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COMPARISON OF FAECAL PIGMENTS AND FAECAL NITROGEN FOR THE ESTIMATION OF FEED-TO-FAECES RATIO OF PASTURE-FED CATTLE

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THE AMOUNT AND QUALITY of pasture herbage that grazing animals consume can best be determined indirectly. The intake value obtained from the harvesting of mowed strips or caged areas before and after grazing rarely agrees with the intake value estimated from the animal's maintenance and production needs. Probably clipping treatments are unreliable because animals do not harvest all of the available forage to a uniform height; instead they selectively graze the plants and portions of plants which they prefer. Both Saltonstall (1) and Hardison *et al.* (2) found that grazing animals selected forage higher in protein and lower in crude fibre or lignin than forage cut from the same pasture. Therefore, it is necessary to estimate the digestibility of grazed herbage by relating the concentration of some constituent of the faeces with the digestibility of the forage consumed. Several faecal indicators have been proposed but the faecal pigments (3) and faecal nitrogen (4, 5) have been most widely used. Except for the work of Raymond *et al.* (6), the relative accuracy of these two methods has not been reported.

The objectives of this experiment were:

- (1) To test under New Zealand conditions the regression formula of Reid *et al.* (3) for estimating forage digestibility from the concentration of faecal pigments.
- (2) To compare the relative accuracy of faecal pigments and faecal nitrogen for estimating the digestibility of pasture herbage.

Experimental Procedure

DIGESTIBILITY TRIAL

Six dry Jersey cows‡ have been fed continuously on harvested pasture herbage since mid-August, 1956. It is intended to continue the feeding as long as grass can be obtained this summer (1957). Results presented in this paper

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‡ A seventh cow was used the first week of the experiment.

cover the period, August 31 to December 20, 1956. The herbage was primarily a ryegrass/white clover mixture with various amounts of Yorkshire fog. Beginning August 31, the digestibility of the forage was determined by collecting the faeces in bags (7) from three of the six cows for one week. Each week or fortnight the cows were alternated for use in the experiment. The data presented in this paper represent 16 weekly trials and are expressed as per cent. digestible dry matter for evaluating the formula of Reid *et al.* (3) and as feed-to-faeces ratios when comparing the use of faecal pigments and faecal nitrogen for estimating forage digestibility.

CHEMICAL METHODS

Faecal pigments were determined by extracting with 85 per cent. acetone as proposed by Reid *et al.* (3, 8) except that the extraction was done in a dark box and all flasks were covered with black cloth. The optical density of the extract was measured in a Beckman spectrophotometer at wavelengths of 406μ and 415μ immediately after the extraction was completed. The average time lapse between weighing the sample of faeces and reading the optical density was 45 ± 15 minutes. The mean values obtained from this modified method are essentially the same as when the procedure of Reid *et al.* (3, 8) is followed, but doing the extraction in the dark decreases the standard error of the chemical determination.

Nitrogen was estimated on the undried and oven-dried faeces by the Kjeldahl procedure as modified by White *et al.* (9). Ash was determined by ignition of oven-dried samples in a muffle furnace at 580° C. for $1\frac{1}{2}$ hr.

All results are quoted on an organic matter basis except when applying the formula of Reid *et al.* (3) which relates per cent. digestible dry matter with concentration of faecal pigments.

Results and Discussion

ACCURACY OF FORMULA OF REID ET AL. (3) FOR PREDICTING DIGESTIBILITY OF FORAGE.

Reid *et al.* (3) derived a formula which relates the optical density (406μ) of the extract of faecal pigments with per cent. digestible dry matter. Early in the season when the digestibility of the forage was high and when the plants were entirely vegetative (no stems), the estimation of forage digestibility by their formula was similar to the measured values (Fig. 1). In mid-October, the flowering stalks of the grasses started to form and the digestibility began to decline slowly from the high value of 78.8 per cent. measured during the week ending October 11. From mid-October to December 20, the discrepancy between the measured digestibility and that calculated by the formula of Reid *et al.* (3) steadily increased.

