EFFECTS OF PHOSPHORUS AND STOCKING RATE ON PASTURE AND ANIMAL PRODUCTION FROM A GUINEA GRASS-LEGUME PASTURE IN JOHORE, MALAYSIA

2. ANIMAL LIVEWEIGHT CHANGE

P. K. ENG*, L. 'T MANNETJE† and C. P. CHEN[1]*

ABSTRACT

Animal production was measured over three years from a guinea grass-legume pasture receiving different maintenance rates of phosphorus fertilizer, and continuously grazed at stocking rates of 2, 4 *and* 6 *animals per hectare. The legumes were* Stylosanthes guianensis *cv. Schofield,* Centrosema pubescens *and* Pueraria phaseoloides.

Stocking rate significantly affected liveweight gain with a negative linear relation between liveweight gain per head and stocking rate. The superphosphate treatment gave significantly higher animal production during the first 24 *weeks but thereafter, no significant main effects of phosphorus treatments on animal production were recorded. However, during the final year, when production was considered over the low and medium stocking rates only, animal production was significantly increased by increasing rates of rock phosphate.*

Liveweight gain per head was related to forage yield during the second year but not to legume yield. In the final year of assessment, liveweight gain per head was linearly related to the phosphorus and calcium concentrations of the guinea grass.

INTRODUCTION

Only limited research has been done on cattle production in Malaysia. In 1973, when the first large commercial beef and dairy enterprises were established, there were only 650,000 head of cattle and buffaloes in the country and 98% of this cattle population was reared by smallholders (Anon. 1974). Some general observations on animal production from grazed pastures have been reported from East Malaysia (Dunsmore and Ong 1969, Lee *et al.* 1971), but in Peninsular Malaysia there are no published reports on animal production from grazed pastures alone. The work that has been reported refers to stall feeding trials where cattle were given cut fodder and concentrate supplements (Flint 1971, Devendra *et al.* 1973, Pathmasingam and Devendra 1974, Devendra and Lee 1975). However, since 1973, considerable areas of grass-legume and pure grass pastures have been established for the purpose of beef or milk production, mainly under grazed conditions. Thus there is a need to assess the productivity and persistence of these pastures under varying levels of grazing intensity and also the levels of maintenance fertilizers needed to sustain pasture and animal production.

In the first paper in this series (Eng *et al.* 1978), the effects of stocking rate and varying levels of annual phosphorus maintenance application on changes in yield, botanical and chemical composition of a guinea grass-legume pasture were described. Stocking rate had a marked overall effect on yield on offer, botanical composition and pasture persistence while phosphorus levels significantly affected the phosphorus and calcium concentration of the pasture in the final year of assessment. This paper describes the influence of treatments on liveweight change and discusses these effects in relation to data reported in the first paper.

* Pasture Unit, M.A.R.D.I., Serdang, Malaysia.
† Division of Tropical Crops and Pastures, C.S.I.R.O., St. Lucia, Qld. 4067.

MATERIALS AND METHODS

Details of the design, methods and climatic conditions during the experiment were given in the first paper. Briefly, the experiment was a 4 × 3 factorial in which the effects of four phosphorus (P) levels and three stocking rates on the growth of cattle continuously grazing a guinea grass-mixed legume pasture were investigated. The P levels were 20, 40 and 80 kg P ha^{-1} yr^{-1} as Christmas Island rock phosphate ($CIRP_{20}$, $CIRP_{40}$ and $CIRP_{80}$) and 20 kg P ha^{-1} yr^{-1} as triple superphosphate (TSP_{20}). The stocking rates were 2, 4 and 6 Kedah-Kelantan bulls ha^{-1} (S_2, S_4 and S_6). The cattle (described by Devendra *et al.* 1973) were 8–12 months old, averaged 80 kg hd^{-1} at the beginning of the experiment and were considered finished after reaching weights of 250 to 300 kg hd^{-1}.

