GRAZED PASTURE PARAMETERS: DEAD HERBAGE, NET GAIN AND UTILIZATION OF PASTURE

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SUMMARY

The pattern of accumulation of dead herbage in pastures grazed by dairy cows under two management systems, continuous and rotational grazing, at two stocking rates, 0.95 and 1.19 cows per acre, is demonstrated. Because of the large amounts of dead herbage which may decay, it is proposed that net gain of available dry matter (A.D.M.) rather than absolute pasture production is the parameter of importance to the grazing animal. The autumn flush, when expressed in terms of net gain of A.D.M., is negligible. It is suggested that the pasture growth in autumn benefits the grazing animal more through increased pasture quality than through any increase in available pasture dry matter. Utilization of pasture at each grazing in the rotational system and between successive fortnightly samplings in the continuous grazing system was found to be of the order of only 20 to 25%. These findings are discussed in relation to critical Leaf Area Index, the summer slump of pasture growth, and grazing management.

INTRODUCTION

THIS PAPER introduces dead herbage as a neglected constituent of the grazed dairy pasture and attempts to show how this dead herbage may necessitate modification of the conventional pasture production and utilization parameters if a realistic evaluation is to be made of the nutritional environment of the grazing animal.

EXPERIMENTAL

The data assembled here were obtained when examining pasture production and utilization under the two grazing management systems and stocking rates at No. 2 Dairy, Ruakura. The four treatments are summarized in Table 1 and a fuller description may be obtained from McMeekan and Walshe (1963).

For the purpose of measuring the pasture parameters, two miniature replicates of both UL and UH treatments were laid down, each grazed continuously by a single cow close to the average liveweight and production of their respective main herds. The areas of the replicates were such as to give the appropriate stocking rates.

TABLE 1: SUMMARY OF GRAZING TREATMENTS

Symbol	*Cows/Acre*	*Grazing Management*	*Conservation Programme*
CL	0.95	Controlled Rotational	29–34% S*
		round	11–16% H
CH	1.19	15 paddocks	35–50% ASP
UL	0.95	Set-stocked	18–21% H
		Day & night	No S
UH	1.19	paddocks	No ASP

* Percentage of farm area closed for S=silage, H=hay, ASP= autumn-saved pasture.

Four replicates of the CL and CH treatments were also laid down, each grazed by two cows every time selected "indicator" paddocks on the main CL and CH farms of No. 2 Dairy were grazed by the main experimental milking herds.

The areas of these replicates were equivalent to the average area grazed by two cows in a paddock of average size on the main CL or CH farms.

Five pre-grazing and five post-grazing random sample cuts were made as close to ground level as possible, with a Tarpen hedge trimmer on previously uncut areas in the C treatments for the estimation of D.M. yield. Production and consumption were thus estimated from the appropriate differences at each grazing over a period of three years.

In the U treatments, 5 similar cuts were made inside and outside exclosure cages at fortnightly intervals. The cages were moved every 2 weeks to random areas on the grazed pasture.

Thus the pasture growth estimated was that above Tarpen cutting height (about ¾ in. above soil level) on a previously grazed area of pasture. It was not re-growth above trimming height upon an area previously trimmed. The technique chosen was considered to be the most realistic for the measurement of grazed pastures, if not the least variable.

No silage or hay was made on the miniature, replicated pasture trial plots but when areas were closed for silage and hay on the main farms grazing pressure was increased on the grassland experiment to the level of that on the grazed areas of the main farms.

Botanical separation of herbage from a sub-sample of the bulked material from each set of 5 plot samples was carried out at the Herbage Laboratory of Rukuhia Soil Research Station. One of the categories into which the pasture samples were separated was dead herbage.

Dead Herbage

With the foregoing necessarily brief experimental background, it is proposed to consider first of all the dead herbage found in these grazed dairying pastures. This is one feature of the grazed sward which has been largely neglected, although its implications are clearly important for animal health through, say, *Pithomyces chartarum* and facial eczema, and for animal nutrition because of the presumably low feeding value of dead material.

In this environment dead herbage may be presumed to be a reflection of poor utilization, inasmuch as pasture not harvested will age and die. The above treatments can be arranged intuitively in order of declining utilization with CH having highest utilization, CL and UH probably being similar and intermediate, and UL having the lowest utilization. From Fig. 1 it may be seen that yield of dead herbage, expressed as lb D.M. per acre, is in the reverse order to the expected intensity of utilization — CH has least dead material and UL most. Several further points are worth making in connection with these data.