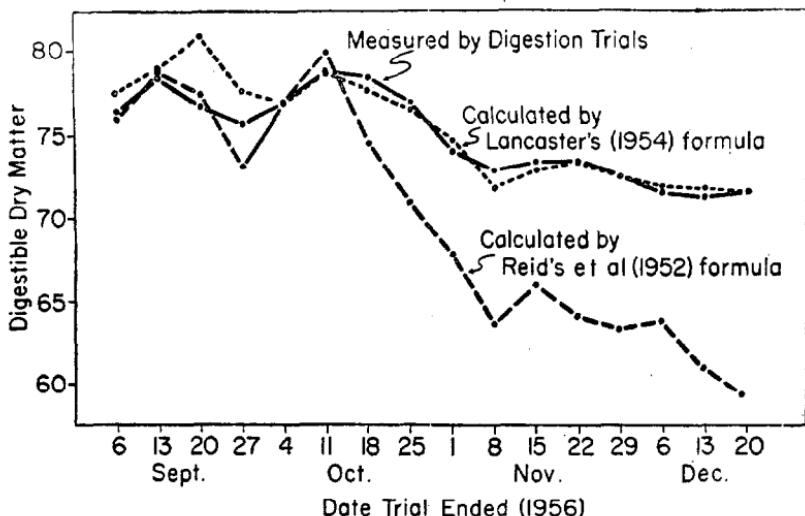


Fig. 1: Calculated and measured digestibilities for mixed pasture forage.

It is quite apparent that the formula derived from studies in north-east United States does not apply to this area of New Zealand.

The reason why the formula is not satisfactory under New Zealand conditions is probably due to the difference in rate of decline in forage digestibility between the two regions. In north-east United States, the digestibility of pasture forage in very early spring, when growth first commences after the dormant winter period, is near 80 per cent. Five to seven weeks later, the heads of grasses are emerging from the upper leaf sheaths and the digestibility is near 60 per cent. In New Zealand, the decline in digestibility is only about one-third this amount, while the drop in faecal pigment concentration is almost as great as observed in north-east United States.

The intake factor, calculated by the formula of Lancaster (5), was plotted on the same average scale as digestible dry matter in Fig. 1. The calculated values agreed very well with the measured values in 15 of the 16 trials. In the week ending September 9, faecal nitrogen over-estimated the digestibility of the forage by about 4 per cent.

COMPARISON OF FAECAL PIGMENTS AND FAECAL NITROGEN FOR ESTIMATING THE DIGESTIBILITY OF PASTURE FORAGE.

The relationships between the intake factor Y (amount of organic matter consumed divided by the amount of organic matter excreted in the faeces) and the concentration of faecal pigments X_1 , faecal nitrogen in undried faeces, X_2 , and faecal

nitrogen in oven-dried faeces, X_3 , are shown in Fig. 2, 3 and 4. Concentration of faecal pigments is expressed as optical density (415μ) of 1,000 ml. of extract per gram of organic matter. Nitrogen is quoted as per cent. nitrogen in the organic matter. The data are plotted on a very large scale; therefore, the discrepancies between the measured values and the calculated regression lines are accentuated.

All three constituents, faecal pigments and both types of faecal nitrogen, showed a linear relationship with the intake factor. The relationship of intake factor Y with concentration of faecal pigments X_1 , was slightly better than with the concentration of faecal nitrogen, X_2 and X_3 . The standard errors of predicting the intake factor Y from the concentration of each of the three constituents were 5.3 per cent. for faecal pigments; 5.6 per cent. for faecal nitrogen in undried faeces; and 6.1 per cent. for faecal nitrogen in oven-dried faeces. The latter value was 3.0 per cent. lower than what Lancaster (5) obtained with 22 digestion trials having a range in intake factors from 2.70 to 6.37. The standard error of prediction for faecal pigments is higher than that obtained by Reid *et al.* (3) from 18 digestion trials with forage ranging from 53.5 to 72.8 per cent. digestible dry matter but is lower than Raymond *et al.* (6) reported for 40 trials with forage having a range in