The first group of cattle was put on the experiment in August 1974. However, the cattle became listless, had rough coats and lost weight due to severe emaciation. This resulted in some deaths even though feed on offer at the start of the experiment was in excess of 4000 kg DM ha^{-1} in all paddocks. Cobalt deficiency in the pasture was diagnosed and remedied in April 1975 (Mannetje *et al.* 1976). All animals received vitamin B_{12} on 29th April 1975 and those in Rep II a cobalt pellet and grinder on 3rd May 1975. Further administration of cobalt pellets was made to animals on Rep I on 6th January 1976 and those on Rep II on 31st March 1976.

Liveweight changes for the experiment were analyzed from 29th April 1975 over periods which corresponded approximately with the annual P fertilizer maintenance application:

Year I	29.4.75–12.10.75
Year II	13.10.75–11.10.76
Year III	12.10.76–11.10.77

The stocking rate treatments were not strictly applied in the S_6 treatments, $CIRP_{40}$, $CIRP_{80}$ and TSP_{20} of Rep II during the second year as they were destocked for six weeks from 27th April 1976 to 8th June 1976 due to severe overgrazing. Cattle in these paddocks had lost 9.8, 11.1 and 9.7% of their peak body weight, respectively, and the total dry matter (DM) on offer had been reduced to a mean 200 kg ha^{-1}. The treatments were restocked with the same cattle on 8th June 1976 and their liveweight recorded from 22nd June 1976 to 12th October 1976 when most of the cattle on the experiment had reached their finishing weight. Zero gain is assumed from these treatments from 27th April 1976 to 22nd June 1976.

A new group of cattle with a mean liveweight of 80 kg hd^{-1} was put on the experiment on 13th October 1976. These remained on the experiment till 11th October 1977 when the experiment was terminated. Each animal received a cobalt pellet and grinder before it was put on the experiment. However, in spite of the much reduced grazing pressure as a result of lower liveweight, the S_6 $CIRP_{80}$ treatment in Rep II again became severely overgrazed. By 21st June 1977, cattle in this paddock had lost 18% of their peak body weight and had to be given supplementary feeding of cut guinea grass at 1% of their body weight on a DM basis. Zero gain is also assumed from this paddock from 21st June 1977 to 11th October 1977.

All cattle on the experiment were provided with shade and adequate water. Cattle were dewormed at six monthly intervals and sprayed for ticks at three to four monthly intervals. Mineral licks were provided to meet any mineral requirements except for P.

Cattle were weighed every four weeks after sixteen hours of overnight fasting. Carcass weights were determined from the first group of cattle after they were turned off the experiment in October 1976. The cattle were starved overnight before being weighed and slaughtered. Carcass weights were determined as cold dressed weights (hot weight less three per cent). Bone P levels were determined from rib samples using the technique of Little (1972). Faecal samples were obtained from all animals in July and August 1977 and the faecal P determined.

RESULTS

Animal production

Mean cumulative liveweight gains (LWG) per head and per hectare at the three stocking rates for each year are shown in Figure 1 and the mean LWG of the main treatment effects are presented in Table 1.

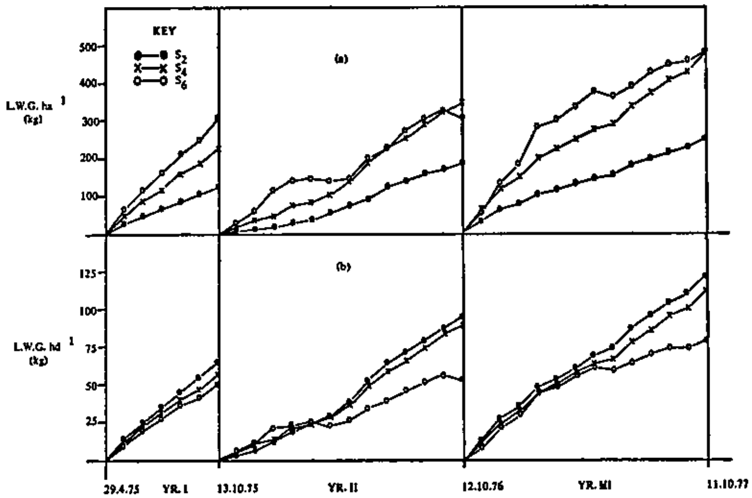


FIGURE 1

Effect of stocking rate on mean cumulative liveweight gain (a) per hectare (b) per head.

