ANIMAL UTILIZATION ASPECTS OF PASTURE AND FORAGE CROP MANAGEMENT IN TROPICAL AUSTRALIA

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INTRODUCTION

All grazing systems aim, as far as possible, to match the quantity of forage (pasture or crop) available with the nutrient requirements of the particular livestock being fed. This presents problems because (a) the rate of growth—and so the supply—of forage differs markedly and often unpredictably between different seasons of the year, and, (b) the daily nutrient requirements of animal populations also vary throughout the year. Under extensive grazing conditions the dominance of (a) may be accepted with consequent wide fluctuations in levels of animal production within and between years. Under more intensive conditions several measures can be adopted to increase the efficiency of utilization of the forage grown. The animal population may be managed so as to bring its pattern of nutrient requirement into phase with the likely pattern of forage production, e.g. by adjusting the time of calving of the dairy cow so that the peak of lactation coincides with the spring peak of pasture growth; forage surplus to current grazing requirements may be conserved to be fed during periods of subsequent shortage; or supplementary feed may be given when the amount of forage to be grazed is deficient (Raymond 1968).

This review is confined to considerations of the reactions of cattle and forages at high intensities of stocking under a grazing regime.

EFFECT OF INCREASING THE GRAZING PRESSURE

General considerations

McMeekan (1960) suggested three basic factors which determine the efficiency of conversion of pasture to animal products:—

(1) the amount, quality and seasonality of the pasture crop,
(2) the proportion of this crop harvested by the animal,
(3) the efficiency of conversion within the animal of the fodder consumed.

The first and last of these factors have been discussed in other papers in this issue. Experimental studies of the effect of stocking rate and management techniques on the efficiency of animal production have been reviewed by McMeekan (1960), Wheeler (1960), Holmes (1962), MacLusky and Morris (1964), and Humphreys (1966). These authors have discussed the results in relation to existing knowledge of the physiology of growth of mechanically defoliated herbage plants. In brief, stocking rate has been shown to be an extremely potent factor on per acre animal production through its effect on the efficiency of harvesting herbage. Moreover, increases in stocking rate have not affected herbage growth rate to the extent that earlier cutting experiments suggested. A general relationship between stocking rate and animal product per head and per acre was derived by Mott (1960).

At very light stocking rates product per animal is high and generally uninfluenced by the stocking rate. These high animal yields result from the absence of rationing of the available feed since large amounts of pasture are available under a low grazing pressure. As the grazing pressure is increased by increasing the stocking rate, the animal's energy intake declines with the result that product per animal falls. If this fall is small product per unit area is increased with the increased grazing pressure. Further increases in stocking rate will reduce production per animal to the extent where yields per unit area are decreased.

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In the temperate region many experiments have demonstrated the large increases in milk production per unit area achievable by increases in stocking rate. (Appendix 1) The response in terms of milk production per hectare to increased stocking rate varied widely between the different authors. A major reason for this would be the position the low stocking rate treatment would occupy on the Mott (1960) response curve.

In the subtropical—tropical areas many similar exercises have been conducted to investigate the effect on beef production of variations in stocking rate. Some selected examples from areas with suitable climates for dairying are shown in Appendix 2.

While the effect of stocking rate variations on beef production have been quite widely investigated in our sub-tropics and tropics, similar dairying studies have not been as extensive. Colman and Holder (1968) conducted such a study; their results are shown in Table 1.

TABLE 1

Mean butterfat production per cow and per hectare and mean liveweight gain (L.W.G.) from calving to the end of lactation at three stocking rates from nitrogen fertilized Kikuyu grass pasture. (Colman and Holder 1968)

Stocking Rate (cows/ha)	1965–66			1966–67		
	Butterfat Production per cow (kg)	Butterfat Production per ha (kg)	L.W.G. kg	Butterfat Production per cow (kg)	Butterfat Production per ha (kg)	L.W.G. kg
1.65	73	119	77	118	183	92
2.47	81	199	24	111	272	93
3.29	68	226	30	99	327	100
L.S.D. P = 0.05	n.s.	33	—	n.s.	42	—

Currently stocking rate studies are underway at the Queensland Department of Primary Industries, Kairi and Ayr Research Stations. At Kairi on a glycine-green panic pasture stocked by Friesian cows at 2.5, 3.3, 4.1, 4.9, cows/ha and at Ayr with Jersey and Friesian breeds stocked at 7.9, 9.9, and 5.9 and 7.9 cows/ha, respectively on a nitrogen fertilized pangola pasture. At Ayr, the heaviest stocked pasture grazed by Friesians has produced 22,370 kg/ha of milk. Cows at a similar stocking rate but supplement on an ad lib basis with a molasses biuret mixture produced 28,296 kg/ha of milk.