(1) Figure 1 underestimates the absolute situation. The samples cut for herbage analysis left a stubble of 400 to 500 lb D.M. per acre. Since dead material tends to be concentrated in the bottom of the pasture, it would be realistic to add 200 to 300 lb D.M. to the summer and autumn data presented, to obtain an absolute figure.

(2) It is most important to appreciate that Fig. 1 petrifies a dynamic process. Thus, the dead herbage of December may have partly or totally decayed before the January or February data were collected. To the extent that this happens the monthly points will be additive. In other words, 1,400 lb of dead herbage in the UL treatment is merely the average of the amounts present on the sampling dates in February over three years. The average annual total yield of dead herbage in this treatment is probably much greater than 1,400 lb.

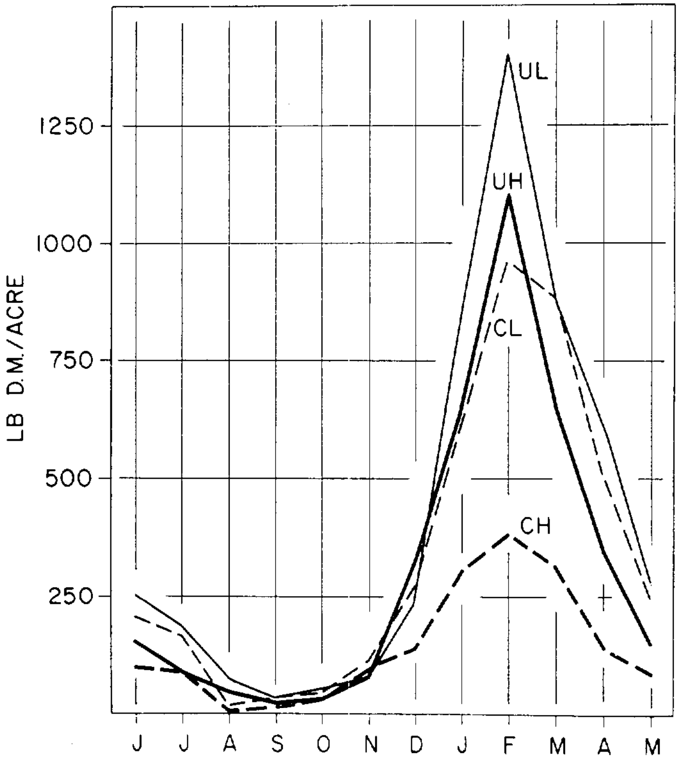

Fig. 1: Yield of dead herbage at all sampling dates in each month averaged over 3 years.

(3) The "light" stocking rates under which these large accumulations of dead herbage took place are still comparatively heavy by industry standards. If the inferred relationship between low utilization and high amounts of dead herbage holds good, the average monthly values of dead herbage in pastures throughout the dairy industry would probably be higher.

(4) Although the CH treatment, involving a combination of high stocking rate and a high degree of silage and hay conservation, reduced the absolute amount of dead material to almost one quarter of that in the UL treatment in February, this was largely through a reduction in total available herbage. Dead herbage comprised about 36% of the CH and 49% of the UL available D.M. in February. It may be that the cows on the CH treat-

ment were no better off from a nutritional viewpoint than those on UL, although dead herbage yield was much lower, because the total herbage available to the CH cows was also much less, and at this lower level of available dry matter their opportunities to graze selectively would be less.

Having established the point that much dead herbage accumulates in pastures during the summer, it is pertinent to consider the parameter "pasture production" upon the measurement of which much reliance tends to be placed in evaluating strains and species of pasture plants and, ultimately, grazing systems themselves.

Pasture Production

Certainly in a controlled or rotational grazing system, but also less obviously under set-stocked conditions, the feed supply of the animal is determined not so much by the absolute production of the pasture as it is by the amount by which gains in feed through pasture growth are offset by losses through pasture decay. That is to say, it is the net change — net gain or net loss — between one grazing and the next which determines the amount of pasture which will be available to the animal for grazing when it goes into a fresh paddock, or in the set-stocked system when the animal returns to graze an area untouched for a period of time.

It is, in effect, this parameter of net change in available D.M. which was measured by the technique employed in this experiment.

