2. Midlothian: AFRC Poultry Research Centre.

Wainman, F. W., Dewey, P. J. S. & Boyne, A. W. (1981). *Compound Feedingstuffs for Ruminants.* Feedingstuffs Evaluation Unit Third Report. Aberdeen: Rowett Research Institute.

**Gastrointestinal influences on short-term regulation of food intake in pigs.**

By D. V. RAYNER and P. C. GREGORY, *Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB*

In many animals the gastric load or duodenal concentration of food nutrients during a meal, especially glucose, have been implicated in the short-term control of food intake (Houpt, 1982). In the pig, however, glucose decreases intake apparently through raising duodenal osmolarity (Houpt *et al.* 1979).

We have tested the effects of stomach or duodenal infusions of glucose (400 g/l), a fat emulsion (200 g lipid/l; Intralipid; KabiVitrum Ltd) and phenylalanine (120 mmol/l) plus tryptophan (60 mmol/l) on short-term control of food intake in pigs previously catheterized under general anaesthesia. The pigs were fed for 45 min twice daily. Infusions were made over a period of 75 min, starting 30 min before the feeding period. The resulting food and energy intakes were calculated as a percentage of the mean intakes from the two meals on the day before and the day after infusion.

| Site of infusion . . . | Stomach | | | | | Duodenum | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Food intake (%) | | Energy intake (%) | | | Food intake (%) | | Energy intake (%) | |
| Infusion | *n* | Mean | SEM | Mean | SEM | *n* | Mean | SEM | Mean | SEM |
| Glucose (ml/min): | | | | | | | | | | |
| 2 | 5 | 107 | 4 | 116* | 5 | 5 | 96* | 1 | 105 | 2 |
| 4 | 6 | 92* | 3 | 107* | 2 | 17 | 91** | 3 | 107* | 3 |
| Intralipid (ml/min): | | | | | | | | | | |
| 1 | | — | — | — | — | 13 | 77*** | 4 | 83** | 5 |
| 2 | 5 | 94 | 11 | 104 | 12 | 53 | 73*** | 2 | 85*** | 2 |
| 4 | 10 | 81** | 4 | 101 | 5 | 17 | 63*** | 3 | 85*** | 4 |
| 2+lignocaine | | — | — | — | — | 11 | 89 | 6 | 100 | 6 |
| Phenylalanine+ tryptophan, 6 ml/ min | | — | — | — | — | 7 | 91 | 6 | 94 | 6 |

Significantly different from control (Student's *t* test): *$P<0.05$, **$P<0.01$, ***$P<0.001$.

Glucose infusion (Table) had little effect on meal size despite its high osmolarity (2200 mosmol/l). Intralipid infusions significantly inhibited food intake; stomach infusions seemed to inhibit intake in proportion to the energy content of the infusion, while duodenal infusions inhibited intake to a greater extent. Local anaesthesia of the duodenum with lignocaine (10 g/l) reduced ($P<0.02$) but did not abolish the inhibitory effect of fat. Infusion of phenylalanine plus tryptophan, which releases cholecystokinin (CCK) in dogs, had no effect. One possibility is that in pigs, fat inhibits food intake partly through a duodenally mediated neuronal mechanism which may not involve CCK.

Houpt, K. A. (1982). *Neuroscience and Behavioural Reviews* **6**, 145–164.

Houpt, T. R., Anika, S. M. & Houpt, K. A. (1979). *American Journal of Physiology* **236**, R328–R337.

**Do chickens consider a glucose solution to be food or water?** By TEHANY S. SHAOBI and J. M. FORBES, *Department of Animal Physiology and Nutrition, University of Leeds, Leeds LS2 9JT*

Chickens offered a solution of 100 g dextrose/l, drink the same amount as they do of plain water but, despite the extra energy intake, do not reduce their food intake (T. S. Shaobi and J. M. Forbes, unpublished results). Mook *et al.* (1983) found that fasted rats that had drunk a glucose solution to satiety ate food vigorously when it was subsequently offered and concluded that the satiety induced by drinking the glucose solution was not the same as that normally induced by food.