Effect of increased grazing pressure on pasture

Fundamentally production increase at increased stocking rates reflects the greater proportion of the pasture that is harvested by the animal at the higher stocking rates. McMeekan (1961) showed that by increasing the stocking rate by 50% the amount of digestible organic matter harvested from each acre increased by 41%. Freer (1960) found that the mean percentage utilization of available dry matter at each grazing of the rotational plots increased from 30 to 74% at stocking rates of 2.47 and 4.20 cows per hectare respectively. The amount eaten at each grazing at the higher stocking rate was equal to the amount that had grown since the previous grazing, whereas, at the lower stocking rate, only 80% of this was eaten. However, although the mean weight of dry matter present after grazing was five times greater at the lower stocking rate, the mean rate of regrowth of the two swards was the same. Gordon *et al.* (1966) reported a similar result. Work on beef cattle grazing by Riewe *et al.* (1963) confirms that a significant reduction in herbage growth rate does not begin until a stocking rate higher than that which permits the maximum animal product per acre is reached. These workers all examined temperate pastures. Habit, tillering capacity and possible root reserves, (Humphreys 1966) will influence persistence under a high grazing pressure.

The complexity of management decisions inherent at high stocking rates was brought out in detail by Campbell and Clayton (1966) and Hutton (1966). Where pastures are not uniform on the farm Lamond (1968) suggested a need to consider the concept of stocking rate per sward area, further adding to the complexity of management decisions.

While in temperate regions prostrate clovers persist well the tropical legume-grass pastures to which Lamond referred may not lend themselves to the high stocking rates currently being imposed on temperate grass clover combinations (Luck 1968, Roe *et al.* 1970). Legumes improve the intake of tropical pastures (Minson 1968) but the tropical legumes are difficult to maintain in a mixture under combination of frequent defoliations and low cutting (Waite 1969). The dairy farmer in our environment faces a problem in finding a system which reconciles the conflict between efficient utilization of tropical pasture and the maintenance of a legume in the pasture. In contrast to this situation nitrogen fertilized grass pastures do not appear to be a problem to maintain at stocking rates in excess of those applied to grass-legume pastures.

The opinion is often expressed that high stocking rates are accompanied by major problems of rejection and waste of herbage by the grazing animal arising from the contamination by faeces. This subject has been reviewed by Barrow (1967) and Marsh and Campling (1970). While obvious rejection of dung contaminated areas occur at low stocking rates, this becomes less as the grazing intensity increases. Greenhalgh and Reid (1968) in a study comparing the forage intake and production of dairy cows grazing dung-fouled herbage with those of cattle grazing clean herbage, showed daily intake of digestible organic matter, milk yield, milk composition and liveweight gains were not significantly reduced by fouling. Marsh and Campling (1970) concluded their review thus: "If more emphasis were given to milk yield per hectare as an index of good grazing management rather than to milk yield per cow or to sward appearance, it is probable that less importance would be attributed by graziers to dung fouling." No studies have been reported on the effect of fouling on tropical species.

Effect of increased grazing pressure on the animal

Since the relationship between feed intake and milk production is one of diminishing returns (Jawetz 1956), then for a wide range of grazing pressures about the point at which maximum production per animal is attained there will be only small change in production. Ferguson (1956) and Blaxter and Graham (1955) showed a large energy loss occurred through incomplete digestion when ruminants were fed to appetite when compared with a maintenance ration, but the difference over the range of feed intakes consumed by grazing cows during lactation is likely to be insignificant. When food is ample voluntary intake is related to some extent to body size (Waite *et al.* 1950, Hadjipieris, Jones, and Holmes 1965). Increases in grazing pressures will decrease feed availability reducing intake and inducing a liveweight loss.

Wallace (1956) has shown that by increasing the stocking rate by 40%, digestible organic matter intake per day decreased by 5% and this resulted in an average liveweight difference of 92 lb over the lactation in monozygotic twin Jersey cows. The loss of weight may lower the maintenance requirement of animals and McMeekan (1956) has suggested that this may be a factor in improving the efficiency in pasture utilization for milk production at high stocking rates. Cattle tend to lose weight for a period after calving and thereafter gain weight throughout the lactation (Wagner and Loosli 1967). An increase in grazing pressure due to increasing stocking rate can alter the magnitude of these liveweight losses and gains, especially in periods of low pasture growth. McMeekan *et al.* (1948) showed liveweight loss in late pregnancy adversely affected subsequent milk production. Wallace (1956) increased the grazing pressure by increasing the stocking rate by 66% imposing a low plane of nutrition in the pre and post calving period. This resulted in a depression from 24.3 to 20.3 lb of F.C.M. per cow per day over the lactation.

Gross underfeeding in early lactation promoted liveweight loss at this stage (Wallace 1957) and increased liveweight gain in late lactation at the expense of milk production when intakes were adequate (Flux and Patchell 1957). S.N.F. levels in milk may also be adversely affected by this situation (Hrdina 1968, Rathore and Scott 1969).

