THE EFFECT OF LACTATION ON INTAKE IN THE DAIRY COW

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SUMMARY

A comparative study has been made of the voluntary intakes and productions of lactating and non-lactating identical twin cattle stall fed exclusively on fresh pasture herbage. Data were obtained for 36 weeks, commencing at calving, in both the 1960–61 and 1961–62 dairying seasons.

Both level and pattern of intake differed markedly within sets. Intake differences averaging approximately 50% were obtained in favour of the lactating twins.

A mean difference of 0.7 units was recorded in the apparent digestibility of the energy consumed, higher values being recorded by the non-lactating group in all but four weeks.

In neither group was a useful relation obtained between the apparent digestibility of the energy consumed and voluntary intake.

Results between and within both groups of cows emphasized the importances of differences in the physiology of the animal in determining level of intake under *ad lib.* feeding. Within-set differences in voluntary intake determined at the same time on identical pasture herbages averaged 131 kcal digestible energy per unit metabolic size during one of three 12-week sub-periods. This was equivalent to a difference of 1.65 lb D.M. per 100 lb liveweight.

These results have been discussed in relation to the requirements of feeding trials in which a measure of appetite is required. The inadequacy of currently available data on this subject is stressed.

INTRODUCTION

RECOGNITION OF THE additional food requirement which lactation imposes on animals is contained in standard tables of feed requirements for domestic animals. This is generally expressed as an amount additional to the maintenance ration. In *Bulletin 48* of the U.K. Ministry of Agriculture, Fisheries and Food (*Rations for Livestock*, 1960) it is recommended that an allowance be made of 0.25 lb starch equivalent (S.E.) per 1 lb fat corrected milk (F.C.M.) produced. In the U.S. National Research Council tables of nutrient requirements for dairy cattle (1956) a roughly comparable figure of 0.32 lb T.D.N. per lb F.C.M. is proposed. The input-output studies of Jensen *et al.* (1942)

indicated that a requirement of 0.46 lb T.D.N. per lb F.C.M. was necessary for attainment of yields in excess of 13,000 lb F.C.M. per cow per annum from stock of high genetic merit. Recently, Reid (1961) has proposed application of a progressive increase in feed allowances for milk production with values rising from 0.3 to 0.4 lb T.D.N. per lb F.C.M., as individual production increases from 1 to 6.5 gallons per day. This is based on the contention that Haecker's studies, from which the N.R.C. standards have largely been derived, were conducted on low-producing stock.

Regardless of the magnitude of the effect, there is therefore general agreement that a cow's appetite is stimulated by the increased needs of lactation and by level of productive performance. It follows that full expression of productive potential will depend very largely on the type of feedstuff available and the feeding level imposed.

It is, therefore, essential to obtain for all economically important feedstuffs a measure of the level of intake required to satisfy appetite and the relation that this has to productive requirements. This need has been recognized by Crampton *et al.* (1960) in their development of a nutritive value index (N.V.I.) for different feedstuffs, where they have attempted to make an appropriate allowance for appetite preferences. In a recent extension to their original concept, Crampton *et al.* (1962) have attempted to extend application of the N.V.I. by calculating its caloric equivalent, and applying it to the requirements of both sheep and cattle. This has necessitated the introduction of certain general assumptions. Of particular importance amongst these is the premise that the "expected intake" of a standard forage is relatively constant at 3 lb air dry weight per 100 lb liveweight for both beef and dairy cattle.

Data presented by Hutton (1962a) covering several part lactations of dairy cattle fed exclusively on fresh pasture herbage indicated, however, that such an approximation could result in a considerable underestimation of voluntary intake by the lactating animal. Additional evidence is now available that considerable systematic changes in feed consumption occur throughout lactation under conditions of voluntary intake where fresh pasture herbage is the sole feed source. Because of their importance in relation to systems of feed evaluation, it is proposed in this paper to present some of these data and to consider the nature and magnitude of changes in voluntary intake as they affect both lactating and non-lactating cattle.

