Some Observations on the Use of the Movable Enclosure Method of Estimation of Pasture Consumption by Grazing Animals

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As you will have noticed, the title of my contribution to this symposium has two differences from that given to me and shown on the printed programme.

Firstly, I have steered away from any detailed consideration of theoretical feed requirements, and secondly I have left out the word individual in regard to animal ingestions. The reason for the first defection is the obvious one, and for the second is that in my work I have had no occasion yet to study in much detail the individual animal.

However, I do feel that there is a place for a general discussion on pasture yield measurements in the present symposium, and it is for that reason that I was very glad to be given the opportunity to bring this aspect forward.

What I wish to do is to stress the value of pasture measurements per se in all grazing trails, not only for their own value in giving a complete experimental picture when joined with the detailed animal studies, but also from their value as an internal check on specialised animal measurements.

But first of all I would like to congratulate Mr. Lancaster on his approach and his method of measuring animal intake by faecal analysis, and also the Ruakura team on the detailed work they are doing along this line. Only those of us who have had dealings with either or both ends of grazing animals, will really appreciate just how tricky such work is, and also how big a step forward it will be when we can reliably use data from one end, to get at figures for events at the other, and also to deal with a group of animals on a sound basis. Also it will be a great help in all pasture measurement work as most of our present techniques have their weaknesses and can stand a lot of checking.

I do feel, however, that we should not let any success with such indirect methods, lead us away from the necessity to continue with direct pasture measurements as well. The least that we will get is a check on the total ingestion of the group of grazing animals, and this in itself is worthwhile adjunct. But the greatest value of such a double approach is that we will get a much more complete picture from a single experiment.

Speaking to the Commonwealth Agriculture Conference in Adelaide in July last, Dr. McMeekan stressed this point and gave a graphic word picture of how Ruakura is integrating the pasture and animal sides into a complete farm-scale experimental set-up. This was followed by a gentle criticism by him of what he suggested as the one-track-mind approach of the agrostologist and of the veterinarian.

It is with his early statement that I fully agree and wish to emphasise. Needless to say there is much we could argue about in his

latter utterance. However, it is, of course, quite true that in much of our pasture work we have purposely or otherwise often subordinated the animal. Indeed we have been, and are extremely busy in trying to devise pasture measurement techniques which will eliminate the actual animal altogether, whilst at the same time retaining the very important effects of their presence on the sward.

It is always necessary to come back to actual grazing trials, however, and in spite of what Dr. McMeekan said we have carried out quite a large amount of such field-scale trials to this end. For this purpose many different methods have been tried for the pasture yield end. Of all these the movable frame enclosure has proved the best to date. This has applied not only in New Zealand but also in other countries working on quite separate problems (1).

There is no need to detail to this audience the various comparisons between methods of cutting areas prior to and after grazing, and between enclosures protected during grazings, or for the reasons to shift frames at each cutting, etc. Nor is there time for a consideration of the pros. and cons. of different methods of cutting the enclosed areas to get the fairest estimate of what the animals have eaten. At Grasslands we have mostly followed the practice of hand-cutting or plucking the herbage down to the same condition as left by the grazing animals. We appreciate fully that this introduces a risk due to possible bias on the part of the operators, and also there are possible weaknesses due to differential growth within the enclosures and the grazed area during grazing. This latter is probably greater with measurements of short herbage and under continuous grazing, than those of taller pasture and under rotational grazing. However, as it is with the latter type that we have mostly been dealing at Grasslands we have not as yet had very much cause for complaint. Another point is that great care is necessary to have sufficient frames in the paddock to overcome the variability of growth within the area. Such variability can itself change with different seasonal growth of the species within the sward, so that a paddock which is a simple sampling unit at one time can be a much more uneven proposition at another period of the year.

Over the past years a very large amount of useful information has been obtained by the use of the frame techniques in this country. At Grasslands we have made many strain, management and manurial comparisons in terms of dry matter and botanical and chemical composition. A similar approach has given the Department of Agriculture very valuable data on the effects of fertilisers, species, water, and climate, although they have used for the most part a slightly more detailed mowing technique in order to avoid the personal hand-cutting factor, against which they feel strongly (2). Between the field workers we have not yet been able to reach much agreement in this matter of different cutting methods, as very few of the above trials have included direct comparisons with animals or their products. Because of this it is very difficult if not almost impossible to check for bias in the various cutting processes. I understand, however, that Mr. Lynch has obtained quite good balances between some of his field data, and between estimations made on the grazing animals.