Twelve male chickens of a layer strain, aged 17 weeks and weighing between 2·3 and 2·7 kg, were kept individually under 16 h light–8 h dark photoperiods. All were given free access to standard food (F) and for several weeks before the experiments half were offered tap water (W) *ad lib.* while the other half were offered a solution of 100 g dextrose monohydrate/l (glucose, G). In the first experiment, F was removed overnight and at 09.00 hours half the birds on each pre-treatment were offered G while the other half were offered F and W. After 1 h the G was replaced by F + W and vice versa. The treatments were repeated 1 week later. The second experiment was similar but following overnight removal of fluid, either F + W or G was offered for 1 h and reversed for the 2nd hour. The intakes are shown in the table.

| Period of treatment (min) . . . | Intake of F, W or G (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0–30 | | 30–60 | | | 60–90 | | 90–120 | |
| | Mean | SEM | Mean | SEM | | Mean | SEM | Mean | SEM |
| Expt 1: | | | | | | | | | |
| F | 25·6 | 2·2 | 5·9 | 1·5 | G | 20·4 | 3·3 | 22·9 | 6·0 |
| G | 12·5 | 1·9 | 14·2 | 1·9 | F | 35·4 | 3·9 | 2·9 | 0·5 |
| Expt 2: | | | | | | | | | |
| W | 62·5 | 11·8 | 26·3 | 5·6 | G | 33·0 | 7·8 | 18·7 | 4·9 |
| G | 62·5 | 10·3 | 36·6 | 7·8 | W | 29·2 | 4·4 | 20·0 | 3·5 |

Thus, when W had been available overnight (Expt 1) the birds drank comparatively little G but ate a large amount of F when this was offered 1 h later. When F had been available overnight, however, there was no difference between the intakes of G or W. The results were the same irrespective of whether birds were accustomed to drinking G or W.

These observations show that the birds considered G to be the same as W and agree with the suggestions for mammals that to be satiating, ingested material must induce internal changes similar to those caused by food, in particular the secretion of insulin.

Mook, D. G., Brane, J. A., Kushner, L. R. & Whitt, J. A. (1983). *Appetite* **4**, 1–9.

**Portal vein injection of adrenaline: effect on feeding in intact and vagotomized cockerels.** By G. A. HOWES and J. M. FORBES, *Department of Animal Physiology and Nutrition, University of Leeds, Leeds LS2 9JT*

The liver is believed to play a role in the control of food intake and Russek (1981) has discussed a possible action of adrenaline (Ad) on the liver in mammals. The present study examined the effect on food intake of injection of Ad into the portal vein of cockerels.

Cockerels prepared with hepatic portal vein catheters (Rusby, 1982) were given the following injections on separate occasions: (1) 1 ml isotonic saline (9 g sodium chloride/l)/kg (control), (2) 0·025 mg Ad/kg at a concentration of 0·025 mg/ml (low dose), (3) 0·05 mg Ad/kg at a concentration of 0·05 mg/ml (medium dose), (4) 0·1 mg Ad/kg at 0·1 mg/ml saline (high dose). The birds were allowed free access to food at all times. The experiment was repeated in birds subjected to abdominal vagotomy. Results are summarized in the table.

| Time from injection (h) | Mean food intake (g) | | | | SEM |
|---|---|---|---|---|---|
| | Control | Low dose | Medium dose | High dose | |
| | | Intact birds ($n$ 8) | | | |
| 1 | 16·5[a] | 12·3[a,b] | 6·5[b] | 4·1[b] | 3·23 |
| 2 | 25·6[a] | 27·3[a] | 15·3[b] | 8·5[b] | 3·40 |
| 3 | 35·6[a] | 32·5[a] | 26·9[a] | 14·5[b] | 3·72 |
| | | Vagotomized birds ($n$ 11) | | | |
| 1 | 13·6[a] | 10·8[a] | 9·7[a] | 10·2[a] | 1·51 |
| 2 | 19·6[a] | 16·9[a] | 18·1[a] | 17·7[a] | 1·89 |
| 3 | 26·6[a] | 22·7[a] | 28·0[a] | 26·3[a] | 2·72 |

[a,b]Within each time period means with unlike superscript letters were significantly different ($P<0·05$).

Ad significantly depressed food intake in intact birds up to 5 h after the injection, but had no effect in vagotomized birds. These results suggest that the liver is the site of action for the reduction of food intake caused by Ad; the mechanism would presumably be via hepatic glycogenolysis and gluconeogenesis (Anderson & Langslow, 1975), with any changes being monitored by glucose-sensitive afferent nerve fibres in the liver (Niijima, 1983).

Anderson, C. E. & Langslow, D. R. (1975). *Biochemical Society Transactions* **3**, 1037–1039.
Niijima, A. (1983). *Journal of the Autonomic Nervous System* **9**, 207–220.
Rusby, A. A. (1982). *Journal of Physiology* **330**, 19P (Abstr.).
Russek, M. (1981). *Appetite* **2**, 137–163.