MATERIALS AND METHODS

Information has been obtained from two series of experiments — one covering the 1960–61, the other the 1961–62 dairying season.

Animals

All were Jersey crossbred. Six sets of identical twins were available in 1960–61; 7 sets in 1961–62. Age distribution was as follows:

Age (Years)	*No. of Sets*
2	2
3	4
4	3
5	2
7	1
8	1

Each twin set comprised one lactating and one non-lactating member. Management of twin pairs during the dry period was aimed at minimizing within-pair differences in liveweight immediately after calving.

Feeding and Management

These have been outlined in detail by Hutton (1962a). They may be summarized as follows:

(a) Intakes and productions were measured continuously under stall feeding conditions from calving onwards for 36 weeks.
(b) All cows were fed to appetite on fresh pasture herbage cut once daily. Cows were fed weighed amounts of this material between 3 and 5 times daily according to the demand. Feed refusals varied between 15 and 20% of the green weight offered.
(c) All cows were accustomed to stall feeding before calving.
(d) Cows were milked twice daily, the same machine being used in both the ordinary feeding and the metabolism stalls.
(e) Cows were weighed each morning at the same time.
(f) When not feeding, cows were muzzled and given access to a bare paddock.

Estimation of Apparent Digestibility

In each season, three of the twin sets were maintained in the metabolism stalls for periods of two consecutive weeks and were replaced in alternate fortnights throughout the trial by another three sets. In addition to supplying information on changes in feed quality, this provided a measure of the ability of genetically identical animals to digest the same feed when either dry or lactating.

Analysis of Data

Intakes were measured in terms of herbage dry matter (D.M.), and as kilocalories (kcal) of gross and digestible energy. Data on feed intake, faecal and milk output and daily samples of each were aggregated for periods of one week. Heats of combustion of representative samples were determined directly by bomb calorimetry.

Most of the results comprise a study of the changes in weekly intake and production characteristics. For reasons which will become apparent, it has also been convenient at times to summarize some aspects of the data by dividing these between three successive 12-week periods.

Because of the high degree of similarity obtained in each season, it has been found convenient to combine both seasons' results in presenting these data.

RESULTS AND DISCUSSION

Gross Energy Intake (*kcal/cow/day*)

For the lactating cattle, lowest intakes were recorded immediately after calving (Fig. 1). Thereafter a steady increase occurred until about the 10th week and although subsequently the rate of increase slowed appreciably, maximum feed consumption was not achieved until the 21st week post-calving. The mean daily intake of approximately 60,000 kcal or 29 lb D.M. recorded at this stage is thus a measure of the physical capacity of this group of cattle

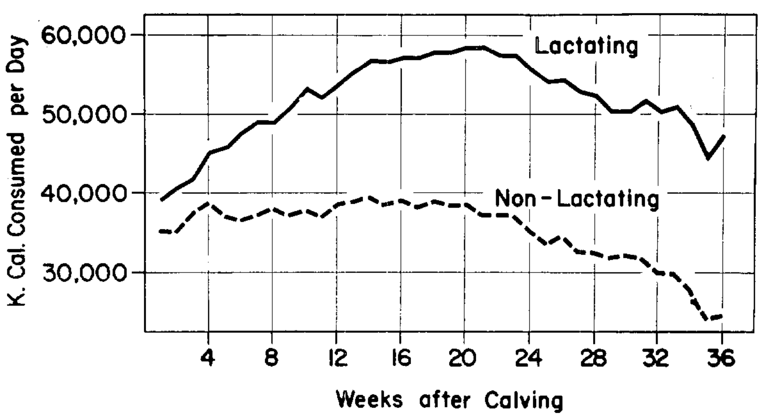

Fig. 1: Gross energy consumed by lactating and non-lactating cows.

for fresh pasture herbage. Intakes of this order were maintained for only a short period, being succeeded by a fairly continuous decline in feed consumption until the end of the trial. Even at this stage, however, the mean daily intake was approximately 20% higher than that for the first two weeks after calving, yet the stimulus of lactation is apparent in the difference between the intakes of dry and lactating cows by the middle of the first week after calving. That this increment is not associated with intra-set differences in body weight will become apparent later.