At Grasslands we have had some cases where the data from frame enclosure has been directly related to animal performance.

In the investigations into Feed Flavours in cream conducted some years ago we used frame enclosures on grazed swards of different botanical composition. Data from these grazing trials fitted very well with stall-feeding results, and were of direct value in defining flavour producing species (3). In the sheep nutrition experiments run in conjunction with Massey College (4) we obtained a reasonable agreement

between stock carrying and between pasture yields, although our field measurements were not sufficient in this case for a close comparison. An important part, however, in this trial was that largely from the botanical data from the cut enclosures, we were able to convince the workers on the animal side that the main thesis of the whole experiment was being departed from, owing to a strong invasion of **Poa trivialis,** and to suggest some management adjustments to bring the pastures back into true position. The important point is that in this experiment we had a constant check on the pasture composition and quality as well as in the stock under measurement.

Over the past ten years we have, at Grasslands, carried out a considerable programme of measuring the effects of dung and urine in the sward. One of the trials gave the opportunity to check pasture consumption estimated from enclosures, against the total excretion of dung and urine. The best set of balances we obtained was for the period December, 1940, to July, 1941, and was as follows: N 98%, Ca 102%, P 124%, K 100%.

This was on a "no return" treatment where we were collecting from all the sheep grazing on a pasture. Balances from some of the other treatments, especially where we collected from only a few sheep within a group, were not so good, the poorest balances being N 58%, Ca 75%, P 74%, and K 67%.

Our suggested reasons for some of the lack of agreement in the various balances are given in the report on this trial (5). In brief, however, our evidence pointed to the strong probability that most of the weaknesses lay in the collections and storage of the dung and urine, rather than in the pasture measurements.

In another trial I have in grogress at Grasslands (6) a comparison is being made between the seasonal spread and total pasture yields under different systems of pasture management. The four systems under trial are:—

(a) Rotational grazing with variable stock numbers.

(b) Hay and silage conservation and rotational grazing.

(c) Special purpose pastures under special rotational grazing.

(d) Crops and pastures in rotation.

The technique is that of a self-contained farming unit for each treatment. The stock used are young wethers with adjustments in numbers to meet the feed requirement curve of a high-producing dairy cow. This is, of course, not as good as using the actual cow, for several reasons, but it is the best we are able to do at present with the limited land and facilities at Grasslands.

In this trial the food consumptions and botanical and chemical compositions (crude protein and organic matter) have been estimated by the use of moveable enclosures in each paddock. From a parallel series of digestibility trials I have made an estimate of the digestibility of the various types of herbage, hay, silage and crops eaten on the four blocks (7) (8) and applied these factors to the field data of the trial. The animal requirements have been calculated from monthly weighings and using the standards given by Woodman in British Feeding Standards (9).

A comparison between the relative yields of the four blocks as determined by these two independent measurement methods is given in Table 1. The treatments are shown above, although they are, of course, only incidental to the discussion, as many other factors have to be considered in the actual comparisons between treatments. As the chemical analyses have not included fibre or fat determinations it is not

possible to make any adjusting calculations to reconcile the absolute figures for the digestibile organic matter with the calculated Starch equivalent requirements.

The evidence in these two very different experiments provides a reasonable basis for believing that, under good pasture growth conditions **with careful field work, and under rotational grazing with fairly good feed utilisation,** the technique with movable enclosures and hand cutting of the herbage does give a good picture of total animal intake. This is, of course, only as should be if the enclosures do actually represent a fair sample of what the animal consumes. The differences which the Ruakura team have found between ingestions calculated from faeces output and these from enclosures, however, cast a shadow over any complacency regarding the position.

The logical process is to question both methods of measurement and to seek the discrepancy. The calculations from the enclosures can be questioned from both the aspect of adequacy of numbers of enclosures per paddock, as well as bias or error in the cutting or plucking of the areas.

On the other side, with the faeces output method there are probably several factors also to be checked. One point did, however, occur to me which may perhaps apply in this question. One large difference in conditions between stall-feeding trials and actual grazing is that the grazing animal piddles on the pasture as it eats. This urine does not apparently affect the palatability of the herbage. The question is just how much does this alter the herbage, as of course there is no urine dropped in the enclosures, nor into feeding bins in stall-feeding trials. Calculations of the amount and frequency of sheep urination from trials at Grasslands, show that in a normal two-day grazing, approximately 1-12th to 1-10th of the paddock receives a shower of urine in a series of concentrated patches.