**The effect of portal vein infusion of 2-deoxy-glucose and 3-methyl glucose on the food intake of cockerels.** By AUDREY A. RUSBY and J. M. FORBES, *Department of Animal Physiology and Nutrition, University of Leeds, Leeds LS2 9JT*

The glucose analogues 2-deoxy-glucose (2DG), which blocks glycolysis, and 3-methyl glucose (3MG), which interferes with glucose transport across the cell membrane, have been used to study mammalian glucose receptors and their role in controlling food intake. Although intraperitoneal injections of 2DG have been shown to reduce food intake in birds (Hatfield & Smith, 1972), there has been no work using 3MG.

Eight cockerels were prepared with portal vein catheters (Rusby, 1982). In the first experiment the following solutions were infused at a rate of 10 ml/h for 3 h into the portal vein of 21-h starved birds: isotonic saline (9 g sodium chloride/l; control), 50, 100 and 200 mg 2DG/kg live weight. The second experiment was a repeat of the first with the following solutions infused: isotonic saline (control), 50, 100 and 200 mg 3MG/kg live weight.

| | Food intake (g) | | |
|---|---|---|---|
| Time from start of infusion (h) . . . | 2–3 | 0–6 | 0–24 |
| Expt 1 (*n* 8) | | | |
| Control | 20·7[a] | 88·7[a] | 159·9[a] |
| 2DG infused (mg/kg per 3 h): | | | |
| 50 | 7·2[b] | 70·2[b] | 132·0[b] |
| 100 | 4·4[b] | 75·9[a,b] | 136·0[b] |
| 200 | 3·4[b] | 56·6[c] | 117·2[b] |
| SEM | 3·05 | 5·10 | 8·52 |
| Expt 2 (*n* 8) | | | |
| Control | 11·8 | 87·9 | 159·9 |
| 3MG infused (mg/kg per 3 h): | | | |
| 50 | 16·3 | 82·6 | 183·5 |
| 100 | 7·1 | 79·2 | 176·1 |
| 200 | 16·6 | 71·9 | 144·2 |
| SEM | 3·31 | 5·56 | 12·12 |

[a,b,c]Within each time period for Expt 1, means with unlike superscript letters were significantly different ($P<0·05$).

2DG infused into the portal vein significantly reduced food intake, conflicting with the evidence for most mammals, whilst 3MG had little effect on intake. However, neither of these analogues affected blood glucose levels. These results would suggest that the avian glucoreceptor employs a different mechanism for monitoring glucose than that of mammals.

Hatfield, J. S. & Smith, C. J. V. (1972). *Poultry Science* **51**, 1816–1820.
Rusby, A. A. (1982). *Journal of Physiology* **330**, 19P (Abstr.).

**The rate of response of growing turkeys to changes in dietary energy concentration.** By M. G. MACLEOD and T. R. JEWITT, *AFRC Poultry Research Centre, Roslin, Midlothian EH25 9PS*

Growing turkeys have been shown to be capable of adjusting food weight intake to maintain relative constancy of metabolizable energy (ME) intake over a three-fold range of ME concentrations produced by adding maize oil, starch and cellulose to a common base formulation (MacLeod *et al.* 1984). To examine the time-course of these responses, two groups of five individually-caged 6-week-old female turkeys, accustomed to diets of about 13·5 MJ/kg, were offered diets with ME concentrations of 7·0 and 19·3 MJ/kg. After food weight and ME intakes had been measured daily for 6 weeks on these diets, each group was offered the diet at the opposite end of the ME range and intakes were measured for a further 10–14 d period. A response to altered dietary energy concentration was judged to be complete when plateau ME intake was attained on the new diet. The results are summarized in the table.

| Group | Diet 1 (MJ/kg) | | Diet 2 (MJ/kg) | ΔME (MJ/kg) | Time (days) to complete response | |
|---|---|---|---|---|---|---|
| | | | | | Mean | SEM |
| 1 | 13·5 | → | 7·0 | − 6·5 | 4 | 0·9 |
| 1 | 7·0 | → | 19·3 | +12·3 | 2 | 0·2 |
| 2 | 13·5 | → | 19·3 | + 5·8 | 2 | 0·2 |
| 2 | 19·3 | → | 7·0 | −12·3 | 10 | 0·5 |

Adjustments of food intake to increases in ME concentration were significantly more rapid than to decreases. This was especially clear in the case of changes from 19·3 to 7·0 and from 7·0 to 19·3 MJ/kg, where there was a five-fold difference in the time taken to reach the final level of intake. The sensitivity of response rate to the direction of change of ME concentration and to the magnitude of a decrease indicates (a) rapid perception of added energy in the form of fat and (b) a constraint of food volume or mass on rate of increase but not rate of decrease of food intake. The latter suggests a physical limit which is susceptible to anatomical or physiological adaptation and which is overruled by biochemical signals in the case of a change to a lower-bulk, higher-energy diet.

