THE NUTRITIVE VALUE OF SOME PASTURE SPECIES EXAMINED IN A SUBTROPICAL ENVIRONMENT

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ABSTRACT

The nutritive value of sixty-two pasture samples grown at Wollongbar were compared in terms of their crude protein (CP) and normal acid fibre contents, dry matter (DMD) and crude protein digestibilities and mean daily dry matter intakes (I). The range of DMD in the samples compared was between 47.1 and 81.4 per cent with a mean value of 61.3 per cent. Intake ranged from 23.4 to 83.4 g (52.6 g) per kg liveweight$^{0.75}$.

A significant relation between DMD and I was established. This was shown to be similar to results recorded by others with tropical pasture swards, but significantly different from a relationship obtained with temperate species. The intake of sheep consuming fresh and dried tropical species appears to fall within the limits of the following four equations: $DMD = 76$, $I = -17 + 1.66DMD$, $I = 83$, *and* $I = -3.6 + 0.43DMD$. *The agricultural implications of these boundaries are that industries requiring pastures of relatively high nutritive value are, to a large extent, likely to be able to compete with those in temperate regions only if higher stocking rates can be maintained on the tropical pastures.*

Nitrogen retention was shown to be related to CPD, CPD^2 *and I* ($R^2 = 0.801$). *It is suggested that as the grazing animal is likely to consume quantities of dry matter different from those consumed by a caged animal and intake has a significant influence on nitrogen retention considerable caution is required in interpreting nitrogen balance studies conducted with caged animals. This will be particularly important when considering negative nitrogen retention.*

INTRODUCTION

Several reviews of the nutritive value of tropical pasture species have been published (French 1957; Hardison 1966; Butterworth 1967; Holder 1967). These reviews have contained little information on kikuyu grass *(Pennisetum clandestinum)* a species that appears well adapted to the subtropical environment of north coastal N.S.W.. Mears (1970) stated that the chemical composition of kikuyu compares favourably with other tropical grasses and the few metabolic studies that have been conducted with it, indicate high animal production potential.

Agronomic studies conducted by the Agricultural Research Station, Wollongbar, have suggested that a wide range of both tropical and temperate legumes and grasses could be adapted to the local environment and either replace or supplement the naturalized paspalum (*Paspalum dilatatum*), carpet grass (*Axonopus affinis*) and kikuyu grass pastures.

Digestibility studies with a number of the introduced and indigenous species commenced in 1961 with the intention of determining if factors within the plant (e.g. crude protein content) or "animal factors" (e.g. voluntary intake) might allow estimation of the animal production potential of swards.

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The paper reviews the results of six years of digestibility studies with legumes and grasses grown in the subtropical environment of Wollongbar, including a number of determinations of the nutritive value of kikuyu and legume/kikuyu mixtures.

METHODS

Wollongbar is situated in an humid subtropical environment. Its location is 28°50'S, 153°25'E at an elevation of about 150 m. Average annual precipitation is 1660 (1,220-2,420)mm and the dominant soil type on the Station is krasnozem.

In most cases pasture samples were cut daily with an autoscythe and chaffed through a chaff cutter into approximately 2.5 cm lengths. In two cases where predominately *Trifolium subterraneum* (sub clover) stands were being evaluated the material was obtained from a nearby farm. On these occasions it was all cut on one day and was dried in a forced air flow dehydrator at 85°C. These samples have been identified in Table 5.

Standard techniques were used in the conduct of digestibility and intake determinations and have been previously reported (Jeffery 1971). Data from individual sheep were removed only when shown to be outliers by application of the "T test" for detecting outlying observations (Grubbs 1969). Nitrogen fertilizer was applied after mowing at the rate of 112 kg/ha N as calcium-ammonium-nitrate.

The swards and samples compared were *Glycine wightii*/kikuyu (glycine/kikuyu), glycine leaf and stem, *Desmodium uncinatum*/kikuyu (desmodium/kikuyu), desmodium leaf and stem, *Vicia sativa*/kikuyu (vetch/kikuyu), kikuyu, kikuyu plus nitrogen fertilizer (kikuyu + N), sub clover, *Dolichos lablab*, paspalum, *Avena sativa* (oats) and carpet grass.