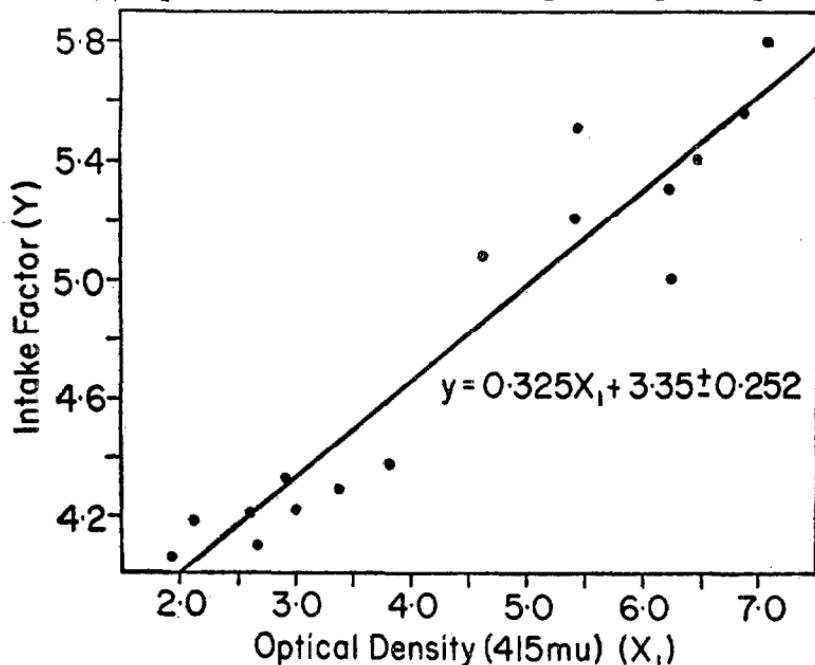


Fig. 2: The relationship between intake factor and faeces pigment.

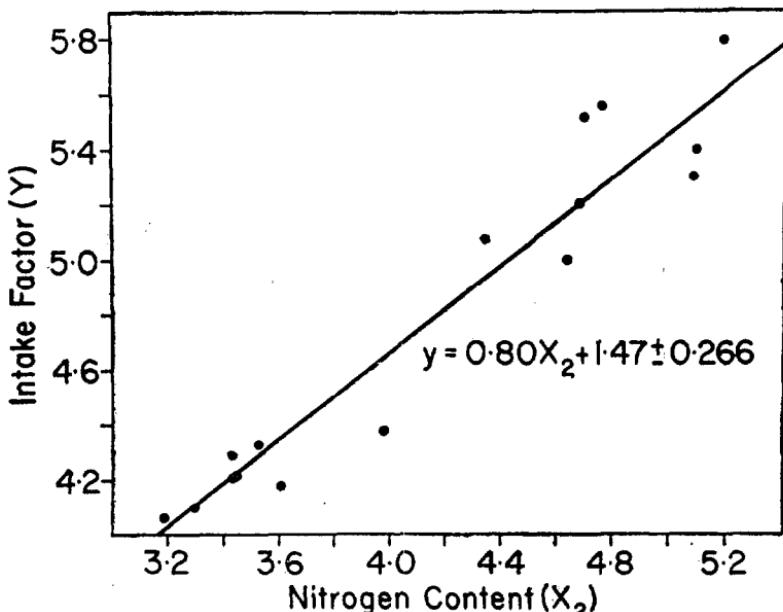


Fig. 3: The relationship between intake factor and faecal nitrogen—undried faeces.

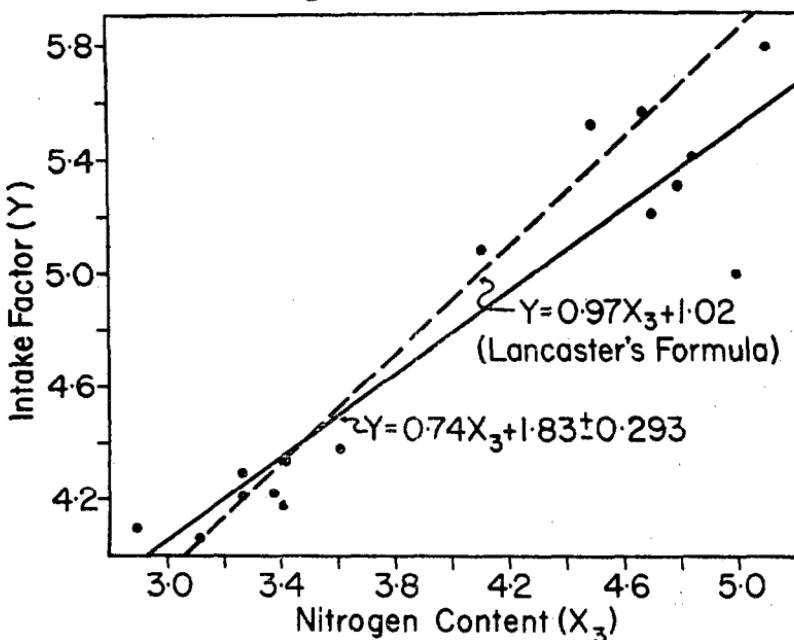


Fig. 4: The relationship between intake factor and faecal nitrogen—ovendried faeces.

intake factors from 2.35 to 6.37. The latter authors found that the standard error of prediction was slightly lower for faecal nitrogen undried faeces, than for faecal pigments.