Conventional pasture production curves obtained from pasture mowing trials have been extensively employed in the past to show the relationship between feed supply and animal requirements (Lees, 1949; McMeekan, 1953). Such curves all show a sizeable and very reassuring hump of autumn flush pasture dry matter production which can be saved for winter feed. However, the net change in available D.M. curves from the present experiment are rather less reassuring (Fig. 2). The pattern of the curves was quite consistent between years, so only average curves of three years' data are presented here. In the control grazed treatments there is indeed a slight increase from February to March in the rate of net gain, but it is of the order of only 300 lb D.M. for the month — about one-third of the D.M. left behind in the stubble of a silage crop. The more intensive is the previous use of the pasture, the greater in

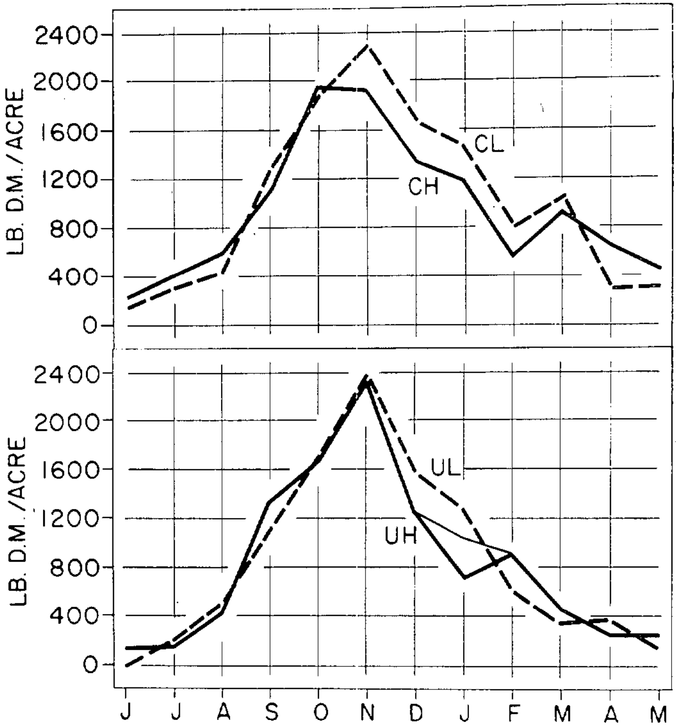

Fig. 2: Curves of net gain of available dry matter in each month averaged over 3 years.

absolute terms is the difference in the rate of net gain between February and March. The set-stocked pastures, although as heavily stocked as the controlled, had no silage made from them so that their overall intensity of use was lower. These show no sign whatever of a conventional autumn flush. The February peak in UH is too early to be an autumn flush and is caused by unaccountably large net losses in one replicate in January of one year. If this replicate's data for January in that one year be excluded, the remaining five-sixths of the data would follow the diminished solid line.

It would seem, then, from these data that only when utilization is very high — higher, probably, than normally occurs in dairy farming practice — is there any likelihood of the rate of net gain of available pasture D.M. increasing in the autumn. And even at high levels of utilization the autumn flush enhances the feed D.M. situation only very slightly.

Each year, of course, despite its illusory nature, the farmer eagerly awaits and clearly sees the autumn flush. Moreover, he saves it for winter feed. The apparent anomaly must be explained by quite large losses of older herbage of small volume but high D.M.% and its replacement by new growth of lower D.M.% and, consequently, greater volume.

From these data it would seem that the benefit of the autumn flush to the grazing animal probably lies substantially in the higher nutritive value of the autumn pasture. The autumn flush in a grazed pasture may well be primarily a nutritional flush and only to a very small and uncertain degree a dry matter flush.

Pasture Utilization

It is evident that pasture not utilized by the grazing animal will not yield animal products. It follows that, in any grazing study, the ability to measure pasture utilization is almost as important as the ability to measure pasture production or, more properly, net gain of available pasture dry matter. Yet the techniques for doing so can give equivocal answers.

The reverse use of feeding standards to predict what the utilization has been depends on the assessment of nutritive requirements per unit of animal output. Recent authoritative estimates of butterfat production from, say, 10,000 lb pasture D.M. show little unanimity. Wallace (1961) estimates 700 lb butterfat from 20,000 lb pasture D.M. and presumably a half of that, or 350 lb fat, from 10,000 lb pasture D.M., using highly efficient cows. Hutton (1963) proposes a range of from 357 lb fat for cows of 10% efficiency to 713 lb fat for cows of 30% efficiency, again from 10,000 lb pasture D.M.

An added complication is that a pound of D.M. may be more valuable for production at one season — *e.g.*, at calving — than at another — *e.g.*, at the end of lactation.

Unfortunately, direct measurement of pasture disappearance under grazing by pre- and post-grazing sampling techniques has its difficulties also.