Apart from a sharp peak in feed consumption in the 4th week after their mates had calved, the intakes of the dry cattle showed a slow but steady increase to week 14. Then followed a period of slow decline with the rate quickening over the last 10 weeks. Intakes in the last few weeks were approximately 30% lower than at the start of the trial.

Obviously, appetite is stimulated in markedly different degrees by the separate demands of lactation, fattening and growth. For the lactating cows, a 50% rise in feed consumption had occurred by the end of the 5th month of lactation. The comparable increase for their co-twins was 13% achieved in 3½ months. In addition, the demands of milk production in late lactation maintained feed consumption relatively much higher at this stage than was apparent with the fattening animal.

The mean within-set difference in intake (16,600 kcal) calculated for the complete 36 week period was equivalent to 47% of the mean intake of non-lactating cows. This may be compared with a 28% difference between wet and dry sheep reported by Cook *et al.* (1961) under range conditions in Utah, and a 28% difference between lactating and dry beef cattle quoted by Elliot *et al.* (1961) under field grazing conditions in Rhodesia.

Apparent Digestibility of Herbage Energy

Changes in feed quality as assessed by the coefficients of apparent digestibility are contained in Fig. 2. To facilitate comparison of the intake and digestibility data for both groups, the full 36-week period has been divided into three 12-week periods and are set out in Table 1. A within-set difference in apparent digestibility averaging 0.7 percentage units in favour of the non-lactating group was obtained during the complete 36-week period. To explain this, it might be suggested that the large intake differences distinguishing the groups were responsible, since they could reasonably be expected to influence the rate of passage of

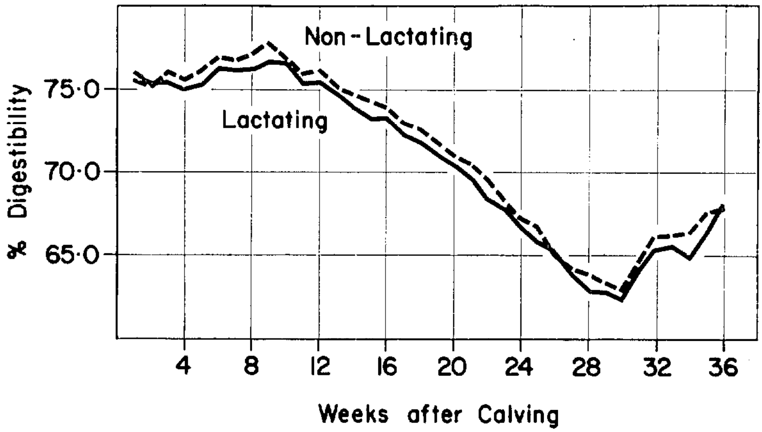

Fig. 2: Seasonal changes in apparent digestibility of the herbage energy — lactating and non-lactating groups.

feed residues through the gut. No quantitative relation of within-set differences in feed consumption to percentage digestibility was apparent, however.

Figure 3 provides very little evidence of a causal relation between the voluntary intake of the dry cows and herbage digestibility. This observation confirms evidence previously obtained (Hutton, 1962b). It has also been extended in the present trials to lactating cows and is not in accord with the findings of Blaxter (1960) and Blaxter *et al.* (1961).