As a preliminary study we recently carried out two small trials at Grasslands. The first was a series of "dunkings" of herbage of different types, in urine to see how much is directly held by the leaves. The technique followed was to tie in a loose bundle the weighed fresh herbage and to immerse this completely in urine. The bundle was allowed to drain and the amount retained after five minutes was measured by simple difference. The results are shown in Table II. There is obviously quite a considerable retention by the leaves, and in the case of the dried-out herbage this was almost equal to the herbage weight. Much more work is obviously needed on this matter to get the full picture for different weather conditions and for different pasture types.

In the second trial we simulated sheep urine patches by taking areas of pure ryegrass and applying to them out of a watering can urine at the rate we calculated as the average for the sheep in our previous grazing trials, i.e. 220c.c. of urine per s. ft. Mr. Mangan, of the Plant Chemistry Laboratory, sampled this herbage and a parallel control, and analysed the herbage and washings for nitrogenous material, at short intervals. The results are shown in Table III. The data in the first part of the table are from an area to which was applied partly decomposed sheep urine of 1.52% total N, strengthened with urea up to a 2.31% total N, whilst the data in the second part are from a trial in which fresh cow urine (.77%N) was applied at the same rate. In both cases the pasture was stunted pure ryegrass, the herbage shown as ryegrass in the "dunking" series being from the same area.

Both series show the very large amount of nitrogen retained on the leaf, the rapid rise in soluble nitrogen within the leaf, presumably due to direct absorption through the leaf tissue as well as a rise per medium of the roots, and the later increase in the true protein of the leaf.

The nett result within these urine patches was thus a very considerable and rapid increase in the total nitrogen content of the herbage. As this is readily eaten by stock it follows that about 1-10th of the consumed food in a paddock could be of much greater N content than would be represented by the cuttings from enclosures. Just what this effect has on the nitrogen excretions of the animal or its digestion of the herbage I do not know, but I certainly feel the matter is worthy of study.

Whatever the verdict of this discussion is, however, I do hope that the Ruakura team will continue with their pasture measurements and will indeed enlarge them to include the botanical aspect. Not the least of the value from many of their trials would be the pasture story coming from the various treatments, and I hope that their lack of agreement between techniques will not put them off this valuable work.

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TABLE I.

Comparison of relative yields of farm management trial, Grasslands Division, Palmerston North, as measured by theoretical starch equivalent requirements of grazing stock (1) and by estimated consumption of digestible organic matter (2).

Period	Item	**Farmlet 1** Full utilisation of pasture	**Farmlet 2** Hay/Silage pasture	**Farmlet 3** Special purpose pastures	**Farmlet 4** Pasture crops
May, 1946	Relative S. E. Requirement	100	99	96	91
—July, 1947	Relative Consumption Dig. O.M.	100	91	97	82
August, 1947	Relative S. E. Requirement	100	90	86	72
—July, 1948	Relative Consumption Dig. O.M.	100	94	99	81
August, 1948	Relative S. E. Requirement	100	87	91	79
—July, 1949	Relative Consumption Dig. O.M.	100	88	89	79
August, 1949	Relative S. E. Requirement	100	88	89	102 (3)
—March, 1950	Relative Consumption Dig. O.M.	100	91	95	103
Totals	**Total** S.E. Requirement (lb.)	34200	31100	31000	29000
	Consumption Dig. O.M. (lb.)	37000	34600	35000	32000
March, 1946	Relative S.E. Requirement	100	91	91	85
—March, 1950	Consumption Dig. O.M.	100	91	95	85

(1) S.E. as calculated from sheep weights and from British Feeding Standards.

(2) Digestible organic matter as estimated from enclosure measurements, chemical analyses of this herbage, and from separate digestion trials.

(3) Changed from winter forage crops to summer forage crops.

TABLE II.

RETENTION OF URINE BY LEAVES OF DIFFERENT PASTURE SPECIES AFTER COMPLETE IMMERSION AND DRAINING FOR FIVE MINUTES.

Type of herbage	C.C. of urine held per 10 grs. fresh weight of herbage.			
	Trial 1	Trial 2	Trial 3	Average
Perennial ryegrass	3.6	3.8	3.4	3.6
White Clover	2.0	2.0	1.6	1.8
Red Clover	2.0	3.2	2.3	2.5
Plaintain (leaves only)	3.8			3.8
Dried out perennial ryegrass "foggage'	11.1	7.6	8.9	9.2

TABLE III.