By direct pasture measurement *via* sample cuts before and after each grazing or inside and outside exclosure cages on the same sampling date, the disappearance of pasture (largely through animal consumption) may be estimated, and the annual percentage utilization derived from the ratio:

$$\frac{D_1+D_2+D_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad D_n}{R_0+NG_1+NG_2+NG_3 \quad . \quad . \quad . \quad . \quad NG_n} \times \frac{100}{1}$$

where

D is estimated disappearance of pasture D.M. at grazings 1 to n.

R_0 is the residue of pasture D.M. from earlier grazings carried forward at the start of the grazing year.

NG is the estimated pasture D.M. net gain in the resting periods immediately prior to grazings 1 to n.

Annual percentages of utilization derived in this fashion for the four treatments outlined previously are presented in Table 2. Percentage utilization is high in all cases and the differences between treatments frequently seem too small, and in at least one case the reverse of what would be expected, in view of the differences in the stocking rates and management.

TABLE 2: ANNUAL PERCENTAGE PASTURE UTILIZATION

	1958-59	*1959-60*	*1960-61*
CL	88.8	94.4	98.2
CH	97.2	96.2	99.7
UL	88.7	88.7	96.6
UH	97.3	90.5	95.6

Again the explanation of these unconformities probably lies in the decay of herbage allowed to reach a stage of maturity at which it dies. Thus, pasture grown and contributing to the net gain in, say, periods 1, 2 and 3 which is not consumed in these or subsequent periods will age, die and eventually decay, so reducing the net gain in later periods. At the end of a year, by this process, the sum of the net gains and the disappearances will tend to be equalized and differences between treatments will be due largely to differences in the R_0 factor.

This difficulty led to an attempt to devise another and more meaningful parameter employing the same data. The result has been a utilization figure which separates the treatments, places them in a more logical order, and, incidentally, sheds unexpected new light on the grazing situation.

The measurement here is of that proportion of the pasture D.M. available to the stock when they enter a fresh paddock which is utilized before they move on to a new paddock or, in the case of the set-stocked treatments, the proportion of the inside cage sample which has been consumed between the fortnightly sampling dates (as estimated from the difference between inside and outside cage samples on the same date).

The ratio here is simply

$$D/(R+NG)\times 100/1$$

where

D is difference between pre- and post-grazing (or inside and outside cage cuts), and

$R+NG$ is the available D.M. at the start of each grazing (or inside cage samples after a period of continuous grazing), being composed of residues of previous grazings plus the net gain in the period prior to the grazing.

Annual weighted averages of the utilization at each grazing (expressed as percentages) have been derived and are given in Table 3.

TABLE 3: AVERAGE PERCENTAGE UTILIZATION AT EACH GRAZING (C) OR FORTNIGHTLY SAMPLING (U)

	1958-59	*1959-60*	*1960-61*
CL	19.7	19.7	32.3
CH	30.8	31.3	37.6
UL	20.2	16.7	22.2
UH	24.9	19.5	24.1

Apart from the discrepancy between CL and UL in 1958–59 the ranking of the treatments and the magnitude of the differences between them is more reasonable than those in Table 2. A fuller discussion of these data will be presented elsewhere. For the purposes of this paper attention need only be drawn to the unexpectedly low magnitude of these average utilizations per grazing.

The average percentage utilization per grazing (or per fortnight in U treatments) over all treatments and years is 25.75%. This is an overestimate of the absolute utilization because the sample cutting technique used to estimate the available dry matter left a stubble of 400 to 500 lb D.M. per acre. If an allowance is made for this, the average absolute utilization per grazing would be about 21%. Remembering that the low stocking rate employed here was still quite high, the probability is that the absolute utilization of available D.M. per grazing in the dairy industry must be below 20% on average throughout the year.

DISCUSSION

Three interrelated parameters derived from grazed dairying pastures have been presented.

Dead herbage accumulated until, in mid-summer, 40 to 50% of the pasture D.M. available for grazing was dead. Increasing the intensity of utilization decreased the weight of this dead herbage present but reduced its proportion in the pasture relatively little. Apart from the obvious nutritional and disease (facial eczema) implications of this dead herbage, it seems probable that by its presence it also affects pasture growth. Thus a high proportion of the incident light which is intercepted by the pasture is being intercepted by dead herbage which is just as incapable of photosynthesis as bare ground. Furthermore, the presence of such large amounts of dead herbage implies the presence of substantial amounts of senescent but still green herbage which has passed its peak of photosynthetic efficiency. Here, without denying the efficacy of irrigation, is another possible factor contributing to the summer slump in pasture growth.