Digestible Energy Intake

A comparison of Figs. 1, 2 and 4 will show that, because of a fall in herbage feeding value after week 9, the periods at which maximum intakes of gross and digestible energy

Table 1: Gross Energy Intake and % Digestibility (means for three 12-week periods)

Weeks	Lactating '000 kcal/cow /day	Lactating % dig.	Non-lactating '000 kcal/cow /day	Non-lactating % dig.
1 to 12	47.3	75.8	40.5	76.4
13 to 24	57.4	71.1	41.7	71.9
25 to 36	50.9	64.7	33.5	65.2

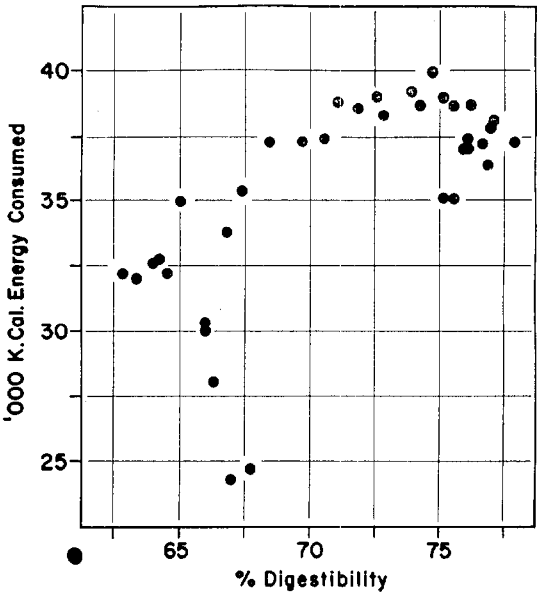

Fig. 3: Relation between voluntary intake of non-lactating cows and apparent digestibility of herbage energy.

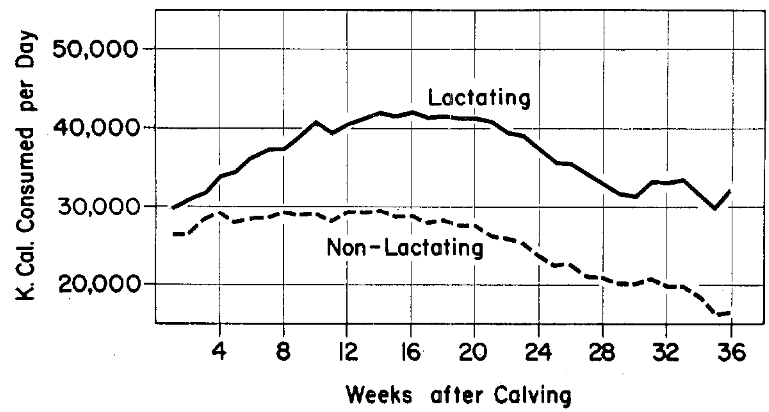

Fig. 4: Voluntary intake of digestible energy for lactating and non-lactating cows.

were achieved did not coincide. Instead, the latter was five weeks earlier for the lactating group. A peak intake of 29,000 kcal of digestible energy per day was achieved by their non-lactating twins by week 4 and was maintained with minor fluctuations for a further 12 weeks. In the later stages of the trial, the decline in herbage digestibility markedly reduced the size of the difference previously distinguishing the intakes of the milking cows at the beginning and end of the trial. Conversely, the corresponding differences for the dry cattle were accentuated by this trend.

As for gross energy, within-set differences in the intake of digestible energy were large, the mean difference for the complete trial (11,300 kcal) representing 45% of the average daily intake of cows in the non-lactating group.

INTAKE AND LACTATION

Peak milk yield was reached in the 6th week of lactation (Fig. 5). At this stage, gross energy intake was only 75% of the maximum intake established 15 weeks later. It is difficult to find a reason for the length of this interval between peak requirement and highest feed consumption, unless it represents the time required for repletion of body reserves used in very early lactation. Any adaptational period in which the cow accustoms herself to a quantitative change in diet could be expected to be much shorter than this. When intake was expressed in terms of digestible energy, the interval between peak intake and production was reduced to approximately 10 weeks. Nevertheless, for the following two months, during which a mean daily intake