As productive value of a feed depends on the amount consumed and the proportion of the consumed feed that is utilized measurements of intake and indices of utilization were recorded where possible. The criteria for evaluating the samples were crude protein (CP) and normal acid fibre (NAF) percentage, dry matter (DMD), organic matter (OMD) and crude protein (CPD) digestibilities and where sufficient labour and/or material was available intake (g) per kg bodyweight$^{0.75}$ (I) and nitrogen retention (NR) determinations in g per sheep per day were conducted. Twenty seven measurements of I and 21 measurements of nitrogen balance at *ad libitum* intake were obtained.

Comparisons of the swards presented in Tables 1 and 2 were made by analysis of variance, with the exception of the pasture composition data which was compared by the χ^2 test (Table 1). Multiple regression equations were calculated by the least squares method and the second and subsequent variables were retained only if their inclusion resulted in a significant ($P < 0.05$) reduction in the variation about the regression.

For purposes of calculation, the date was regarded as the date of commencement of the collection period with day 1 being January 1, day 2 being January 2, etc.

The relations between DMD and I between swards and between the overall relation and those obtained by Troelsen and Campbell (1969) and the equation established from the data of Milford (1960b) were compared by analysis of covariance.

The data in Figure 2 have been obtained from the following publications: Elliott and Topps (1963), Milford (1967), Milford and Minson (1968a, 1968b), Minson (1966; 1967), Minson and Milford (1967a, 1967b; 1968) and Playne (1968; 1969; 1970). Where the intake of sheep was not expressed as I, this was calculated assuming the weight of the sheep to be the mean value of the range of weights presented. The results of Minson (1966) and Minson and Milford (1967a) were recalculated in this manner. A total of 137 observations with fresh, frozen or dried, chopped tropical species have been plotted.

RESULTS

An experiment comparing a glycine/kikuyu sward at two stages of growth revealed that the more mature sward had a higher CP and CPD, and that sheep consumed greater amounts and retained more nitrogen of it than of the less mature sward (Table 1).

The increases in CP, CPD, I and NR in the glycine/kikuyu sward 14 weeks post establishment (Table 1) are associated with an increase in legume content of the sward. Kikuyu has been shown to decrease in CP content with age (Milford and Haydock 1965) thus the increased CP and consequently CPD can be attributed to an increase in the legume component of the sward. As CP and I are both related to NR the increases in these two parameters would account for some of the increase in NR. The differences in I are associated with an increased legume component, however, there is no difference in DMD between the two samples. The factors causing these effects are at this stage unclear.

Two experiments conducted in 1964, comparing the leaf and stem fractions of glycine, revealed no differences in DMD whereas the CP of the leaf had a higher digestibility (Table 2).

These experiments suggested that the legume fraction of a glycine/kikuyu sward was more digestible than the grass fraction. In both cases the DMD of the leaf and the stem of glycine were higher than that of the sward. However, the data from the experiment commencing on 9.ii.65 suggested that the grass fraction may have been more digestible than the total legume component.

In 1965, the leaf fraction had a higher DMD whereas CPD values were not significantly different. Desmodium leaf had a higher CPD than the stem. In the two comparisons of glycine/kikuyu swards with desmodium/kikuyu swards similar DMD were recorded although a higher CPD was found with the former sward. The three samples of glycine/kikuyu taken from the same plots and each at seven weeks regrowth decreased in NAF content as the season progressed.

The DMD and CPD values presented in Table 3 are higher than those found with the tropical legume/grass swards. The comparison of vetch 17 and 21 weeks post establishment (22.ix.64 and 21.x.64) revealed a lower DMD and CPD with the more mature stand. As the vetch in the former experiment was approaching maturity (flowering) these effects were not unexpected.

Kikuyu and kikuyu + N swards are compared in Table 4. Application of nitrogen fertilizer to kikuyu swards increased the CP and CPD and decreased NAF of the swards. All samples obtained between July and April had DMD values of 60% or more, and CP did not drop below 12%. The simple correlations between date (independent variable) and CP, DMD and I explained a negligible proportion of the total variance, in all cases $r < 0{\cdot}4$. The multiple regression equations relating date and regrowth period to CP, DMD and I resulted in non-significant equations in each case ($R = 0.237$, 0.512 and 0.477 respectively). The DMD values obtained with kikuyu were high compared with the results obtained from other tropical species (Milford 1960a; Butterworth 1967). Even the winter carryover feed (27.x.63 and 7.xi.63) had DMD values exceeding 52%. These samples were also relatively low in fibre content.