Some part of this dead herbage almost certainly decays and thereby reduces the amount of D.M. available to the grazing animal. This being so, data of absolute pasture production are of less immediate interest to the grazing animal than are the net changes in the feed supply. Particularly in autumn, when decay seems to be most rapid and extensive, absolute production measurements may give an unduly optimistic picture of the changes in the quantitative feed situation. Except where utilization in spring and summer has been very high, the grazing animal is probably not faced with an autumn flush in quantitative but only in qualitative terms. Methods devised for the management of the feed supply in autumn may be effective, but if they are the best that can be devised they are probably right for the wrong reasons.

The percentage utilization at each grazing in the C treatments and over fortnightly periods in the U treatments is quite low, and not very dissimilar between C and U treatments. Other forms of rotational grazing might yield different results. To give an extreme example, Linehan and Lowe (1946) found 80% utilization at each grazing employing an alternation between two paddocks every 13 days on average.

At this low level of periodic utilization, dead material accumulated in quite large amounts except where stocking rates and conservation levels were high (CH).

If these low levels of periodic utilization are sufficient to impair the Leaf Area Index (L.A.I.) (Brougham, 1956) critical for complete light interception, still lower periodic utilization will allow the accumulation of more dead material. This in turn will lead to losses in nutritive value, losses through decay, and losses through light interception by senescent and dead herbage.

On the other hand, these low levels of periodic utilization may indicate that L.A.I. is not likely to be reduced below the critical level by current forms of grazing management. Clearly there is a need to know more about this critical L.A.I., and the penalties to be expected from transgressing to either side of this dimly lighted path. Do the losses incurred by reducing light interception below optimum exceed those incurred by allowing dead material to accumulate? The dilemma, at least, is apparent.

Dead herbage, net change in available D.M., and utilization at each grazing probably interact even more extensively than has been suggested here, and progress in unravelling the complexities of the situation is likely to be slow until techniques are devised for the measurement of losses through decay.

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DISCUSSION

P. B. LYNCH: *Could Mr Campbell give more details of the dead matter to which he refers? In summer on uncontrolled grazing the dead matter would be stalky — at other times it would be dead leaf of presumably different nutritive value.*

I would also like to point out that the autumn flush is a most variable feature of pasture production and question if Mr Campbell's sample of years is adequate to comment on this matter.

A. G. CAMPBELL: The seasonal changes in the make-up of the dead material fraction would follow the lines Mr Lynch suggests, but further separation into leaf and stem of the 1,200 or so samples involved was not undertaken. So far as I know, no digestibility trials have been carried out with dead pasture separated from the living in environments where dead and living material are present in the pasture together. The micro, *in vitro* technique of Tilley *et al.* (Tilley, J. M. A., Deriaz, R. E., Terry, R. A., 1960: *Proc. 8th Internat. Grassl. Congr.*, p. 533) may assist a finer understanding of the nutritive value of dead material, though one would suspect that it would be no better than poor hay.

Almost any sample of years at one site is, of course, inadequate to permit extrapolation of absolute estimates of any parameter to all years and sites. But it is to be hoped that the principles involved are of wider application. These principles are that net change in available D.M. better defines the changes in the feed supply to the grazing animal than does absolute pasture production; decay of dead material influences this net change; and pasture utilization affects dead material accumulation. In these circumstances there can be little argument that in environments where dead material accumulates in summer and decays in autumn, measurements of absolute growth in autumn, be this at a high level or a low level, will overestimate changes in the feed supply (in terms of D.M.) to the animal.

DR P. C. BARCLAY: *Lancashire, at Grasslands Division, Palmerston North, has found large differences in summer debris depending on the strain of ryegrass present. What species constituted Mr Campbell's pastures and how do their proportions vary from season to season?*

MR CAMPBELL: The pastures employed had very diverse botanical composition, being at least 20 and probably more years old. Ryegrass accounted for about 35% of total yield, cocksfoot 20%, white clover 15%, Yorkshire fog 15% and *Poa trivialis* 10% throughout the spring, but in summer all of these proportions declined because of the rise in percentage of dead material and it was not possible to separate this fraction into its component species.

Q: *Can Mr Campbell suggest how this dead material fraction can be reduced?*

MR CAMPBELL: It can be reduced to a small extent, proportional to total available herbage, and to a large extent in absolute amount, by increased utilization in spring through heavy stocking and conserving relatively large areas of the farm for silage and hay. This is the CH situation depicted in the paper. How it can be reduced further can only be decided by comparing diverse management systems, and probably after making species and strain comparisons as suggested by Dr Barclay.