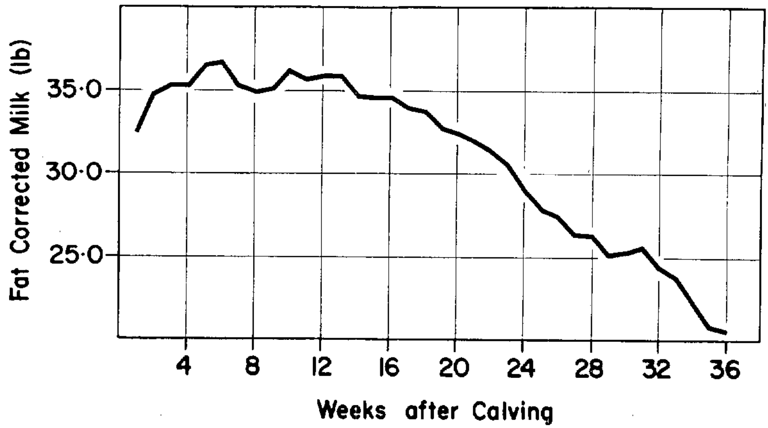

Fig. 5: Changes in milk production (lb/cow/day).

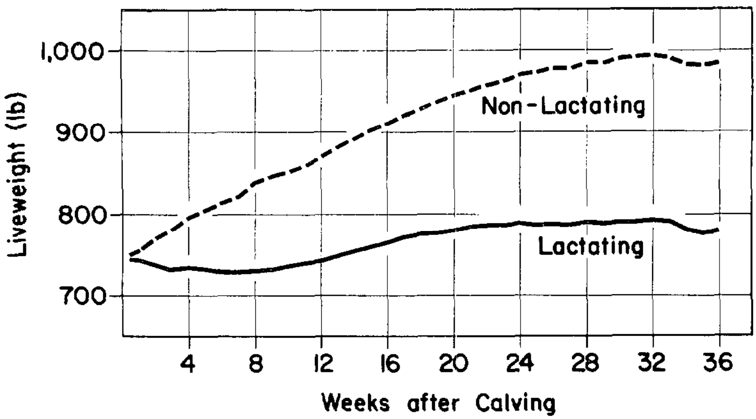

Fig. 6: Mean liveweights of lactating and non-lactating cows.

of about 41,000 kcal was maintained, a steady fall in milk yield occurred. Subsequently production fell at a faster rate despite a high digestible energy intake, and before stage of pregnancy effects normally become apparent.

Trends in intake during early lactation similar to those described above were observed by Wallace (1956) from field intake studies with dairy cattle.

Further evidence suggesting that such changes are not peculiar to cattle fed fresh pasture herbage *ad lib.* is contained in the work of Graves *et al.* (1938). These workers showed that Friesian cows given free choice, but fed solely on lucerne hay throughout two lactations, consumed 24% more dry matter in the 5th month of lactation than in the 1st month. This was despite falling milk production and body weight in the intervening period. More recently, Legates *et al.* (1956) reporting on the voluntary intake of cows fed hay *ad lib.* after receiving 40% of their maintenance needs from grain, suggested that D.M. consumption reached a maximum eight weeks after calving. Possible reasons for these changes were not advanced.

INTAKE AND LIVEWEIGHT

The familiar pattern of post-calving changes in liveweight for the milking cows is contained in Fig. 6. The success achieved in controlling within-set differences in true body weight during the pre-calving period can also be judged from the initial group difference. For the dry cows, highest intakes of digestible energy and rates of gain

TABLE 2: INTAKE AND PRODUCTION DATA

(MEANS FOR THREE 12-WEEK PERIODS)

LACTATING COWS

Weeks	F.C.M. lb/cow/day	L.W. (lb)	L.W.C. (lb/day)	D.E. Intake ('000 kcal/cow/day) Actual	Estimated	A–E	kcal D.E./lb $L.W.^{0.73}$/day	lb D.M. /100 lb L.W./day
1 to 12	35.3	735	0	35.9	34.3	1.6	291 ± 25	3.16 ± 0.32
13 to 24	33.0	773	0.5	40.8	36.1	4.7	319 ± 21	3.70 ± 0.31
25 to 36	24.7	786	—0.2	33.0	27.0	6.0	254 ± 19	3.24 ± 0.28

