The effects of defaunation of the rumen on the growth of cattle on low-protein high-energy diets

By S. H. BIRD and R. A. LENG

Department of Biochemistry and Nutrition, University of New England, Armidale, NSW 2351, Australia

(*Received* 24 *January* 1978 – *Accepted* 28 *February* 1978)

1. The effects of defaunation of the rumen of cattle on low-protein diets was studied using animals given free access to a basal diet of liquid molasses and 1500 g oaten straw/head per d. These diets induced moderate numbers of protozoa in the rumen.

2. Nonyl phenol ethoxylate (trade name teric GN9) was used for defaunation; 100 g teric GN9 was found to be sufficient to eliminate protozoa from the rumen.

3. In cattle given the basal diet without bypass protein supplementation, defaunation had no effect on growth rates. Addition of 240 g of a feed pellet containing bypass protein increased growth rate significantly. Growth rates were significantly increased by 43 % in cattle on the higher protein intake and where protozoa were removed. Intake of molasses was apparently stimulated by a protein supplementation but not by defaunation and this finding is discussed.

4. The results demonstrate that in cattle given a molasses-based diet, low in bypass protein, growth rates can be stimulated by defaunation without an effect on feed intake, the main effect apparently arising through an increased efficiency of utilization of feed.

Over the last decade, considerable interest has been generated in the use of feeds such as sugar cane and molasses for cattle, particularly in tropical countries. These feeds have supported only relatively low production, but this has been increased by supplementation with either bypass protein (Preston & Willis, 1970) or concentrates (Preston, 1977). In cattle given these feeds large populations of protozoa usually occur in the rumen. In cattle given molasses based diets the ruminal fluid volatile fatty acid (VFA) patterns usually show high butyrate, low propionate concentrations (Marty & Preston, 1970). With cattle on diets based on sugar cane, although propionate levels in the rumen are high, large populations of protozoa occur in the rumen (Leng & Preston, 1976). The effect of these large populations of protozoa on animal production has been the subject of much speculation, particularly since Weller & Pilgrim (1974) suggested that few of these protozoa leave the rumen intact.

In studies of the effects of defaunation of ruminants there have been only small effects on production, in general a reduction in growth (Abou Akkada & el Shazeley, 1964; Christiansen, Kawashima & Burroughs, 1965; Klopfenstein, Purser & Tyznik, 1966). These results have been obtained with lambs on diets of preserved and dried feeds or grains in which considerable protein was present. Recent knowledge (see for review Kempton, Nolan & Leng, 1977) suggests that these feeds contained considerable bypass protein probably in excess of requirements of growing lambs. On diets high in metabolizable energy but low in bypass protein, the retention of protozoa may reduce net microbial protein availability to the animal and thus reduce production.

To test this hypothesis cattle were established on molasses-based diets supplemented with sufficient urea for rumen fermentation (Preston & Willis, 1970) and the effects on growth of eliminating protozoa at low levels of bypass protein in the diet were examined.

A number of defaunating agents have been used with ruminants. Many of these agents were found to be inadequate in these laboratories but recently Wright & Curtis (1976) described the antiprotozoal effects of the nonyl phenol ethoxylates (trade name terics, ICI

(Aust.) Ltd). The teric GN9 has been successfully used to eliminate protozoa from the rumen of sheep and cattle in these laboratories.

MATERIALS AND METHODS

Experimental animals

Mixed sex Hereford weaner cattle weighing approximately 180 kg were used. All cattle were inoculated against Clostridial diseases and were drenched to control intestinal parasites. The animals were randomized into four groups of nine and held in group pens with adequate watering points and feed troughs. Between the faunated and defaunated groups a sheet metal fence 3 m high was erected with electric fences 1 m from this on both sides so that animals could not touch each other. The group pens were also isolated by at least 10 m from grazing animals.

Dietary regimens

All animals were given free access to molasses containing 4% (w/w) urea plus 1% (w/w) $Ca_2P_2O_7$, 0·5% (w/w) NaCl and 0·5% (w/w) of a trace mineral–vitamin mix (Minavit, Cooper, Aust. Pty. Ltd). The quantity of molasses added to the trough to make it up to a known volume was measured every second day. At 08.00 hours each day, 1·5 kg oaten straw was given per head and this was consumed within 30 min. The animals were allowed 3 weeks to adjust to the diet then following allocation to the four diets, the two groups were drenched with 100 g teric GN9 (ICI (Aust.) Ltd) in 800 ml water. The treated cattle were allowed 2 d to re-adjust to their feeding regimen. During this time, the amount of feed made available to the cattle in the untreated groups was adjusted to that consumed by the treated groups.