MacLeod, M. G., Fisher, C. & Jewitt, T. R. (1984). *Proceedings of the XVIIth World's Poultry Congress, Helsinki 1984.* (In the Press.)

**The relation between sex differences in growth response to trenbolone acetate and the suppression of adrenal activity in male and female rats.** By M. N. SILLENCE, T. R. GIRLING, E. A. LORETTO, K. PARRY, I. G. TAYLOR and R. G. RODWAY, *Department of Animal Physiology and Nutrition, University of Leeds, Leeds LS2 9JT*

Trenbolone acetate (TBA) is a synthetic anabolic agent commonly used in agriculture. In addition to stimulating growth in cattle and sheep, it is effective in female but not in male rats (Toong & Perry, 1981). Thomas & Rodway (1982) have found reduced plasma corticosteroid concentrations in TBA-treated female rats and sheep. The aim of this study was to compare the effects of TBA on plasma corticosteroid concentrations in male and female rats.

All animals were housed individually, fed on a standard laboratory diet *ad lib.* and maintained on a 12 h light–12 h dark cycle with lights on at 07.00 hours. Injections (subcutaneous) of either 200 μl arachis oil or 80 μg TBA in 200 μl arachis oil were given at 10.00 hours daily. The animals were weighed daily and started the trial at 100 g. On the last day the rats were killed at either 10.00, 17.00 or 22.00 hours. Peak plasma corticosterone levels are known to occur at 17.00 hours.

Two studies were conducted using female rats bred in the Department of Animal Physiology and Nutrition. The first, using ten rats, lasted 9 d and the second, using twelve rats, lasted 10 d. In each case TBA improved growth rate by 38% ($P<0.01$) and 20% ($P<0.05$) respectively. Food intake was not significantly affected, but food conversion efficiency (FCE) was improved by 21% ($P<0.01$) and 16% (not significant). Peak plasma corticosterone levels at 17.00 hours were decreased by 54% ($P<0.05$) and 55% ($P<0.01$).

Three experiments were conducted using male rats. The first used eighteen rats bred in the Department of Animal Physiology and Nutrition, the second used eighteen males bred in the Department of Medicine (Leeds University) and the third used twelve males bred from a mixture of Animal Physiology and Medical School stock. The first TBA-treated group grew 9% faster than controls ($P<0.1$) and corticosterone levels were lowered by 30% ($P<0.1$). The second and third groups showed no change in growth rate or corticosterone levels. No differences in food intake or FCE were observed in any of the three male groups.

The results for female rats support earlier published work (Thomas & Rodway, 1982). A strain difference may be responsible for the different responses seen in the male sex, with the strain that gave a growth response to TBA also showing a decrease in glucocorticoid levels. There appears, therefore, to be a relation between the lowering of catabolic glucocorticoid hormone levels in plasma and the growth response to TBA. This lends support to the argument that TBA exerts some of its anabolic influence through the suppression of adrenal activity.

Thomas, K. M. & Rodway, R. G. (1982). *Proceedings of the Nutrition Society* **41**, 138A.
Toong, A. & Perry, B. N. (1981). *Proceedings of the Nutrition Society* **40**, 99A.

**Body tissue mobilization in the underfed pregnant ewe.** By SUSAN M. EAYRES[1], M. A. LOMAX[2] and M. J. BRYANT[1], *Departments of* [1]*Agriculture and* [2]*Physiology & Biochemistry, University of Reading, Whiteknights, Reading RG6 2AJ*

Little information is available regarding the extent to which body tissue mobilization can make up for energy deficit without affecting fetal growth. We report an experiment in which body tissue mobilization and energy requirement of underfed pregnant ewes have been estimated by measuring energy balance by indirect calorimetry.

Thirty-three shorn, Bluefaced Leicester cross Swaledale ewes, each carrying two or three fetuses and in body condition score 3·5, were fed on a ration of barley concentrate and ammonia-treated straw. The animals were divided into three treatment groups, fed at two levels below energy requirement (see table); treatment C animals received a supplement of fish meal to give an increment of about 8 g rumen undegradable nitrogen (RUDN)/sheep per d. Ewes were individually housed 6 weeks prior to lambing and metabolizable energy (ME) intake measured during a 7-d balance period. During the last 3 weeks of gestation each ewe was placed in a calorimeter for periods of 24 or 48 h to measure heat production (H).