TABLE 1

Effect of stocking rate and annual phosphorus rate on mean LWG for the October to October periods

Main effects	Mean LWG					
	$g\ hd^{-1}day^{-1}$			$kg\ ha^{-1}$		
	1974–75†	1975–76	1976–77	1974–75†	1975–76	1976–77
Stocking Rate						
2 hd ha^{-1}(S_2)	380	265	342	128	190	249
4 hd ha^{-1} (S_4)	337	244	319	226	355	465
6 hd ha^{-1} (S_6)	307	143	222	310	311	485
L.S.D. ($P < 0.05$)	40	48	74	28	101	153
Phosphorus Rate						
(kg P $ha^{-1}yr^{-1}$)						
20 as CIRP ($CIRP_{20}$)*	338	216	262	220	294	362
40 as CIRP ($CIRP_{40}$)	309	212	312	194	281	436
80 as CIRP ($CIRP_{80}$)	339	227	318	222	302	416
20 as TSP (TSP_{20})	384	214	286	248	269	384
L.S.D. ($P < 0.05$)	47	n.s.	n.s.	32	n.s.	n.s.
Overall mean	341	217	294	221	285	400

† April to October 1975 only (24 weeks) * 1976-1977–nil P applied
n.s.—not significant

Stocking rate significantly affected LWG during all three years ($P < 0.01$). In each year, LWG hd^{-1} was lowest at S_6 whilst LWG ha^{-1} was lowest at S_2. LWG ha^{-1} was significantly higher ($P < 0.01$) at S_6 than at S_2 and S_4 during the first year (24 weeks only) but thereafter, differences in LWG ha^{-1} between S_4 and S_6 were not significant.

Animal production was low in the second year due to the recurrence of cobalt deficiency. The LWG from 13th October 1975 to 5th January 1976 in Rep I (minus cobalt) and Rep II (plus cobalt) was 14 and 346 g hd^{-1} day^{-1}, respectively (Mannetje *et al.* 1976). Animals in Rep I were given cobalt pellets on 6th January 1976 but those in Rep II again developed the deficiency, such that LWG from 6th January 1976 to 30th March 1976, was 258 and 28 g hd^{-1} day^{-1} for Reps I and II, respectively. LWG was uniform from 30th March 1976 when animals in Rep II were redosed with cobalt pellets.

During the first year TSP gave higher LWG hd^{-1} and LWG ha^{-1} than the other P treatments ($P < 0.05$). There was no effect of P treatments in the second year. In the third year, there was a significant response to P treatments in LWG hd^{-1} and LWG ha^{-1} over S_2 and S_4 (Table 2). Low pasture availability at S_6 probably masked the P effect where data from S_6 was included in the analysis (Table 1). The P effects on LWG became evident about eight weeks after the beginning of the third year (Figure 2).