A number of animals treated with the terics were found to contain small numbers of protozoa (less than 10^3/ml or 1% of the numbers in the control groups) on the second and third week of the trial and all animals were re-treated with 100 g teric but no attempt was made to adjust feed intakes of the groups.

The treatment of each group was: group A, molasses (containing 4% (w/w) urea) and minerals *ad lib.* + 1·5 kg oaten straw (basal diet); group B, same treatment as group A except that the animals were defaunated; group C, basal diet plus 240 g bypass protein meal which had been pelleted and contained 50% soya-bean meal, 30% cottonseed meal, 10% meat meal and 10% fish meal (55% crude protein (N × 6·25)); group D, same treatment as group C, but the animals were defaunated.

The bypass protein pellets were given at the same time as the straw and were consumed by the animals within 15–20 min. The protein pellets were distributed through the whole trough and trough length was sufficient to allow all animals to feed undisturbed.

Experimental procedures

The cattle were weighed at weekly intervals and at that time, samples of rumen fluid were taken by stomatch tube.

Protozoa were counted using procedures described by Warner (1962). Proportions of volatile fatty acid in rumen fluid samples taken by stomach tube were estimated by gas–liquid chromatography (Leng & Leonard, 1965).

Table 1. *The effects of defaunation of cattle on VFA proportions in rumen fluid and on feed intake, growth and feed conversion ratio*

(Each value is the mean ± SE of nine animals. Each animal in Groups A and B were consuming approximately 3·3 kg molasses mixture and 1·5 kg cereal hay. Animals in Group C and D were each consuming approximately 3·7 kg molasses, 1·5 kg cereal hay and 240 g of protein pellets)

Group	Initial liveweight (kg)	No. of protozoa in rumen fluid† (10^{-5}/ml)	Per cent VFA in rumen fluid as				Mean dry matter intake (DMI) (kg/d)	Mean growth rate (g/d)		Feed conversion ratio (g DMI/g growth)
			Acetic	Propionic	Butyric	Others				
A	177 ± 9	2·6	55	17	24	4	3·76	451 ± 93	NS	8·3
B	178 ± 10	—	50	17	30	3	3·65	490 ± 59		7·4
C	176 ± 12	1·7	60	15	21	4	4·15	530 ± 61	*	7·8
D	185 ± 10	—	49	14	32	5	4·23	757 ± 61		5·6

NS, not significant, * significant at $P < 0{\cdot}05$.

† The mean numbers of the protozoal species present/ml were as follows for groups A and C respectively: *Isotricha* spp. $2{\cdot}7 \times 10^4$ and $2{\cdot}5 \times 10^4$; *Polyplastron* spp. $6{\cdot}7 \times 10^3$ and $8{\cdot}0 \times 10^3$; *Epidinium* spp. $2{\cdot}3 \times 10^4$ and $2{\cdot}2 \times 10^4$; *Entodinium* spp. $2{\cdot}0 \times 10^5$ and $1{\cdot}2 \times 10^5$. Four samples of rumen fluid were taken from all cattle over the experimental period and the results were averaged for each animal and then for each group.

RESULTS

The effects of defaunation

Feed intake growth, rate and feed conversion ratio for each treatment group are given in Table 1 together with VFA proportions and protozoal numbers in the rumen fluid. Addition of 240 g/d of a protein meal pellet to the basal diet increased the intake of molasses and growth of the cattle. In cattle on the molasses diet without protein supplementation defaunation had no significant effect on growth rate although there was a trend towards increased growth, However, in cattle on the basal diet supplemented with 240 g protein concentrate/d defaunation increased growth rate significantly ($P < 0{\cdot}05$) by 43% without apparently affecting molasses intake.

In both dietary groups, feed conversion ratio was apparently decreased in response to defaunation of the rumen.

The effects of defaunation on VFA proportions in rumen fluid

The mean proportions of acetate, propionate, butyrate and branched and higher fatty acids in rumen fluid taken by stomach tube from cattle are shown in Table 1. No significant differences were aparrent between dietary treatments but acetate proportions decreased and butyrate proportions increased significantly ($P < 0{\cdot}05$) in the animals treated to eliminate protozoa from the rumen.