TABLE 1

Comparison of a Glycine wightii/Pennisetum clandestinum *sward at two stages of growth*

Date of commencement of collection	Stage of regrowth	Dry matter a yield of pasture (kg/ha)	Pasture composition (%)		Crude protein (%)	Dry matter digestibility (%)	Crude protein digestibility (%)	Intake (g) per kg bodyweight$^{0.75}$	Nitrogen retention (g/sheep/day)
31.v.66	8 week	1211	legume	54	12.4	59.9	63.1	37.6	0.97
			grass	44					
			weed	2					
31.v.66	14 week	3654	legume	83	14.1	60.4	74.9	47.1	8.63
			grass	17					
			weed	0					
Level of significance $P < 0.05$, ** $P < 0.01$		**	**		**	Non significant	**	**	*

TABLE 2

Comparison of Glycine wightii/Pennisetum clandestinum (*Glycine/kikuyu*) *and* Desmodium uncinatum/Pennisetum clandestinum (*Desmodium/kikuyu*) *swards and the leaf and stem fractions of the legumes*

Date of commencement of collection	Sward	Fraction	Description	Crude Protein (%)	Normal acid fibre (%)	Dry matter digestibility (%)	Crude protein digestibility (%)
14.ii.64	Glycine/kikuyu	Whole sample	Full seasons growth	15.2	38.3	52.2[a]**	66.3[b]
		Glycine leaf	Third year stand	27.2	28.7	60.1[b]	77.1[c]
		Glycine stem		11.7	42.6	61.9[b]	57.5[a]
28.iv.64	Glycine/kikuyu	Whole sample	74 per cent glycine	14.6	39.1	51.8[a]	68.4[ab]
		Glycine leaf	26 per cent kikuyu	23.8	33.0	64.3[b]	75.5[b]
		Glycine stem	21 week regrowth	13.2	42.0	62.9[b]	66.1[a]
9.ii.65*	Glycine/kikuyu	Whole sample	Topdressed 377 kg/ha	20.5	40.9	65.7[b]	79.3
		Glycine leaf	super potash on 4.i.65	25.6	38.6	66.6[b]	82.7
		Glycine stem	7 week regrowth	13.2	42.1	53.5[a]	75.7

TABLE 2 (continued)

Date of commencement of collection	Sward	Fraction	Description	Crude protein (%)	Normal acid fibre (%)	Dry matter digestibility (%)	Crude protein digestibility (%)
9.ii.65*	Desmodium/kikuyu	Whole sample	Third year stand	14.7	36.5	58.8	54.4b
		Desmodium leaf		25.7	40.7	56.9	57.1b
		Desmodium stem		11.5	49.9	57.9	37.7a
8.iv.65*	Glycine/kikuyu	Whole sample	7 week regrowth	11.9	37.6	52.3	61.0a
	Desmodium/kikuyu	Whole sample		10.0	41.6	50.3	40.2b
3.vi.65*	Glycine/kikuyu	Whole sample	7 week regrowth	14.2	34.4	58.6	63.1a
	Desmodium/kikuyu	Whole sample	Frosted before commencement of experiment	12.8	37.8	57.2	45.7b
16.ii.62	Glycine/kikuyu	Whole sample	Glycine sown 29.xi.61 11 week post establishment Approximately 85 per cent glycine	18.9	42.8	61.7	80.1
17.v.62	Glycine/kikuyu	Whole sample	Same plot as immediately preceding experiment Glycine in flower (some pods)	20.3	37.0	59.6	79.3
7.ii.63	Glycine/kikuyu	Whole sample	Same plot as immediately preceding experiments Second year stand Ungrazed for previous 13 weeks	18.6	38.4	64.6	76.8
4.vi.64	Glycine/kikuyu	Whole sample	Glycine heavily seeded, leaves senescent	14.9	40.2	55.7	56.6
8.vii.64	Glycine/kikuyu	Whole sample	Same plot as immediately preceding experiment	12.9	38.8	56.2	66.6
8.vii.65	Glycine/kikuyu	Whole sample	Glycine sodsown 5.ii.65 First cut post establishment 17 week growth	13.8	31.8	62.6	70.6
7.xii.65	Glycine/kikuyu	Whole sample	Same plot as immediately preceding experiment 15 week regrowth	12.3	—	58.4	54.9
5.iii.64	Desmodium/kikuyu	Whole sample	Approximately 80% desmodium	11.0	44.5	54.7	47.1
14.v.64	Desmodium/kikuyu	Whole sample	Approximately 95% desmodium Desmodium mature, in full flower	15.6	47.3	54.5	63.4

* These samples all come from the same plot.

** Figures within an experiment, in the same column, bearing different superscripts are significantly different ($P < 0.05$).