Many experiments incorporating different stocking rates and different degrees of nutritional stress prior to mating have failed to establish any significant differences in cow fertility. However McClure (1965) and Wallace (1955) have shown slight adverse effects on fertility at high rates of stocking.

MANAGEMENT TECHNIQUES

Management techniques such as rotational grazing and strip grazing have been widely adopted as a result of experiments in which swards were cut at different heights and time intervals. Many of these show the maximum annual growth of herbage to derive from a treatment combining close cutting and long intervals between defoliations. However there is little experimental support for incorporating this principle in a grazing system. Many reported experiments provide no useful information because their design neglected the facts that (a) a difference in stocking rate between the techniques under test will have an effect on production that obscures the effect of the technique (Lucas and McMeekan 1959, Line 1960), and (b) comparisons at stocking rates far below the optimum are unlikely to test the techniques and are of little practical interest. A few comparisons at uniform stocking rates have shown insignificant differences between strip, rotational, and continuous grazing (Campling, MacLusky and Holmes 1958, Freer 1959, Line 1960). A general review of the subject was made by Wheeler (1960) who concluded "contrary to frequently expressed opinion, forms of rotational grazing *per se*, have not, in objectively conducted experiments proved appreciably more productive than continuous grazing".

McMeekan and Walshe (1963) reported that optimum stocking rate under continuous grazing is reached at a level some 5-10% lower than the optimum rate applicable to controlled or rotational grazing. This means that controlled grazing must be associated with high stocking rates to exploit fully the greater efficiency of the more intensive grazing method. The role of stocking rate as a key and more important factor influencing the utilization of dairy pastures again emerge in this work. McMeekan and Walshe (1963) pointed out that in the project reported the controlled rotational grazing treatments were characterised by conservation of more than twice the area for winter feed as compared with continuous grazing. They speculated that this difference may be responsible for the small superiority in per acre output associated with rotational grazing. This experiment of McMeekan and Walshe (1963) is of special interest in that it is one of the few reports where the stocking rate has been raised to such an extent that production per acre actually declined.

Campbell (1966) has suggested that in the experiment of McMeekan and Walshe (1963) the differences between the grazing technique and stocking rate treatments in annual production per cow were largely due to differences in grazing pressure during the critical and uncertain months of August and September, immediately after calving. A slight easing of grazing pressure at this time by supplementation might be expected to have a large effect on annual production per acre. However, although management technique differences are shown at high high stocking rates, they may have little practical importance if optimum economic production is achieved at stocking rates lower than the biological optimum (Conway 1963 a,b, Hildreth and Riewe 1963, Chisholm 1965).

Rotational grazing has a place in the case of plants such as lucerne which are particularly sensitive to injury during continuous grazing (Barker, Hanley and Ridgman 1957). Although the degree of selective grazing is least at high grazing pressures, continuous grazing at these pressures may cause profound changes in botanical composition whereas intermittent grazing may stabilise the sward components (Morley 1966). The basic question to be asked is does the new botanical composition have an effect on animal production?

Only one study could be found on the effect of grazing management on animal production from a tropical species; Woolcock (personal communication) has found no real difference between continuous and rotational grazing of a pangola grass pasture. The particular pasture is stocked with 7.4 Hereford cows/hectare and heavily fertilized. Continuous grazing favours animal production in summer and rotational grazing improves winter performance. The nett result is little difference between the systems.

CONCLUSIONS

From the foregoing review, the following general conclusions are drawn. Increases in stocking rates to the optimum grazing pressure result in:—

1) Large increases in animal production per acre at the expense of individual animal production. (McMeekan and Walshe (1963) suggested that maximum per acre production is achieved when individual cows production is depressed by 10-12% below the maximum for that situation.)
2) Improved efficiency of pasture utilization.
3) No apparent effect on animal fertility.

These principles apply to both temperate and tropical regions. There is speculation as to whether tropical legumes will persist under high grazing pressures. Economically there may be a place for nitrogen fertilized grass pastures, especially in view of the high percentage of dairy farms in certain districts (Rees and Minson 1970), with existing irrigation facilites. The irrigation area quoted per cow is small when viewed in the light of existing stocking rates on grass-legume pastures. How ever it may be adequate at high nitrogen levels to support much of the existing dairy herd.

FUTURE RESEARCH

From a forage viewpoint

1) Selection of species (legumes, grasses or crops) which, while having a high nutritive value, are capable of withstanding high grazing pressures.
2) Study the economics of highly fertilized pure grass swards for dairy production at very high grazing pressures.
3) Define the interactions between forage growth rates in various seasons and the feeding of conserved and supplemental feeds.

From an animal viewpoint

For various feedings systems determine:—

1) Acceptable annual weight fluctuation curves for lactating cows.