DISCUSSION

These studies were carried out over 10 weeks which is a short period of time for growth studies with cattle; however, the animals were allowed 3 weeks of this period to adjust to the basal diet before the various treatments were begun and all animals were consuming considerable amounts of basal diet before allocation to the treatment group. The growth rates (450 g/d) in untreated cattle on the basal diets were a little higher than those (390 g/d) reported by Preston and his colleagues (Preston & Willis, 1970).

The antiprotozoal agent used here appeared to be very effective in eliminating protozoa in sheep (Bird, Baigent, Dixon & Leng, 1978). However, a number of cattle either had some residual protozoa or some contamination occurred and small numbers of protozoa appeared in some animals (less than 1% of the control group) in the second and third week of the growth trial. A further drenching of these animals resulted in no protozoa being present for the rest of the experiment. The feed intake of the cattle was depressed for 1–2 d after treatment. Although feed intakes were adjusted immediately following the initial dose of teric no attempt was made to adjust the feed intake of the control groups of cattle during the 7-week experimental period; all animals having free access at all times to molasses. The results given in Table 1 for live weight change in the defaunated animals can therefore be regarded as minimal values.

One animal died following drenching with 100 g teric and post mortem examination showed extensive damage to the capillary bed of the kidney. It is not certain that these symptoms were the effects of the teric. In the other animals hyper-excitability symptoms were observed for approximately 1 d after dosing.

The results demonstrate that the absence of protozoa in young cattle on these basal diets supplemented with protein resulted in increased growth and confirm results with growing lambs on low-protein diets (Bird *et al.* 1978).

In the groups of cattle given the supplement of bypass protein pellets, growth was increased significantly in response to defaunation. Feed intake increased in response to bypass protein but no apparent increase in feed intake occurred in response to defaunation at either level of bypass protein intake. This is surprising, since if removal of protozoa increased

the availability of protein at the duodenum, from the results reported here it should have increased feed intake. It is well established that bypass protein increases feed intake on this diet (Preston, 1972). A possible explanation of the increased efficiency of utilization of feed, and the lack of response in feed intake, is that the absence of protozoa may have enhanced both the availability of protein at the duodenum and energy nutrients from the rumen. This may maintain a relatively constant protein to energy ratio such that feed intake was unaffected.

Although protozoa were eliminated it cannot be discounted here that other changes in the rumen ecosystem brought about by the action of the terics resulted in some of the increased production.

The outstanding finding in this study is that in cattle on diets containing only minimal levels of bypass protein, growth rates were stimulated by 43% when the rumens of the animals were maintained substantially free of protozoa.

We wish to acknowledge the financial assistance of the Australian Meat Research Committee, the Dairy Research Committee and the Rural Credits Development Fund. Mr B. Cochran and Mr R. Woodgate are thanked for their valuable assistance.

REFERENCES

Abou Akkada, A. R. & el Shazeley, K. (1964). *Appl. Microbiol.* **12**, 384.
Bird, S., Baigent, D. R., Dixon, R. & Leng, R. A. (1978). *Proc. Aust. Soc. anim. Prod.* **12**, 137.
Christiansen, W. C., Kawashima, R. & Burroughs, W. (1965). *J. Anim. Sci.* **24**, 730.
Kempton, T. J., Nolan, J. V. & Leng, R. A. (1977). *World Anim. Rev.* **22**, 2.
Klopfenstein, T. J., Purser, D. B. & Tyznik, W. J. (1966). *J. Anim. Sci.* **25**, 765.
Leng, R. A. & Leonard, G. J. (1965). *Br. J. Nutr.* **19**, 469.
Leng, R. A. & Preston, T. R. (1976). *Trop. Anim. Prod.* **1**, 1.
Marty, R. J. & Preston, T. R. (1970). *Rev. Cuba. Cienc. Agric.* (Engl. ed.) **4**, 183.
Preston, T. R. (1972). *World Rev. Nutr. Dietet.* **17**, 250.
Preston, T. R. (1977). *Trop Anim. Prod.* **2**, 125.
Preston, T. R. & Willis, M. B. (1970). *Intensive Beef Production.* Oxford: Pergamon Press.
Warner, A. C. I. (1962). *J. gen. Microbiol.* **28**, 119.
Weller, R. A. & Pilgrim, A. F. (1974). *Br. J. Nutr.* **32**, 341.
Wright, D. E. & Curtis, M. W. (1976). *N.Z. J. agric. Res.* **19**, 23.

Printed in Great Britain