TABLE 3

Comparison of Vicia sativa/Pennisetum clandestinum *swards at varying stages of regrowth*

Date of commencement of collection	Description	Crude protein (%)	Normal acid fibre (%)	Dry matter digestibility (%)	Crude protein digestibility (%)
14.ix.61	*Vicia* sp. About 20% in flower. Stand almost pure *Vicia* sp.	29.9	36.2	74.0	88.2
12.x.61	*Vicia* sp. post-flowering. Pods included in feed	21.6	42.5	62.8	79.4
6.x.62	Sown 15.v.62. Stand well established, approaching flowering	17.7	42.4	65.9	76.9
18.x.62	Same plot as immediately preceeding experiment. *Vicia* sp. pre-flowering	18.1	39.6	66.7	77.3
22.ix.64	*Vicia* sp. sodsown 27.v.64. 17 week growth. Flowering of *Vicia* sp. commencing 58% *Vicia* sp. 42% *Pennisetum* sp.	22.9	34.3	70.0	81.4
21.x.64	Same plot as immediately preceeding experiment. 21 week growth	16.8	34.1	63.7	72.1
20.ix.66	*Vicia* sp. sodsown 26.iv.66. *Vicia* sp. preflowering 31% *Vicia* sp. 69% *Pennisetum* sp.	16.8	—	63.3	70.8

TABLE 4

Comparison of Pennisetum clandestinum (*kikuyu*) *swards with and without nitrogenous fertilizer* (*N*)

Date of commencement of collection	Description	Crude protein (%)	Normal acid fibre (%)	Dry matter digestibility (%)	Crude protein digestibility (%)
	No nitrogen applied				
1.vii.61	Approximately 30-38 cm high	12.9	33.3	66.4	63.5
17.i.62	Stem avoided in cut	14.1	40.9	68.7	70.0
1.ii.62	Same plot as immediately preceding experiment	14.9	40.8	62.4	64.4
9.iv.62	Stem avoided in cut Same plot as immediately preceding experiment	12.3	38.9	64.1	64.6
26.iii.63	Regrowth period less than 12 weeks	12.2	41.6	64.3	64.7
31.v.63	17 week regrowth Same plot as immediately preceding experiment	13.8	33.3	70.8	72.6
27.x.63	Feed was that remaining after winter with some green shoots appearing	6.2	36.5	53.3	25.9
7.xi.63	Feed cut adjacent to that used in immediately preceding experiment	7.2	39.7	52.6	42.5
	112 kg/ha N applied as calcium-ammonium-nitrate				
10.iii.65[a]	Topdressed 9.ii.65 4½ week regrowth	12.9	33.2	60.4	58.8
28.iv.65[b]	Topdressed 22.iii.65 6 week regrowth	18.8	27.1	74.0	70.6

TABLE 4 (continued)

20.v.65[a]	Topdressed 12.iv.65 6 week regrowth	19.1	32.3	69.2	67.4
8.viii.65[b]	Topdressed 1.vi.65 10 week regrowth	19.4	28.7	68.3	67.3
23.ix.65[a]	Topdressed 15.vi.65 14 week regrowth	14.8	—	71.3	68.8
21.x.65[b]	Topdressed 6.ix.65 7 week regrowth	14.8	—	64.3	61.5
1.ii.66[a]	Topdressed 21.xii.65 6 week regrowth	14.3	—	57.8	61.7
6.vii.66[a]	Topdressed 10.v.66 8 week regrowth	20.7	—	66.4	70.1

a) Grass used in experiments with the same superscripts obtained from the same plots.

TABLE 5

Comparison of Trifolium subterraneum (*sub clover*), Dolichos lablab, Avena sativa (*oats*), Paspalum dilatatum (*paspalum*) *and* Axonopus affinis (*carpet grass*)

Date of commencement of collection	Description	Crude protein (%)	Normal acid fibre (%)	Dry matter digestibility (%)	Crude protein digestibility (%)
9.vi.61	Sub clover[a] Second year's stand Leaf and 10 cm of stem cut for experiment	23.1	34.6	74.4	80.5
29.viii.63	Sub clover—dried 26 weeks regrowth	16.1	33.5	70.0	58.7
12.ix.63	Sub clover—dried 22 week regrowth	16.9	31.1	74.7	66.3
24.vi.64	Sub clover Second year stand	33.1	34.6	74.4	80.5
8.ix.64	Sub clover Second cut 10 weeks regrowth	23.7	34.6	81.4	84.1
3.v.62	*Dolichos lablab* Sown 21.xii.61 Commencing to flower Whole plants chaffed	16.3	34.4	63.0	79.2