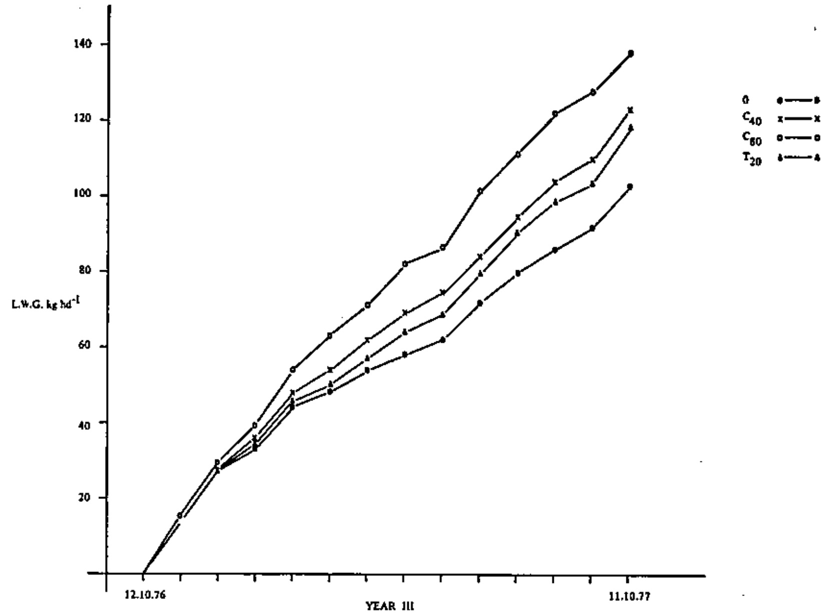


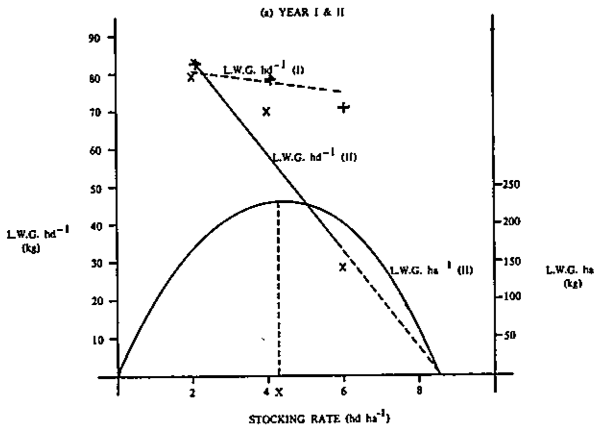
FIGURE 2
The effect of maintenance phosphorus on mean cumulative liveweight gain per head over the low (S_2) and medium (S_4) stocking rate during year III.

TABLE 2
Effect of maintenance phosphorus on mean LWG at S_2 and S_4 during Year III

Treatment	Mean LWG g hd^{-1} day^{-1}	Mean LWG kg ha^{-1} yr^{-1}
Phosphorus (kg P ha^{-1} yr^{-1})		
Nil	280	296
40 as CIRP	337	366
80 as CIRP	379	412
20 as TSP	326	353
L.S.D. ($p < 0.05$)	45	51
($p < 0.01$)	67	72

Relationship between stocking rate and animal production

Inspection of Figure 1 suggests that LWG hd^{-1} for the three stocking rates was similar for 40 weeks for the first group of animals (Year I + II) and for 28 weeks for the second group of animals (Year III), after which LWG hd^{-1} for S_6 diverged from that for S_2 and S_4. Average liveweight at this point was approximately 150 kg hd^{-1}. The interval prior to this apparent point of divergence has been called Period I and that afterwards, Period II. The regression lines for the equation, Y = a-bx, where Y = gain per animal and x = stocking rate, for each Period and group of animals are given in Figure 3.



(a) Period I 29.4.75 3.2.76 (40 wks.) : Y = 83.3 1.4 x (r = 0.87)
Period II 3.2.76 12.10.76 (36 wks.) Y = 109.4 12.7 x (r = 0.94)

(b) Period I 13.10.76 23.5.77 (28 wks.) Y = 74.3 2.0x (r = 0.99)
Period II 23.5.77 11.10.77 (24 wks.) Y = 76.6 8.8x (r = 0.91)

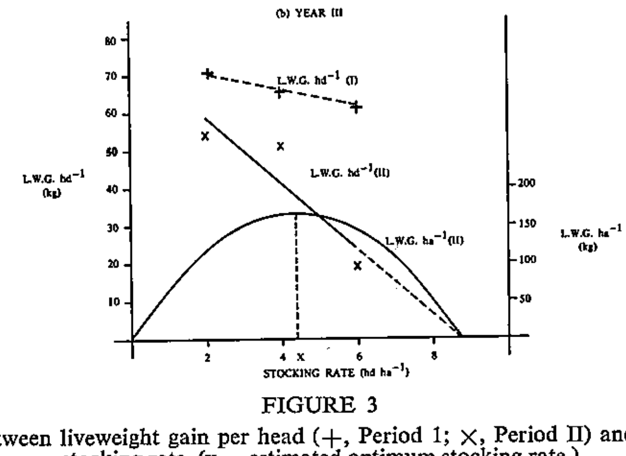


FIGURE 3

Relationship between liveweight gain per head (+, Period 1; ×, Period II) and per hectare and stocking rate. (x = estimated optimum stocking rate.)