Effect on nitrogen content of ryegrass pasture of applying urine at rate normally dropped by sheep during grazing. Analyses by Mr. J. Mangan, Plant Chemistry Laboratory, Palmerston North.

Trial period	Time after urine applied	Treatment	% N. of Dry weight of herbage			
			Wash. N	Sol. N	True Prot. N	Total N
12/4/50 to 17/4/50	5mins.	Control	.01	.26	2.02	2.30
		Urine	1.62	1.13	2.16	4.91
	4hrs.	Control	0.4	.28	2.05	2.37
		Urine	1.03	1.47	2.17	4.68
	24hrs.	Control	0.1	2.9	2.37	2.67
		Urnie	.44	1.59	2.30	4.33
	48hrs.	Control	.03	.31	2.22	2.57
		Urine	.36	1.58	2.42	4.35
	123hrs.	Control	.02 (1)	.28	2.18	2.48
		Urine	.03	1.13	2.75	3.92
18/4/50 to 12/4/50	5mins.	Control	.03	.33	2.19	2.54
		Urine	1.20	.59	2.27	4.06
	17hrs.	Control	.04	.31	2.27	2.62
		Urine	.40	.83	2.66	3.90
	46hrs.	Control	.05	.33	2.28	2.66
		Urine	.17	1.06	2.64	3.87
	70hrs.	Control	.05	.33	2.18	2.56
		Urine	.14	1.00	2.72	3.86

(1) Heavy rain between 48 hours and 123 hours.

Discussion on Symposium on Measurement of Feed Consumption

Prof. CAMPBELL: How difficult is the chromium estimation? Could a technician do it?

Mr. COUP: A good technician could do it.

Mr. MacFARLANE: Has the technique been used in sheep?

Mr. COUP: Studies on sheep are in progress at Ruakura.

Dr. CUNNINGHAM: Dr. Morice, while working at Wallaceville, found that with certain precautions the method could be used with sheep to show a dry matter content of faeces within about 5-7% of the true value. Uniform mixing of the gut contents and the faeces was a problem and it was necessary to dose twice a day with an "explosive" capsule made by mixing bicarbonate with the chromic oxide. The evolution of the carbon dioxide on contact with the rumen contents dispersed the oxide. Even with this precaution samples from single defaecation did not give a true mean chromium content. To get the accuracy stated, sheep had to be bagged and the greater part of the faeces collected for six days, The method, at the stage Dr. Morice reached, therefore had the advantage over the measurement of total dry weight of faeces in that loss from collecting bags could be neglected.

She found that the weight of stored faeces decreased presumably through oxidation by moulds. Storage with toluene prevented this and treatment with toluene was essential either for measuring dry matter content by direct weighing or by the chromium method.

Mr. ANDREWS: Has the use of monastral blue as a marker been abandoned?

Mr. COUP: This method is useful in sheep.

Mr. LANCASTER: There is little to choose between the chromium and the monastral blue methods but the latter substance has been in short supply.

Mr. CLARE: What number of men would be required to carry out a trial on 32 cows?

Mr. COUP: Seven operators including two analysts. If ready-made capsules were available this number could be reduced.

Dr. JACKS: What are the variations in metabolic nitrogen? Might not enzymes be used to separate the two fractions?

Mr. LANCASTER: There has been no attempt to determine metabolic nitrogen. There is no justification for assuming that it is constant though it is generally accepted as being constant.

Mr. CAMPBELL: What differences are there between animals in selecting pasture of different nitrogen content?

Mr. HANCOCK: There is a difference which is best seen under hard grazing conditions. The magnitude of the differences shown in this paper cannot all be ascribed to differences due to selective grazing.

Dr. CUNNINGHAM: What is the accuracy of the estimate of intake of a single animal?

Mr. LANCASTER: Plus or minus 18% for single animals but my figure of 3% for groups is possibly too low.

Mr. DICK: Eighteen per cent. is a very great improvement on what was possible previously.

Prof. CAMPBELL: Can this method be used for estimating the amount of pasture eaten by animals on a milk-pasture mixture when the amount of milk is known?

Mr. LANCASTER: The method would not work with calves on a milk-pasture ration. An attempt is being made to measure the pasture eaten on a silage and pasture mixture. The nitrogen may fail but some other method such as the lignin method may work.