TABLE 5 (continued)

Date of commencement of collection	Description	Crude protein (%)	Normal acid fibre (%)	Dry matter digestibility (%)	Crude protein digestibility (%)
28.iii.63	Paspalum All plants in head	5.3	46.4	52.3	36.7
26.xi.63	Paspalum Winter carryover Dry material plus some green shoots Cut to about 8 cm	5.6	44.5	50.0	19.4
18.iii.64	Paspalum	5.0	44.3	50.8	22.8
11.viii.61	Oats Commencing to "head out" Weed and rust free	19.7	31.6	74.5	63.6
24.viii.61	Oats Commencing to "head out" Followed *Dolichos lablab* crop Heavy rust infection at end of collection	16.8	31.7	79.2	79.3
27.vii.64	Carpet grass Included leaf, but all plants carrying seed heads	5.3	40.9	47.1	19.7

a) All sub clover cut for same plot.

TABLE 6

The relation between dry matter digestibility (DMD) and intake (g) per kg liveweight$^{0.75}$*(I)*

Source	Number of observations	Equation	Correlation coefficient	Residual standard deviation
Glycine wightii/Pennisetum clandestinum	6	Ip= 54.3 + 0.199DMD	0.059	18.4
Vicia sativa/Pennisetum clandestinum	4	I = 148.8 — 1.508DMD	—0.432	19.9
Desmodium uncinatum/Pennisetum clandestinum	3	I = —20.5 + 1.520DMD	0.895	4.8
Pennisetum clandestinum	4	I = —11.6 + 0.825DMD	0.491	18.0
Pennisetum clandestinum + nitrogenous fertilizer	9	I = 0.2 + 0.822DMD	0.832	13.3**
Overall regression (this study)	27[a]	I = 11.7 + 0.678DMD	0.432	17.4*
Milford (1960b)	90	I = —0.8 + 0.813DMD	0.501	13.8**
Milford (1960b) and this study	117	I = —0.9 + 0.835DMD	0.560	14.7**
Troelsen and Campbell (1969)—alfalfa	48	I = —23.9 + 1.51DMD	0.866[b]	7.4**
Troelsen and Campbell (1969)—grasses	96	I = —30.1 + 1.50DMD	0.831[b]	8.6**

* $P < 0.05$.
** $P < 0.01$.
a Includes one observation obtained with *Paspalum dilatatum*.
b Calculated, may be subject to rounding errors.

Temperate species (sub clover and oats) compared in Table 5 had higher DMD than the naturalized grasses (paspalum and carpet grass) and the introduced tropical legume *Dolichos lablab*. The naturalized grasses had the lowest CP contents of any of the swards evaluated and paspalum was found to have a high NAF content. Although the sub clover stands evaluated varied between 10 and 26 weeks regrowth their DMD were within the range 70.0 to 74.7%.

The relation between DMD and I for five of the swards tested and the overall regression are presented in Table 6. The regression established from the data of Milford (1960b) is also presented. Analysis of covariance revealed non-significant differences in slope and intercept for the five swards and a non-significant difference between the overall regression from this study and the equation obtained from Milford's data. The kikuyu + N relationship is the only within-species regression that is significant. Combining the data from all observations in this study resulted in a significant regression, $I = 11.7 + 0{\cdot}678$ DMD. This regression could not be demonstrated to be different from the one obtained from the data of Milford (1960b) in either slope or intercept. They were thus combined and are presented in Fig. 1. The combined regression $I = -0.9 + 0.835$ DMD had a significantly different slope from the regression of Troelsen and Campbell (1969).

Nitrogen balances were conducted in 21 of the experiments in which animals were fed *ad libitum*. The nitrogen retention (NR) in g per sheep per day could be predicted from the following equation

$$NR = 18.16 - 1.033\,CPD + 0.0110\,CPD^2 + 0.1023\,I \pm 1.98$$
$$(R = 0.895)$$

The effects of all the variables in this regression were significant ($P < 0.01$). This regression explained 80% of the total variation between diets in NR.

DISCUSSION

The difference in botanical composition between the two swards compared in Table 1 appears to be responsible for the different DMD and CPD values recorded. This suggests that an increased legume component will increase the DMD and CPD of a sward. The experiments conducted on 14.ii.64 and 28.iv.64 (Table 2) support this contention, but the experiment conducted on 9.ii.65 indicates that the legume would have a lower DMD than the kikuyu component of the sward.