NON-LACTATING COWS

Weeks		L.W. (lb)	L.W.C. (lb/day)	D.E. Intake ('000 kcal/cow/day) Actual	Estimated	A–E	kcal D.E./lb $L.W.^{0.73}$/day	lb D.M. /100 lb L.W./day
1 to 12	....	818	1.5	28.4	20.7	7.7	212 ± 29	2.17 ± 0.30
13 to 24	....	930	1.1	27.5	21.0	6.5	188 ± 20	2.05 ± 0.24
25 to 36	....	984	0.1	20.0	15.3	4.7	131 ± 14	1.56 ± 0.21

averaging 1.5 lb/day were obtained during the first 12 weeks. During the succeeding 12 weeks, the mean intake of this group declined and rate of gain fell to 1.1 lb per day. Thereafter the changes in body weight were negligible.

Comparison of both intake and liveweight data for the lactating and dry cattle suggested that liveweight was less affected by change in intake, herbage digestibility and hence gut fill for the latter than for the former. Changes in liveweight amongst the dry cows could thus be interpreted with some degree of confidence. It appeared that, under the initial conditions of high intake, a rapid rate of growth and fattening was achieved. This was followed by a decline in appetite as a maximum degree of fatness was approached until finally intake was sufficient only for the maintenance of these very fat animals.

This interpretation implies that changes in voluntary intake are largely determined by alterations in the physiological requirement of the animal. Some qualification of this might be deemed necessary if it could be shown that the net availability of the digested nutrients declined in association with the fall in percentage digestibility apparent for much of the present trial. Had this been important, such a change might have been expected to show its greatest effect during the period of lowest digestibility. At this stage, some compensatory increase in D.M. intake might then have been anticipated. That this did not occur, suggests that limitations in the net availability of herbage energy were relatively unimportant to these animals at this particular stage of fatness. This conclusion requires testing, however, in circumstances in which differences in animal condition are unconfounded by differences in herbage quality.

In Table 2 actual intakes of digestible energy have been compared with estimates derived from feeding tables for both groups of cattle. Maintenance requirements were based on the intakes of fresh pasture herbage required to maintain non-lactating cattle at constant weight during 24 of the 36 weeks considered in this paper. The estimated maintenance requirement expressed as digestible energy (95 kcal/lb L.W.$^{0.73}$) is similar to values contained in standard tables of feed requirements. Allowances of 0.32 lb T.D.N. per lb F.C.M. and 2.8, 3.2 and 4.0 lb T.D.N. per lb L.W.C. were also made, the latter increasing with stage of fattening. As with similar comparisons (Wallace, 1961; Hutton, 1962a) large discrepancies between the actual and estimated values are apparent. For the milking cows, differences were smallest in the first weeks of lactation, actual values falling below estimated requirements during weeks 1 to 3. The magnitude of this difference was small, however, being accounted for by the loss of only 7 lb of body fat. Measurement of loss in body condition was not possible at this stage because of the associated complication of a steadily increasing intake. It is difficult to believe, however, that this was so small as to be equivalent to only 7 lb of body fat. This further emphasizes the limitations of the so-called feeding standards in their application to nutritional studies with pasture herbage when fed to appetite.

Of particular interest in this regard also, are the data contained in the two columns at the extreme right of Table 2. They emphasize the extent to which free choice of pasture herbage is influenced by major differences in the physiology of the dairy cow. Further, they indicate within the separate lactating and non-lactating groups that stage of lactation and degree of fatness are both related to level of voluntary intake. The size of the ratio D.M. consumed per 100 lb L.W. for each group and period is of considerable interest since it has been suggested that for cows and sheep fed to appetite this approaches a constant of 3.0 lb air dry feed per 100 lb L.W. These data do not support this contention. The extremely low values for the dry cattle indicate that it would be most unwise to generalize from these results to beef cattle of similar weight fed in the same manner. It must be concluded that a greater degree of standardization than has been practised hitherto should be applied to trials designed to measure the relative nutritive values of different feedstuffs. This is considered essential where animals are fed *ad lib.* and requires the experimenter to have a full appreciation of all factors likely to affect his results, particularly the contribution of the animal. Such information is not contained in standard feeding tables but will be obtained only from specifically designed trials.

