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SUPPLEMENTATION OF ENERGY AND/OR PROTEIN TO STEERS GRAZING SUMMER VELD

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OPSOMMING: BYVOEDING VAN ENERGIE EN/OF PROTEÏEN AAN OSSE OP SOMERVELD

Sommige aspekte van die effek van strategiese byvoeding van energie en/of proteïen aan osse op somerveld is ondersoek. 40 Friesosse in die ouderdomsgroep 12 tot 18 maande is in vier groepe verdeel en het die volgende behandelings ontvang (hoeveelheid aangegee is per dier per dag) : Groep 1 kontrole, geen byvoeding; Groep 2 strategiese byvoeding van 1,36 kg mieliemeel; Groep 3, strategiese byvoeding van 1,36 kg van 'n mengsel van gelyke dele mieliemeel en 'n hoë proteïenkonsentraat en Groep 4 ook strategiese byvoeding van 1,36 kg van 'n hoë proteïen konsentraat. Die grootste effek op verhoogde daaglikse massatoenames is behaal met 1,36 kg hoë proteïen konsentraat en die swakste effek is met mieliemeel behaal. Die verhoogde daaglikse massatoenames van Groepe 2, 3 en 4 is verkry deur 8,86; 4,10 en 3,50 kg byvoeding vir elke addisionele 1 kg lewende massatoename respektiewelik. Ten spyte van 'n betekenisvolle effek van byvoeding op gemiddelde daaglikse massatoenames vir twee uit die drie jaar, is finale lewende massa nie betekenisvol beïnvloed nie. Die gradering van karkasse is ook nie betekenisvol verhoog deur byvoeding nie. Deur implementering van 'n 90 dae afrondingsperiode na die somer weiperiode is die karkasgraad verhoog van 'n aanvanklike Graad 3 na Prima.

SUMMARY:

Some aspects of the effect of supplementary energy and/or protein, strategically provided to steers on summer veld, were investigated. 40 Friesland steers in the age group 12 to 18 months were divided into four groups and received the following treatments (quantities of supplement are per animal per day): Group 1 control, no supplementary feeding; Group 2 strategic supplementation with 1,36 kg maize meal; Group 3 strategic supplementation with 1,36 kg of a mixture consisting of equal parts of maize meal and a high protein concentrate and Group 4 strategic supplementation with 1,36 kg of a high protein concentrate. The greatest response to strategic supplementation in respect of average daily mass gains was obtained with 1,36 kg of high protein concentrate and the poorest response with maize meal. The increased average daily mass gains of Groups 2, 3 and 4 was achieved with 8,86; 4,10 and 3,50 kg supplement for each additional 1 kg live mass gain respectively. In spite of significant effects from supplementation on average daily mass gains in two out of three years, final live mass was not significantly influenced. Grading of carcasses was also not improved by strategic supplementation. A 90 day fattening period after the summer grazing period improved the grading of carcasses from an initial Grade 3 to Prime.

The scientific literature on ruminant nutrition is overwhelmingly devoted to handfeeding practices, yet the vast majority of the world's ruminants are nourished by pastures (McDonald, 1971). Due to unfavourable climatic conditions in some of the major grain producing countries recently, grain shortages were experienced and consequently the prices of feed grains escalated. It can be foreseen that feed grains will not always be available in sufficient quantities and that the price of such grains will not always permit extensive implementation in fattening rations for cattle. It follows that there will be a continuous need to study the basic principles which determine the use of pastoral lands by ruminants.

A considerable variation, both quantitative and qualitative within and between seasons is a characteristic of the natural pasture occurring in the eastern parts of the Highveld region. The fluctuating nature of the nutritive value of the pasture is also reflected in considerable fluctuations in the growth response of animals which utilize these pastures. During some summer months average daily mass gains of some 1 300 g have been obtained whilst these gains in some months were negative. In respect of monthly gains, mass changes in different years during October have varied from a loss of 3,0 kg to a gain of 36,9 kg. Long term mass determinations of steers at this Station have shown that an average daily gain in mass of some 600 g can be expected from steers in the age group 12 to 18 months when kept on veld during the period September 15 to April 1. The question was posed whether the strategic provision of energy and or protein to steers grazing summer veld could not sustain an even average daily mass gain of some 700 g.