The LWG hd^{-1} decreased with stocking rate for each Period and group of animals but there was a marked decrease in the slope of the regression line from Period I to Period II. That is, there was little effect of stocking rate in Period I but a pronounced effect in Period II. These effects of stocking rate on LWG were similar for both groups of animals. Jones and Sandland (1974) have shown that maximum

LWG per unit area will occur when the stocking rate is half that of the stocking rate at zero gain. For Period II, this was calculated from Figure 3 as 4.3 and 4.4 hd ha^{-1}, for the first and second group of animals, respectively.

There was also a significant effect of stocking rate on dressing percentage with animals on S_6 dressing out (54.3%) significantly lower ($P < 0.05$) than those at S_2 and S_4 (mean of 56.4%).

There was an increase in bone P concentration from a mean of 176.6 mg P cc^{-1} fresh bone at $CIRP_{20}$ to 183.7 at $CIRP_{80}$, but differences were not significant. Faecal P concentrations were significantly increased ($P < 0.05$) from 0.33% at nil P to 0.38% at $CIRP_{80}$.

Relationship between animal production and pasture measurements

LWG hd^{-1} was related to forage yield (kg ha^{-1}) and forage allowance (kg animal^{-1}) during the second year when periods of cobalt deficiency were omitted from the LWG data (Figure 4). However, there was no relation between LWG hd^{-1} and legume yield or legume allowance during this period. Nor was there any relationship between LWG with any of the pasture attributes measured during the first or third year.

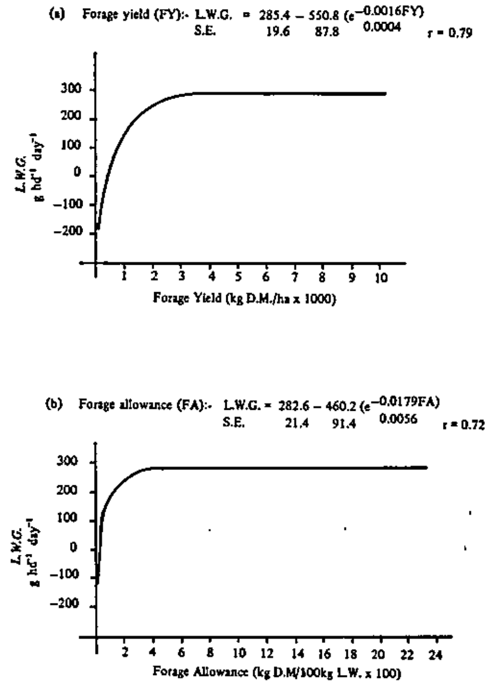


FIGURE 4

Relation between L.W.G. and feed availability (a) forage yield (b) forage allowance over 28 day periods during year II.

The LWG hd^{-1} at S_2 and S_4 was linearly related to both the P and calcium (Ca) concentration of guinea grass in the third year (Figure 5). Guinea grass constituted 71% of the total DM on offer during this period. LWG hd^{-1} increased from 280 g hd^{-1} day^{-1} at the nil P level to 379 g hd^{-1} day^{-1} at the $CIRP_{80}$ level and this was associated with similar increases in the mean P concentration from 0.13% to 0.19% and mean Ca concentration from 0.18% to 0.26% (Eng *et al.* 1978).

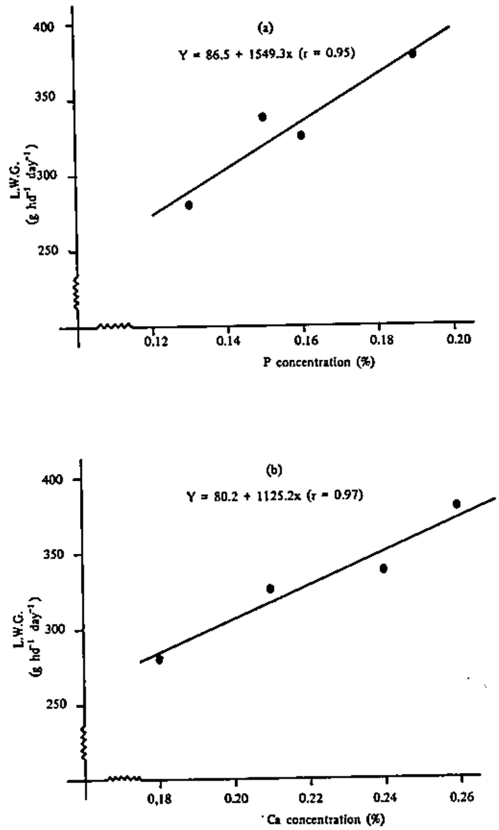


FIGURE 5

Relationship between (a) phosphorus (b) calcium concentration of guinea grass and liveweight gain over the low (S_2) and medium (S_4) stocking rates during year III.