2) Examine McMeekan and Walshe's (1963) suggestion that maximum production per acre occurs at a stocking rate that depresses animal product by 10-12% below the maximum, irrespective of management systems. From this work, for particular environments, determine target herd production means.
3) Determine the effect of different intergrazing intervals on animal production during periods of low forage availability.

It is unfortunate that little useful experimental work has been reported on the grazing management of dairy cows in the tropics. Given the complexity of the interactions in any grazing system there is a real need for experiments comparing several variables simultaneously.

APPENDIX 1

Effect of variations in stocking rate on per head and per unit area milk production and daily intake

Reference	Stocking Rate Cows/ha	Milk Production per cow per Lactation or per day (kg)	Milk Production per Hectare per Year or Experimental Period (kg)	Daily Intake per Head (kg)
Freer (1960)	2.47 (a)	2575	6360	—
	4.20 (a)	2517	10571	—
	2.96 (b)	2503	7409	13.4
	4.94 (b)	2310	11411	10.4
Line (1960)	Low	16.7	328	12.6
	Low+20-25%	15.9	381	11.1
McMeekan (1963)	2.25 (a)	4200	9450	—
	2 79 (a)	3837	10705	—
	2.25 (b)	4095	9214	—
	2.79 (b)	3776	10535	—
	2.33 (c)	4396	10242	—
	2.87 (c)	3748	10756	—
	2.33 (d)	3876	9031	—
	2.87 (d)	3321	9531	—
Gordon (1966)	Low	13.6	953	15.0
	Med	13.5	1199	13.4
	High	13.2	1619	10.6
Castle (1968)	1.0 (a)	16.1	222	—
	1.4 (a)	14.9	277	—
	1.0 (b)	17.7	240	—
	1.7 (b)	14.7	318	—
Greenhalgh (1970)	20.4*	16.8	13260	10.8
	15.9*	16.6	14950	11.9
	11.4*	16.2	16250	9.9

(a) 1st year (b) 2nd year (c) 3rd year (d) 4th year
* presentation yield offered kg D.M./cow/day.

APPENDIX 2

Liveweight production of steers as influenced by stocking rate

A. South East Queensland

(i) Evans, T. R. and Bryan, W. W. (1970).

Stocking Rate Steers/ha	Animal Liveweight Gain kg/ha Jan.-Dec. 1969					
	Pangola			Setaria		
	281 kg N/ha	479 kg N/ha	674 kg N/ha	281 kg N/ha	479 kg N/ha	674 kg N/ha
1.24	348			270		
2.15	640	685		371	494	
3.09	775	955	1045	483	573	697
4.00		1067	1112		416	629
4.70			1382			742

APPENDIX 2 (continued)

(ii) Bryan, W. W. and Evans, T. R. (1970). Increasing the stocking rate on a grass legume pasture from 1.23–2.47 beasts/ha significantly increased liveweight gain/ha by 41 kg/ha.

(iii) Young and Chippendale (1970).

Stocking Rate		kg/ha Liveweight Gain		
Expt. 1	Steers/ha	Nov. '65-Sep. '66	Dec. '66-Dec. '67	Dec. '67-Dec. '68
	1.7	296	291	151
	2.5	411	427	201
	5.0	632	547	Withdrawn
		Dec. '66-Sep. '67	Sep. '67-Nov. '68	
Expt. 2	2.0	290	245	
	2.5	350	272	
	3.3	470	271	

(The legumes in the experimental pastures did not persist).

(iv) Bewg *et al.* (1970)

Steers/ha	kg/ha Liveweight Gain
1.23	209
1.82	269

B. Atherton Tableland

(i) Winks *et al.* (1970) (*Panicum maximum*/*Glycine wightii* pasture)

Steers/ha	kg/ha Liveweight Gain
1.25	348
2.50	578

(ii) Evans (personal communication) (*Digitaria decumbens* pasture)

Steers/ha	kg/ha Liveweight Gain/day (mean 500 days) N Level kg/ha		
	337	506	674
7.4	5.24	5.73	
9.9	6.40	6.36	7.07
12.4		7.92	7.87

C. Wet Tropics. (Thurbon unpub. data) (*Panicum maximum*/*Centrosema pubescens* pasture)

Steers/ha	kg/ha Liveweight Gain/day
2.5	1.88
3.2	2.27
3.7	2.25

D. Central Tropics. French (1970)

Crop	Stocking Rate Steers/ha	Days on Crop	Av. Gain/head/day (kg)	Liveweight Gain/ha (kg)
	1.5	116	0.54	98
Sorghum	3.0	89	0.44	115
alum	4.4	81	0.31	113
	1.5	116	0.68	117
Zulu	3.0	81	0.49	120
	4.4	81	0.41	149
	1.5	116	0.73	123
Sugardrip	3.0	89	0.64	170
	4.4	19	0.30	26

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