The provision of supplementary feed to animals grazing summer veld is regarded as yet another aspect which could possibly have a direct bearing on increased beef production. In South Africa Pieterse & Preller (1965), Preller, Lesch & Kruger (1967 and Lesch, Preller & Van Schalkwyk (1968) obtained promising results with energy supplementation to steers which were grazed on veld during summer. The provision of supplementary concentrates as a means of increasing live mass gain at high stocking rates has been advocated by Musangi, Holmes & Jones (1965) with cattle on barley supplement; by Forbes, Raven & Robinson (1966) to cattle that were fed grass indoors in Britain; by Conway (1968) and by Tayler & Wilkinson (1972) also in Britain on perennial rye grass pastures. On the other hand disappointing results on the influence of supplementary feeding to cattle have been obtained by Alder, Head & Berting (1956) on grass/clover and grass/lucerne pastures; by Castle & Walker (1959) on clover/cocksfoot/rye grass pastures; by Dodsworth & Ball (1962) on natural grass; by Kreft (1966) on veld and by Prescott & Hinks (1968) on natural grass. It would appear that responses obtained in previous reported investigations vary considerably and may possibly be due to the fact that experiments were performed on different grasses and pastures under widely differing managerial conditions and stocking rates and

with supplements differing in composition. Favourable reactions with supplementation of non protein nitrogen to cattle were obtained by Altona, Rose & Tilley (1960) and with natural protein by Bredon, Lyle & Swart (1970).

The present investigation was initiated to study the growth response of steers supplemented strategically over the summer grazing period with either maize meal, maize meal plus high protein concentrate or high protein concentrate only.

Procedure

Animals

40 Friesland steers of comparable age (± 18 months), conformation and live mass were bought annually from surrounding districts during May. After treatment against internal and external parasites they were dehorned and then group-fed to the end of September.

Treatments

Immediately after arrival at the Agricultural Research Station steers were divided into four comparable groups of ten each, according to live mass and conformation. During the wintering period which extended from May to September 30 annually, steers were group fed on a ration of maize silage and *Eragrostis curvula* hay with a required minimum average daily gain of 450 g. The four groups of animals were assigned to the following treatments.

Group 1 received no supplementary feed during the summer grazing period.

Group 2 was strategically supplemented with 1,36 kg maize meal during summer so that animals could maintain an average daily mass gain of 700 g. During those periods when the veld was able to sustain an average daily gain of 700 g, no supplementary maize meal was provided (total daily amounts of nutrients from supplement: TDN = 1 115 g. CP = 122,4 g). Depending on the response from 1,36 kg maize meal, additional maize meal to a maximum of 2,3 kg per steer per day was given.

Group 3 received 1,36 kg per steer per day of a mixture made up of equal parts of maize meal and a high protein concentrate given strategically during summer, whenever average daily gains dropped below 700 g. Supplementary feeding was terminated whenever average daily gains exceeded 700 g (total amount of nutrients from supplement: TDN = 123 g, CP = 367,2 g). This concentrate mixture was composed of equal parts of yellow maize meal and groundnut oil cake meal.

Group 4 received 1,36 kg of a high protein concentrate given strategically during summer whenever average daily gains of 700 g could not be maintained by the veld (total amount of nutrients from supplement : TDN = 1 131 g, CP = 612 g). The high protein concentrate consisted of groundnut oil cake meal only.

Grazing of the veld commenced annually on October 1. The veld was divided into five paddocks, each being 6,8 ha in extent. The four groups grazed the five paddocks as a single rotating herd. A stocking rate of 1,5 ha per Mature Livestock Unit (MLU) was applied.

During those periods when steers received supplementary concentrates, they were fed in individual pens. During the 1969/70 season steers were supplemented from 8 October to 4 November and again from 24 January to 1 April 1970. During 1970/71 the periods were from 1 October to 10 December and from 7 March to 1 April. In the 1971/72 experimental period supplementary feeding was practised from 1 October to 5 November and again from 25 February to 1 April 1972.

On April 1 annually, five steers of each group of ten steers were slaughtered. The remaining five animals of each group were intensively fed for a period of 90 days on a ration of good quality maize silage *ad lib.* plus 3,63 kg of a concentrate mixture with CP 13,6% and TDN 83,0%.

All experimental animals had access to a dicalcium phosphate and salt lick in the ratio 1:1 throughout the experimental period. Animals were also regularly treated against internal and external parasites.

Experimental technique

(a) *Live mass*

The mass of animals was measured at the beginning of the wintering period and thereafter at fortnightly intervals at 07h00 after feed and water had been withheld for 14 h. During the summer grazing period the mass of animals was measured at weekly intervals at 06h00 without a starvation period but before being given access to water.

(b) *Feed intake*

During the wintering period all the animals were group fed and rations were mass measured daily. When the steers entered the feeding pens on April 1 annually, they were individually fed and intakes were determined. Maize silage which was fed *ad lib.* was offered at a rate of 15% in excess of the previous week's daily intake.