Prof. CAMPBELL: Is there any correlation between the figures for intake and the grazing time? In the theoretical estimate was there any allowance made for grazing?

Mr. PERCIVAL: No allowance was made for grazing.

Mr. DICK: Was the theoretical requirement obtained from the use of the frame technique? Might this not be a vicious circle?

Mr. PERCIVAL: The theoretical figures were from Morrison's Standards and were derived from indoor work.

Mr. LAMBOURNE: As the difference between the two methods was greater in the late summer might it not be that the metabolic nitrogen was higher when the cows were losing weight?

Mr. PERCIVAL: These cows were 2-year-olds and showed an increase in weight.

Dr. WALLACE: The difference is too great to be due to differences in the digestibility figures but it is due to the high estimate of the output of faeces as the season advanced.

Prof. CAMPBELL: What type of season was it?

Mr. PERCIVAL: The 1948-49 season was one with good growth throughout the summer.

Mr. LANCASTER: In the spring, requirements force up the appetite and when requirement fall away does the appetite follow or is it maintained at a higher level?

Mr. PERCIVAL: The intake of pasture in the spring may be limited by the low dry matter of the grass.

Dr. McMEEKAN: We have no accurate standards against which to check these three methods. The chromium-nitrogen method may be accurate and the frame method and the theoretical figure may be wrong. It appears that cows do eat less in the summer. We know that cows produce well under very adverse conditions and one's estimate of consumption may be quite erroneous.

Miss BARTRUM: How was the grass fed to the sheep? Was it at a constant dry weight per day or on a constant wet weight per day? It is important in calculating digestibility in grazing animals where the pasture is rapidly changing in composition. The results apply to grazing sheep only if they eat a constant amount.

Mr. PERCIVAL: We fed the pasture cut from the frames and it varied from day to day. It was fed to one or two sheep depending on the amount available.

Dr. WALLACE: We cannot accept this theoretical curve as there is no correction for exercise and it is based on 3.5lb. T.D.N. per lb. live weight gain. These animals were pregnant so that the gain might be largely fluid, in which case the gains would be made economically or on the other hand, as embryonic tissues have a high metabolic rate, the gains might have been less economically. We simply do not know. The conversion to T.D.N. for feeds of different quality at different times of the year may not give a good measure of the value of the feed. It was developed under entirely different conditions.

Mr. CAMPBELL: No mention of the quality of the protein has been made. Perhaps Dr. Melville could enlighten us.

Dr. MELVILLE: We do not know what is in the grass, we do not know what happens to it in the animal, and we do not know what the conditions are in the different parts of the gut. From the practical aspect of intake measurement it is a useful tool..

Mr. BRUCE LEVY: At the International Grasslands Conference emphasis was placed on pasture measurement techniques. At the next conference it would be very appropriate to have papers such as these from New Zealand. What is the labour required for each method? Why is dung taken as the criterion of nitrogen content rather than urine?

Mr. PERCIVAL: The frames require 2-4 man-hours to cut. Two men are required to feed the sheep, but they can do other work as well. In the chromium-nitrogen method two men are occupied at each milking dosing capsules and taking faeces samples. One man can bulk 60 samples in four hours. The operators prefer the latter method.

Dr. WALLACE: One method gives group intake and the other gives a wealth of information that can be used for other purposes.

Mr. LANCASTER: Dung is used because there is a fairly uniform output for the amount of grass eaten. How soon was the urine-soiled grass eaten and what was the method of protein analysis?

Mr. SEARS: Fairly soon. Not as crude as crude protein but not as true as true protein.

Mr. CARTER: What is the place of other methods such as lignin and chromagen?

Mr. LANCASTER: The lignin ratio method is not very satisfactory. The concentration increases in the grass as the indigestible material increases. The concentration is relatively constant in faeces irrespective of the digestibility. Lignin may be useful in that there is a close correlation between its content in the grass and the digestibility of the grass. This, however, would require sampling the grass.

Mrs. ALTON: What is the effect of seasonal changes in the nitrogen content of the grass.

Mr. LANCASTER: There would be no effect as this would be taken care of in the regression equation.

Mr. CLARE: To do the chemical side of the chromium-nitrogen method would require one analyst and one technician on 40 hours per week and the field side would involve two hours per day on a seven-day week.

Mr. COUP: I suggested one chemist, one technician and three unqualified assistants.