The increase in DMD in the glycine/kikuyu plot sampled on 7.ii.63 compared with that found with the samples cut on 16.ii.62 is difficult to account for as the first cut was taken 11 weeks after establishment and could be expected to be less mature and therefore more digestible than the later cut. This difference could represent a climatic effect.

At Wollongbar the tropical legume component of a sward under grazing generally decreases markedly after April. At this stage the plants have ceased active growth, are flowering and beginning to set seed. Thus it is not surprising that the lowest DMD obtained with the tropical legume/kikuyu swards occurred in autumn. Also at this time of the year the kikuyu growth rate is relatively low.

In general, the tropical legume/kikuyu swards had higher CP and CPD than the pure kikuyu swards. As not many botanical separations were conducted on the mixed swards it is not possible to determine whether this was due to the legume alone, or whether the kikuyu in the mixed swards also had a higher CP and CPD. The relation between CP and CPD for these swards has been considered elsewhere (Jeffery 1971). An increase in CPD was observed with an increase in CP content. This feature can be seen in Tables 1 to 5. Approximately 90% of the change in CPD can be accounted for by the change in CP.

The inclusion of vetch in a kikuyu sward appeared to increase the CP, DMD and CPD (Table 3). The CP and CPD of the vetch/kikuyu swards were comparable with those of the sub-clover stands. The experiments conducted on 22.ix.64 and 21.x.64 indicate that a decrease in CP and CPD occurs as the swards become older and the experiments conducted on 14.ix.61, 22.ix.64 and 20.ix.66 demonstrate a decrease in these parameters with a decreasing vetch component of the pasture.

The DMD and I values obtained in this study with the kikuyu swards were comparable with those reported by Minson and Milford (1968). Date of cutting and length of regrowth appear to be factors likely to affect CP, DMD and I, however, either singly or in combination they explained only a small portion of the between-experiment variance. Therefore, it seems likely that more complete definition of the agronomic and physiological features of the plant would be necessary for accurate prediction of either CP, DMD or I.

The CP contents of winter carryover feed of kikuyu (27.x.63 and 7.xi.63, Table 4) and paspalum (26.xi.63, Table 5) is at a level that would appear inadequate for lactating dairy cows. Milford and Haydock (1965) demonstrated that caged sheep fed *ad libitum* are likely to enter a negative nitrogen balance if CP contents are lower than about 7%. Although the grazing animal may be able to be more selective than animals in metabolism cages, it would appear unlikely that a cow could select feed of a CP content sufficient to satisfy her maintenance and production requirements (Agricultural Research Council 1965). Hence it is likely that provision of either a protein supplement or species of higher CP content would be a critical factor affecting production at this time of the year.

The potential importance of oats as a forage crop is demonstrated in Table 5. At a time when the summer growing naturalized pastures species have low nutritive values the two oats crops evaluated had DMD in excess of 74%. Subterranean clover also maintained a high digestibility. Even though some stands had not been cut for 26 weeks, the digestibility was always greater than 70%. These results, as well as those presented in Table 3 demonstrated that higher CP, CPD and DMD can be expected with temperate species.

Blaxter, Wainman and Wilson (1961) demonstrated that a good relation between DMD and I may be obtained with temperate pastures. Milford and Minson (1965) indicated that this relation did not appear to hold for tropical species. The results of this study, in which within and between sward regressions were calculated, support the contention of Milford and Minson (1965) (Table 6). Troelsen and Campbell (1969) investigated the relation between DMD and I of six temperate species. The correlation coefficients obtained by them and the standard errors of the temperate relationships indicate that considerably more precision can be obtained by predicting I from DMD with temperate species. This is particularly so as Troelsen and Campbell used individual sheep as the experimental observations whereas in this study the mean values obtained from generally three or four sheep were the experimental observations.

The maximum DMD found with the tropical species in this study was 74.0%. A maximum value of 76.0% was obtained by Milford (1960b) and Butterworth (1967). Hardison (1966) recorded a maximum total digestible nutrient value of 73·2%; the conversions presented by Heaney and Pigden (1963) would estimate this as 77.5 ± 1.1 DMD. Thus it seems likely that the DMD of tropical species will exceed 76.0% by only a small amount, if at all. Thus a "boundary" of DMD = 76 has been plotted on Fig. 1. Also, all data with the exception of one point are contained within the further "boundaries" of I = 1.66 DMD −17 and I = 83.