(c) *Dry matter*

Dry matter of all feeds offered and those which were not consumed during the overwintering and fattening periods were determined at weekly intervals in order to calculate dry matter intake.

(d) *Nutritive value of veld*

Ten grass samples were collected at random by clipping quadrates from each camp being grazed at fortnightly intervals. The samples were thoroughly mixed and subsampled for chemical analyses; N, DM, NFE and ash were determined. Four oesophageal fistulated steers were brought in once in 14 days to acquire representative grass samples for chemical analyses.

(e) *Carcass data*

Cold carcass mass without kidney and kidney fat was determined after cooling for 24 h at -3°C. Buttock length, carcass length and chest depth were also determined.

The following measurements were taken after a clean cut had been made between the 12th and 13th thoracic vertebrae.

Length (A) and depth (B) of *Musculus longissimus thoracis.* Area of *M. longissimus thoracis.* Fat covering of *M. longissimus thoracis* was measured on two sites i.e., on a height of $\frac{1}{4}$ (C) and $\frac{3}{4}$ (D) of the dorsal arch of *M. longissimus thoracis.*

After carcasses had been cooled for 24 h at -3°C they were graded according to generally accepted standards to the nearest one-third of a grade.

Processing of data

The experimental design was a complete randomised design. In order to calculate whether differences were statistically significant, the values of the studentized range for the corresponding degrees of freedom of Student – Newman – Keuls (May, 1952) was applied.

Definitions and abbreviations

N = Number of animals
SS = Statistical significance
NS = Statistically non-significant (P = 0,05)
CV = Coefficient of variation
Tab. F = Tabulated F
Cal. F = Calculated F

Results and Discussion

Table 1
Average mass at end of summer and daily mass gains of steers during summer for three seasons

Groups	n	Mass end summer 1969/70	ADG 1969/70	Mass end summer 1970/71	ADG 1970/71	Mass end summer 1971/72	ADG 1971/72
		(kg)	(g)	(kg)	(g)	(kg)	(g)
1	10	376,2	549	309,3	702	335,6	363
2	10	389,1	629	310,3	722	356,7	444
3	10	403,3	709	318,3	722	364,8	505
4	10	408,2	739	309,9	718	355,7	484
SS		NS	4>1** 3>1*	NS	NS	NS	3,4>1** 2>1*
CV		8,95	17,90	9,29	11,43	7,32	17,26
Cal. F.		1,68	5,26	0,21	1,31	2,30	6,50
Tab. F.							
(P=0,05)		2,86	2,86	2,86	2,86	2,86	2,86
(P=0,01)		4,38	4,38	4,38	4,38	4,38	4,38

	Group comparisons	LSD P=0,05	LSD P=0,01
LSD 1969/70	4>1**	142,0	174,0
	3>1*	129,0	161,0
LSD 1971/72	3>1**	93,0	115,0
	4>1**	85,0	106,0
	2>1**	70,0	93,0

During the 1969/70 season, favourable responses were obtained with strategic supplementation of energy and/or protein. Although no statistically significant difference in respect of final live mass was observed (Table 1), Group 4 gained highly significantly ($P<0,01$) faster than the Control group and Group 3 made significantly ($P<0,05$) greater mass gains than the Control group. The response to maize meal i.e. Group 2 was much less. The increased mass of animals in Group 2 over the controls (Group 1) was achieved with 8,6 kg of maize meal per kilogram additional live mass increase. In the case of animals in Group 3 which had a mass advantage of 27,1 kg over Group 1, the response was 4,1 kg supplement per kilogram additional gain. The figure for Group 4 versus Group 1 was 3,5 kg supplement per kilogram additional live mass gain.

During the 1970/71 season no statistically significant responses to supplementary feeding in respect of final mass after summer or average daily gains were obtained. However, during the 1971/72 season a statistically highly significant ($P<0,01$) response in respect of average daily gains of Groups 3 and 4 over Group 1 was observed as well as a significant ($P<0,05$) response of Group 2 over Group 1. Final mass of the different groups after summer was not significantly different.

At the Wiregrass Substation (1966) additional mass gains over that of the control group was obtained at a supplementation rate which varied between 10,45 and 16,86 kg supplement for each additional kilogram gain.