DISCUSSION

An important outcome of this investigation was the recognition in Peninsular Malaysia of cobalt deficiency (Mannetje *et al.* 1976). Currently, a survey is being undertaken by the Pasture Unit of MARDI to determine the cobalt status of pastures grown on various soil types in the country.

Although the highest LWG per hectare was obtained at S_6 during the first and third years, the decline in pasture yield on offer and legume content at this stocking rate reported in the first paper (Eng *et al.* 1978) indicates that this was too high a stocking rate to sustain stable pastures. The low LWG obtained at S_6 during the second half of the second and third year (Figure 1) indicates that cattle could not be finished on the pasture at this stocking rate. This is of particular importance to the beef industry where the main source of revenue is from the sale of finished cattle.

In assessing the optimum stocking rate for maximum LWG per hectare, the marked decrease in slope for the regression lines for both groups of cattle from Period I to II (Figure 3) indicates a drastic decline in LWG per head at S_6 once pasture yield became limiting and overgrazing occurred. When this happened, that is in Period II when animals had reached approximately 150 kg liveweight, the optimum stocking was found to be just above four Kedah-Kelantan cattle per hectare.

The high LWG per hectare at S_6 during the first 24 weeks of grazing is partly due to the reserve of pasture available prior to stocking rate having an effect on the pasture. The low animal liveweight resulted in low demand on the pasture. However, by the end of the second year the low LWG per hectare showed the high stocking rate was excessive. In Year III, when there was no reserve of feed at S_6, the LWG for new animals was high for 28 weeks and then declined, again indicating the interaction of animal liveweight and stocking rate on LWG.

The highest LWG per hectare of 544 kg from the S_4 $CIRP_{80}$ treatment during the third year is similar to 558 kg per hectare reported by Mellor *et al.* (1973) from the third year of a grazed guinea grass-centro pasture at Innisfail, Queensland. The value obtained however, is much higher than animal production levels reported by Grof and Harding (1970), Evans and Bryan (1973), Jones (1974) and Winter *et al.* (1977) from other experiments on grazed grass-legume pastures in Queensland.

The growth rate of healthy Kedah-Kelantan cattle measured in this experiment from grazed guinea grass-legume pastures during the first and third years, is much higher than weight gains previously reported from stall feeding trials using the same breed of cattle. A LWG of 446 g per head per day was recorded over 24 weeks in Year I from the S_2 TSP_{20} treatment while 385 g per head per day was obtained from the S_2 $CIRP_{80}$ treatment over the 52 weeks in Year III. Flint (1971) reported mean LWG of 295 g per head per day for these cattle when stall fed with green chop *ad lib.* and concentrate supplement over a 180 day period. Devendra (1973) reported a mean LWG of 194 g per head per day for similar male calves which were grazed on carpet grass (*Axonopus compressus*) and then stall fed with cut guinea or napier (*Pennisetum purpureum*), plus one kg per head per day of concentrate supplement. Later work by Devendra and Lee (1975) reported that these cattle gave a much improved LWG of 339 g per head per day when fed a mixture of 50% guinea grass and 50% concentrate whereas those on pure grass or pure concentrate feed alone, gained only 275 and 272 g hd^{-1} day^{-1}, respectively.

The mean dressing percentage of 55.7% obtained in this experiment is higher than the 52.3% for Hereford cattle reported by Evans and Bryan (1973), suggesting that the dressing percentage of local Kedah-Kelantan cattle is at least comparable to that of European breeds when both are grazed on good quality tropical pasture.