The combined regression calculated from the data of Troelsen and Campbell (1969), using the mean values obtained with each diet as the experimental observations, has a slope of 1.69, which is virtually parallel to the arbitarily drawn boundary that delineates the data of Milford (1960b) and this study. If the population limits

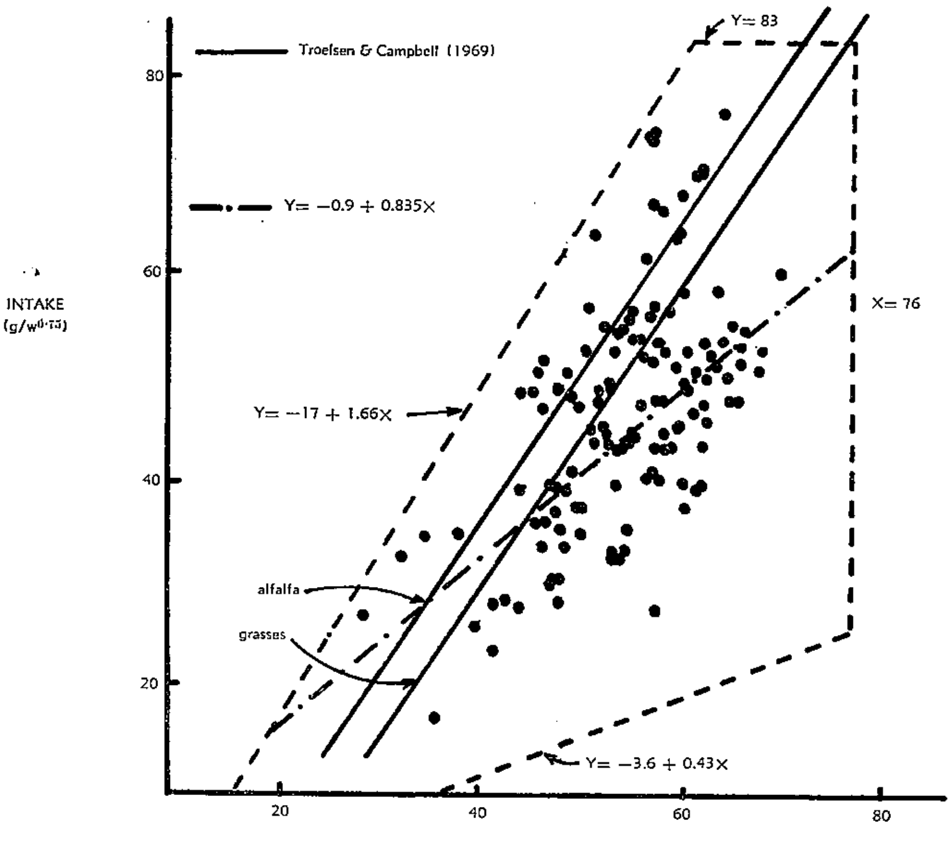

FIGURE 1
The relation between dry matter digestibility and intake (g) per kg bodyweight$^{0.75}$

of the temperate species regression are considered to be parallel to this overall regression then the similarity of these two slopes could indicate that a similar factor restricts intake of both temperate and tropical species so that at a fixed digestibility it will not exceed some particular intake, but that at any given DMD the temperate species have the potential of having a greater I.

To further test validity of these boundaries, the data from several other publications have been plotted (Fig. 2). With the exception of data obtained with pelleted feed, all of these 153 observations fall within the "boundaries". The pelleted feeds appear to follow more closely the relationships obtained with temperate species. It is thus suggested that the three lines, DMD = 76, I = 1.66 DMD −17 and I = 83 define the likely "upper" limits of the tropical species. The "lower" limits would probably be defined by a line with a positive slope—little data is available that would aid in the definition of this boundary, though at this stage a boundary of I = 0.43 DMD −3.6 appears reasonable, as this excludes only one of the 254 diets of chopped fresh or dried tropical species considered.