Responses in terms of increased average daily mass gains in the present study were generally small and considerably less than the increases reported by Perry, Huber, Mott, Rhykerd & Taylor (1972). In their study control animals had average daily gains of 431 gm in comparison with gains of 840 g for steers which received 2,8 kg energy supplement daily. Tayler & Wilkinson (1972) reported average daily mass gains of 730, 1070 and 1220 g for steers in the Control, Group 2 supplemented with 1,61 kg and Group 3 supplemented with 4,35 kg of concentrates respectively. Bredon, *et al.* (1970) working in East Griqualand obtained a response of 9,25 and 31 kg gain in live mass above the Control group by providing 41; 100 and 199 g additional crude protein per day respectively. Promising results have also been reported by Forbes, Raven, Irwin & Robinson (1967) who obtained an improvement of 24% in live mass gain by providing 1,5 kg barley per animal per day under indoor conditions.

The poor response to supplementary feeding during the 1970/71 season (Table 1) can most probably be ascribed to the considerably higher crude protein content of the natural grazing as shown in Table 5. The crude protein content as obtained for samples from oesophageal fistulated steers was also considerably higher than that obtained from hand clipped samples. This result is in agreement with similar results reported by Bredon *et al.* (1970). As may be judged from the average daily mass gains of some 700 g, steers were most probably ingesting sufficient nutrients and a lowered pasture intake could have resulted in those groups which received supplementary feed due to a substitution effect. In this context Hart, Bond, Carlson & Rumsey (1971) showed that cattle which were given supplementary maize meal harvested some 60% less net energy per ha from grass than cattle on grass alone.

Small and erratic mass gains are encountered especially during early summer and also during March when the crude protein content of the veld declines. Clanton, Hildebrand & Jones (1971) conducted a study on supplementary feeding over a three year period and concluded that there was little advantage in feeding more than 0,45 kg of a 24% protein supplement at any time of the summer season and that this advantage was more evident in the later two-thirds of the summer, indicating that protein was more limiting than energy. In the present investigation no response was obtained with 1,36 kg of maize meal. However, when the level was increased to a rate of 2,3 kg per animal per day, slight gains were recorded. This result is in agreement with that of Clanton *et al.* (1971) who found that energy supplementation did not increase mass gains until a level of 1,8 kg per animal per day was reached.

In spite of a response to supplementation in respect of average daily gains, final mass after summer revealed no significant differences and strategic supplementation can consequently not be advocated. Also, the response from energy supplementation as provided by maize meal was consistently poorer than the effect of protein supplementation on average daily gains. Considering the improvement live mass responses obtained by Altona *et al.* (1960) with NPN and Bredon *et al.* (1970) with true protein supplementation and the effect obtained by Pieterse (1967) and Preller, *et al.* (1967) with supplementary energy, further investigations are required to evaluate the effect of energy and/or protein supplementation to animals grazing summer veld.

From Table 2 it may be seen that no response in respect of improved grading was obtained by supplementary feeding. This result was further substantiated by the $\frac{C + D}{2}$ measurement which showed no response to previous imposed treatments such as supplementary feeding. Furthermore, no consistent trend in respect of the fat to lean ratio as obtained from the ratio $\frac{C + D}{2} : B$ was observed. Contradictory to these results, Pieterse (1967) and Hart *et al.* (1971) reported that grading was improved by the provision of supplementary feeds to

cattle grazing natural pasture. The absence of a response in respect of improved grading in the present investigation can possibly be attributed to the fact that supplementation was practised strategically over periods of short duration. Continuous supplementation as implemented in the studies of other workers could probably have influenced the grading of animals. It was conclusively shown that marketable carcasses could not be produced from dairy type steers in the age group ± 18 months which had been grazed on summer veld.

Table 2

Cold carcass mass, grading of steers, fat covering of **M. longissimus thoracis** *and ratio of* $\frac{C + D}{2}$ *to depth (B) of* **M. longissimus thoracis** *of steers slaughtered on April 1 annually*

		Groups						
	n	1	2	3	4	SS	CV	Cal. F.
							%	
1970								
Cold carcass mass (kg)	5	175,6	190,8	197,6	195,3	NS	11,39	1,04
Grading (points)	5	11,6	11,2	12,2	11,2	NS	16,13	0,32
$\frac{C + D}{2}$ (mm)	5	0,39	1,50	1,19	1,09	NS	117,12	0,71
$\frac{C + D}{2}$. B (1:)	5	160,0	31,3	42,7	47,7	NS	104,75	1,27
1971								
Cold carcass mass (kg)	5	148,2	146,6	154,7	141,3	NS	9,99	0,69
Grading (points)	5	7,4	7,6	7,8	7,6	NS	8,32	0,33
$\frac{C + D}{2}$ (mm)	5	3,19	3,10	3,59	3,39	NS	19,75	0,57
$\frac{C + D}{2}$: B (1:)	5	15,9	18,8	14,5	14,6	NS	20,87	1,81
1972								
Cold carcass mass (kg)	5	157,5	179,5	181,8	172,0	NS	9,58	2,19
Grading (points)	5	7,0	7,6	7,6	7,0	NS	12,99	0,66
$\frac{C + D}{2}$ (mm)	5	0,10	1,30	1,29	0,00	NS	172,76	1,66
$\frac{C + D}{2}$: B (1:)	5	371,4	33,5	20,9	∞	NS	60,87	1,60