While faecal pigments provided a slightly better regression equation for predicting the intake factor \bar{Y} than faecal nitrogen, it should be noted that the range in intake factors, 4.06 to 5.80, was relatively small and a wider range in forage digestibility might alter both the formulae and the standard errors of prediction.

Conclusions

- (1) The formula proposed by Reid *et al.* (3) for estimating forage digestibility from the concentration of faecal pigments is unsatisfactory for New Zealand conditions.
- (2) Concentration of faecal pigments does appear to be closely related to forage digestibility and with more data a suitable regression formula showing the relationship between intake factor and concentration of faecal pigment can be calculated.
- (3) Final conclusions regarding the relative accuracy of faecal pigments and faecal nitrogen for predicting the intake factor should be reserved until more data have been obtained. This experiment is being continued until May, 1957, and a final report will be made at that time.

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DISCUSSION

Q.: Dr. Kennedy has shown that one cannot directly apply a formula derived in America to New Zealand conditions without first checking its suitability in our particular environment. Faecal chromogens arise from the concentration of pigments present in the plant. A faecal nitrogen, on the other hand, is mainly a metabolic product of the animal and for this reason it is probable that the nitrogen method would apply over a wider range of conditions than the chromogen method.

A:: In the United States many people have adopted Reid's *et al.* formula without checking its accuracy for their particular environment. As just reported, probably some serious errors have resulted from this practice, but when Reid's *et al.* formula has been checked by other workers in the eastern portion of the United States the agreement between observed and calculated values has been excellent. At present we do not know which indicator, faecal pigment or faecal nitrogen, will apply over a wide range of conditions. Under conditions where the botanical composition of the pasture varies widely, the nitrogen method may not be as satisfactory as the faecal pigments for estimating the digestibility of pasture.

Q:: *I was interested in the discrepancy found by Cornell workers between the quality of the herbage grazed by the animal and that plucked by hand. When a field is grazed, most of the feed is eaten. Why, therefore, should there be such large differences between the quality of the feed eaten and that plucked?*

A:: Even where large herds of cattle are turned into a field so that almost complete defoliation is obtained, cows still do a great of selective grazing. Even under such conditions we are still unable to balance the nutrients present in pasture obtained by clipping and those which the animals must have obtained for their productive needs.

Q:: *Does the preference shown by stock for herbage containing a high proportion of protein still apply where pastures contain protein levels well above the needs of the animals?*

A:: I think it does. Stock seem to be very adept at plucking more succulent and more digestive parts of the pasture and these portions of the plant are very high in protein.

Q:: *I would agree with Dr. Kennedy that some form of indicator to measure intake is ideal for an individual cow but I cannot believe that plucking or the cage and strip method technique is so very far out.*

A:: I agree to differ, especially when trying to measure small differences. It is true an indicator could give an error of ± 12 per cent. but this is still lower than with the cage and strip technique.

Q:: *Assuming that the two methods described by Dr. Kennedy are equal in accuracy, is one method any advantage over the other in respect to the amount of work involved in its determination?*

A:: I would have to concede that the nitrogen method has definite advantages because most laboratories have the necessary equipment. However, from the point of view of the time involved, if it was necessary to organize one's technique to carry out a long-term programme, the faecal pigment method can be made reasonably competitive with the nitrogen technique.

Q:: *Could Dr. Kennedy suggest any modification of his technique so that it could be used by agrostologists in analysing grass directly?*

A:: There is a close relationship between the amount of faecal pigments in grass and that in faeces, but it is difficult to extract all of the pigments from the plant. At Oregon State College, Dr. Ritchie Cowan has been comparing the pigment content of different strains of tall fescue and has found large differences. At present he is determining the relationship between pigment concentration and the digestibility of this grass. If a good relationship exists, then we can probably modify the extraction procedure so that grass can be analysed.

Q:: *How could either of these techniques be applied when specimens such as silage, hay or crops are being fed in addition to pasture?*

R. J. LANCASTER:: We have been investigating this problem at Ruakura but so far there does not seem to be much hope of overcoming this difficulty.