As an approach to the important problem of accounting for the appetite factor in feed evaluation, these details of technique should obviously be considered first. The chances of later obtaining useful and repeatable standards will then be increased. This procedure appears potentially more profitable than attempting to calculate relative feeding values for these rather special conditions, from data supplied by trials designed for other purposes.

ACKNOWLEDGEMENTS

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DISCUSSION

DR D. J. MINSON: *The comparison between actual and estimated intakes in Table 2 suggests that the overseas feeding standards are too low. Is it not equally possible that the difference is caused by a lower utilization of grass digestible nutrients associated with a low proportion of propionic acid in the rumen?*

DR J. B. HUTTON: Overseas feeding standards assess various pasture herbages in terms of their T.D.N. and S.E. values. If we use these data to calculate the expected intakes of our cattle, we find they grossly underestimate the latter. The same standards provide information on intakes which it is anticipated will satisfy appetite requirements. These are expressed as lb air dry material/100 lb L.W. and have been derived from diets comprised mostly of hay but sometimes including small quantities of concentrates. If we use such data to estimate the probable intakes of our lactating cattle, again we underestimate intake, this time in respect of appetite potential. In the latter comparison it would be difficult to anticipate the nature of the rumen fermentation products from each diet. The concentration of propionic acid could well be higher in the rumen fluid of cows fed fresh pasture of high quality than from cows fed on even good quality hay. In any case, the significance of the proportions of the different rumen volatile fatty acids in relation to milk yield and composition is not clearly established and such discussion must be purely speculative.

DR G. ANDERSON: *In U.S.A. the level of winter feeding of beef animals can markedly influence the rate of spring and summer fattening on pasture. In Dr Hutton's work, might not pre-experimental differences in nutrition, brought about by one group being pregnant and the other non-pregnant, have influenced subsequent intake and production levels?*

DR HUTTON: The limited amount of information we have suggests that differences in the voluntary intakes of pregnant as compared with non-pregnant cattle are small. In the present experiments we tried to maintain the true body-weights of the pregnant (excluding foetus, uterus and contents) and non-pregnant twin members similar, to obtain animals of similar bodyweight and condition in the first week after calving. This should have effectively removed any possibility of effects of the type to which Dr Anderson alludes.

Q: *Is there any evidence that level of dry matter intake rises with increasing dry matter percentage of the pasture?*

DR HUTTON: There was no significant correlation in the present experiments.

Q: *Level of phosphorus in the feed may limit lactation. Was there any evidence of a pasture phosphorus deficiency?*

DR HUTTON: No. We have estimated P concentration in pasture herbage in other seasons. Always the intake of P was greatly in excess of estimated needs.

Q: *Does Dr Hutton think that his Fig. 3, showing the intakes of dry cattle, could be interpreted as showing a relatively constant level of intake at high levels of herbage digestibility, and that intake only declines once the digestibility of the herbage falls below a certain critical level?*

DR HUTTON: The relation shown in Fig. 3 is not good. I would hesitate to place any interpretation on it.

Q: *Has Dr Hutton any data on the intakes by lactating cows of two rations differing in nutritive value? This might help to explain the mechanisms involved in determining intake.*

DR HUTTON: No, I have no such data.

DR A. T. JOHNS: Has Dr. Hutton considered that the relationship between digestibility and intake shown in his Fig. 3 could be a real and meaningful one? Blaxter has suggested that intake does not increase with increasing digestibility above about 70%. For all we know, intake might decline where digestibility of the feed is very high.

DR HUTTON: This might be so. Figure 3 lends little support to this, however. Animal factors appear to have a greater modifying influence on voluntary intake than has been appreciated hitherto.