There was a trend during the second year at S_4 only for LWG per head to increase (217–269 g per head per day) with increasing rates of P. However the effect of annual maintenance dressings of P fertilizer on animal production became more evident during the third year, especially at S_2 and S_4. Since total DM on offer or botanical composition of the pasture were not significantly affected by varying P levels during this period (Eng *et al.* 1978), and in view of the significant linear relationships between LWG per head and the mean P and Ca concentrations of the guinea grass (Figure 5), it is likely that these differences in LWG per head (Table 2) can be attributed to the level of P and Ca concentration in the guinea grass and legume.

The response in LWG to increasing P concentration of guinea grass is not unlikely as P concentrations were below values of 0.2% to 0.3% recommended for growing steers from 150 kg to 300 kg liveweight (NRC 1976). Furthermore, faecal P concentration increased in a similar manner to P concentration of the guinea grass and other species. This response in LWG to increasing P levels could be due to a number of factors which may have been induced by the higher P concentration. Thornton and Minson (1973) reported that the mean estimated dry matter digestibility (DMD) of a *Digitaria decumbens*-legume pasture increased from 41.6% to 44.9% when P concentrations increased from 0.11% to 0.15%. Ozanne *et al.* (1976) have shown in pen feeding trials that increasing the P concentration in dry feed by higher P fertilizer rates resulted in increased LWG. However, the responses obtained were not necessarily due to P *per se*.

The LWG response to increasing Ca concentration of the pasture is supported by the findings of Rees and Minson (1977) who showed in pen feeding trials with sheep that increasing the Ca concentration of pangola grass from 0.22% to 0.38% increased DMD by 2.1% whilst DM intake was increased by 11.3%.

Results from this experiment showed a good relation between LWG per head and forage yield in Year II (Figure 4a) although other studies reported a better relation to the amount of green material available (Mannetje 1974, Mears and Humphreys 1974). In Malaysia, the pasture usually remains green throughout the year as a result of uniform and adequate conditions for growth. The better relationship obtained between LWG per head and forage yield instead of forage allowance (Figure 4) is in agreement with Murtagh (1975) who reported that forage yield is a better measure of forage supply than forage allowance or grazing pressure.

The lack of a good relationship between LWG per head and legume availability is in contrast to reports by Norman (1970), who worked with *Stylosanthes humilis*-native grass pastures at Katherine, N.T., and Evans (1970), who worked with a mixed grass-legume pasture in south-east Queensland, that animal production is well related to the legume content of the pasture. Their results were obtained from areas with a prolonged dry spell during which voluntary intake of the mature grass may be limited by protein deficiency as reported by Milford and Minson (1966). However, in the humid tropics where the grass grows actively and maintains a uniform nutritional value throughout the year, the main role of legumes may be one of N supply to the pasture. Furthermore, legume content of the pastures was fairly high (mean of 21%) throughout the three years (Eng *et al.* 1978) and it is unlikely N supply to the animals was ever limiting their intake.

The general conclusions that can be drawn from this study are:

(i) good levels of animal production may be obtained from stable guinea grass-legume pastures in Malaysia. The optimum stocking rate for beef animals with an average liveweight of *c.* 150 kg appears to be 4 animals per hectare;

(ii) rock phosphate can be used to sustain pasture and animal production. This is economically important as rock phosphate is much cheaper per unit P than superphosphate;

(iii) the local Kedah-Kelantan cattle have good potential for growth when grazed on improved pastures;

(iv) it is desirable that evaluation of animal production from grassland be under grazing conditions where animals have free selection of feed.

Further work will be needed to elucidate the nature of the response to phosphorus fertilization and whether this can be achieved in part by mineral supplementation.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. L. R. Humphreys, Dr. P. C. Kerridge and Mr. N. H. Shaw for valuable advice in the conduct of the experiment.

We thank En. Mohd. Zin b. Rashid for his capable assistance and the day to day care of the animals. We are also indebted to Miss Chia Joo Suan for the bone P analysis and Miss Santha Kurup for the faecal P analyses.

We would also like to thank Dr. Ajit Singh Sidhu for his encouragement and the Director-General MARDI for permission to undertake the study.

This experiment was part of the MARDI-CSIRO Pasture Research Project under the auspices of the Colombo Plan.

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(Accepted for publication October 3, 1978)