| | ME intake | | H | | Body tissue mobilization† | | Energy requirement‡ | | Total lamb birth weight (kg/ewe) | | Gravid uterus accretion§ (MJ/d) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MJ/kg body-wt$^{0.75}$ per d | | | | | | | | | | | |
| | Mean | SEM | Mean | SEM | Mean | SEM | Mean | SEM | Mean | SEM | Mean | SEM |
| Treatment A | 0·35 | 0·01 | 0·59 | 0·02 | 0·27 | 0·02 | 0·62 | 0·02 | 9·73 | 0·49 | 0.64 | 0·06 |
| Treatment B | 0·29** | 0·01 | 0·58 | 0·02 | 0·31 | 0·02 | 0·60 | 0·02 | 9·46 | 0·46 | 0·65 | 0·05 |
| Treatment C | 0·29** | 0·01 | 0·62 | 0·02 | 0·35* | 0·03 | 0·64 | 0·02 | 9·94 | 0·57 | 0·70 | 0·05 |

Significances (treatment A *v.* B or C) assessed by Student's *t* test: *$P<0·05$, **$P<0·01$.
†Body tissue mobilization = (H + gravid uterus accretion) – ME intake.
‡Energy requirement = H+gravid uterus accretion.
§Calculated from Tissier *et al.* (1980).

The rations offered resulted in treatment A animals obtaining a higher proportion of their ME requirement from the diet (treatment A, 57 (SEM 2) %; treatment B+C, 47 (SEM 3) %; $P<0·05$, $n$ 32). However, the lower levels of ME intake in treatments B+C did not result in any change in lamb birth weight (LBW). The rate of body tissue mobilization was increased with treatment C.

The present study indicates that the shorn pregnant ewe can supply sufficient energy from body tissues to compensate for a deficit of at least half of its energy requirement without adversely affecting fetal growth rates.

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**The effect of supplementation on non-ammonia nitrogen flows at the abomasum of lactating grazing ewes.** By H. DOVE, *CSIRO Division of Plant Industry, Canberra, Australia* and J. A. MILNE, C. S. LAMB, H. A. MCCORMACK and A. M. SPENCE, *Hill Farming Research Organization, Bush Estate, Penicuik, Midlothian*

A positive linear relation between abomasal non-ammonia nitrogen (NAN) flow and milk yield has been demonstrated in housed lactating ewes (Gonzales *et al.* 1982). The provision of supplements to grazing lactating ewes in the spring increases lamb live-weight gain (Milne *et al.* 1981; Dove *et al.* 1984), presumably by increasing milk yield. However, the effect of supplements on abomasal NAN flow in grazing lactating ewes has not been studied.

Measurements of flows of abomasal NAN and microbial N were made with nine crossbred ewes fitted with ruminal and abomasal cannulas. Milk yield measurements were made on eighteen intact ewes. The ewes grazed perennial ryegrass swards maintained in a vegetative state at a low herbage mass (780–950 kg dry matter/ha) and were allocated to three treatments: no supplement (O), 600 g/d molassed sugar beet pulp (E) and 600 g/d of a 1:1 (w/w) mixture of molassed sugar beet pulp and formaldehyde-treated soya-bean meal (P). Supplements were given individually for the first 7 weeks of lactation. Abomasal flow rates were determined in weeks 3, 5 and 7 of lactation using Ru-phenanthroline and Cr-EDTA as digesta markers, infused intraruminally by portable infusion pumps. In each week four abomasal digesta samples were taken in each of three 24 h periods after 5 d of marker infusion. In two periods of each week, [$^{35}$S]sodium sulphate was also infused to enable the estimation of microbial N in abomasal digesta. Milk yield estimates were made on the intact ewes by hand-milking after oxytocin injection. Mean values of the 3 weeks are given in the table.

| Treatment . . . | O | E | P | SEM |
|---|---|---|---|---|
| Abomasal NAN flow (g/d) | 44·2 | 55·1 | 68·9 | 4·31 |
| Abomasal microbial N flow (g/d) | 41·3 | 46·9 | 53·2 | 4·59 |
| Ruminal ammonia (mM) | 24·1 | 16·4 | 20·1 | 2·34 |
| Milk yield (g/d) | 2048 | 2133 | 2846 | 110·4 |

Supplementation of the grazing ewe increased both NAN and microbial N flows through the abomasum. Abomasal NAN flows were considerably higher than those reported by Gonzales *et al.* (1982) (29–38 g/d) and increases in milk yield were associated with increasing NAN flows. The reduction in ruminal ammonia concentration on energy supplementation (treatment O *v.* E) was not associated with reduction in abomasal NAN and microbial N flows, suggesting that the efficiency of microbial capture of rumen-degradable N was increased.

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