The importance of measurements of intake in feed evaluation studies has received support from Milford and Minson (1965) and Reid and Jung (1965). As measurement of I with temperate pastures frequently exceeds 83 g and as DMD

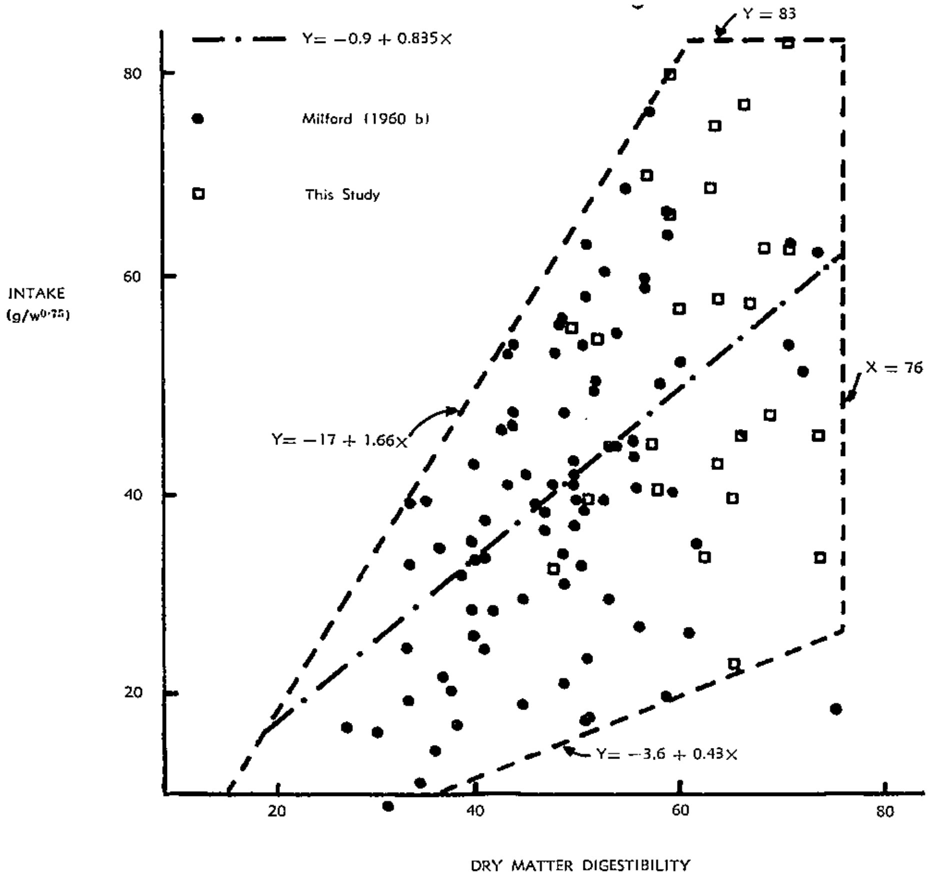

FIGURE 2

The relation between dry matter digestibility and intake (g) per kg bodyweight$^{0.75}$ from 137 chopped tropical feeds. Data has been obtained from the following publications, Elliott and Topps (1963), Milford (1967), Milford and Minson (1968a, 1968b), Minson (1966; 1967), Minson and Milford (1967a, 1967b; 1968) and Playne (1968; 1969; 1970).

also frequently exceeds 76% (Reid and Jung 1965; Troelsen and Campbell 1969), this implies that production per animal from ruminants grazing tropical pastures is unlikely to equal that obtainable from animals grazing temperate pastures. The implication of this effect would be that where animal product obtainable from tropical pastures must compete with that obtainable from temperate pastures any advantage that the tropical pastures exhibit is likely to be a reflection of either increased stocking rates or lower land values. This will be particularly important when considering industries, such as dairying, which rely on pastures maintaining high levels of nutritive value over relatively long periods of time.

Milford and Haydock (1965) reported a curvilinear relationship between CPD and NR. These data also showed evidence of curvature, but inclusion of I in the regression with CPD and CPD^2 reduced the residual standard deviation (RSD) from 2.55 to 1.98 g per sheep per day. Milford and Haydock did not present the RSD associated with their regression, but consideration of the greater range of NR and lower coefficient of determination ($R^2 = 0.602$) obtained in their study would suggest a RSD exceeding 2.5 g per sheep per day. The lower RSD obtained in this study suggests that I should be considered in predictions of NR. As intake was a significant factor affecting NR and as caged animals are likely to consume quantities of feed different from those consumed by grazing animals this suggests that considerable caution must be exercised in interpreting NR data obtained from caged animals. In particular, the biological interpretation of negative nitrogen balances is critical. The quadratic relationship established in this study between NR and CPD predicts zero nitrogen balance at 51.5% CPD. Milford and Haydock (1965) obtained an estimate of 49.3% for this value. Whilst these two values are in close agreement the importance of the effect of intake on nitrogen balance must not be overlooked. If a feed of 51.5% CPD is fed and I is 35 g a NR of −2.39 g is predicted, whereas if I is 70 g a NR of 1.19 g is predicted.

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