Grading points given as follows: Super + = 20, Super 19, Super –18, ... Grade 1+ = 14, Grade 1 = 13, Grade 1– =12 . . . . . Grade 3+ = 8, Grade 3 = 7 and Grade 3– = 6.

Results provided in Tables 3 and 4 indicate that satisfactory average daily mass gains of some 800 to 1 000 g were recorded for those animals which were intensively fed annually from April 1 to July 1 after the summer grazing period. Grading was improved from Grade 3 at the start of the fattening period to Prime at the conclusion of this period. The improved grading figures were also substantiated by the fat covering of *M. longissimus thoracis*, i.e. $\frac{C + D}{2}$ as well as a considerably narrower ratio of fat to lean as provided by $\frac{C + D}{2}$: B. After the fattening period, when animals were slaughtered, no statistically significant effects in the different carcass parameters which could be ascribed to previously imposed treatments such as supplementation of energy and or protein could be observed.

Table 3

Average daily mass gains of steers during fattening and final mass

Groups	n	Final mass	ADG	Final mass	ADG	Final mass	ADG
		1970		1971		1972	
		(kg)	(g)	(kg)	(g)	(kg)	(g)
1	5	462,6	999	387,6	787	422,6	963
2	5	477,4	1043	402,8	917	451,7	1052
3	5	471,6	843	398,6	859	458,2	1033
4	5	488,4	875	389,4	851	450,3	1039
SS		NS	NS	NS	NS	NS	NS
CV(%)		8,82	17,71	7,64	13,66	7,13	17,81
Cal. F.		0,33	1,66	0,29	1,19	1,23	0,23
Tab. F.							
(P=0,05)		3,24	3,24	3,24	3,24	3,24	3,24
(P=0,01)		5,29	5,29	5,29	5,29	5,29	5,29

Table 4

Cold carcass mass, grading, fat covering of **M. longissimus thoracis** *and ratio of* $\frac{C+D}{2}$ *to depth (B) of* **M. longissimus thoracis** *of steers slaughtered on July 1 annually after a fattening period of 90 days*

		Groups						
	n	1	2	3	4	SS	CV	Cal. F.
							%	
1970								
Cold carcass mass (kg)	5	251,1	258,2	253,4	259,0	NS	8,78	0,14
Grading (points)	5	14,6	15,6	15,2	15,6	NS	9,03	0,58
$\frac{C+D}{2}$ (mm)	5	7,0	7,0	6,0	5,6	NS	37,86	0,41
$\frac{C+D}{2}$: B (1:)	5	8,3	9,1	14,4	11,6	NS	70,40	0,65
1971								
Cold carcass mass (kg)	5	199,5	206,2	208,6	191,8	NS	9,20	0,82
Grading (points)	5	14,0	15,0	16,0	14,8	NS	15,75	0,60
$\frac{C+D}{2}$ (mm)	5	4,7	5,0	4,9	6,8	NS	25,82	2,39
$\frac{C+D}{2}$: B (1:)	5	11,6	11,3	10,6	7,1	NS	34,94	1,68
1972								
Cold carcass mass (kg)	5	225,0	249,2	245,3	243,6	NS	6,73	2,21
Grading (points)	5	15,4	16,8	15,6	16,4	NS	10,14	0,82
$\frac{C+D}{2}$ (mm)	5	7,9	7,3	7,6	7,4	NS	31,00	0,06
$\frac{C+D}{2}$: B (1:)	5	6,8	8,8	7,5	7,9	NS	42,60	0,33

Table 5

Chemical composition of grass samples (Dry basis)

Date	Clipped samples			Oesophageal fistula samples		
	CP	DCP	P	CP	DCP	P
	%	%	%	%	%	%
15.10.69	3,09	–0,17	0,06			
15.11.69	5,78	2,34	0,11			
15.12.69	5,64	2,26	0,14			
15.1.70	3,80	0,70	0,09	Oesophageal fistulated		
15.2.70	4,14	0,93	0,08	animals included as from		
15.3.70	3,50	0,31	0,06	15.12.70		
15.10.70	4,31	1,12	0,07			
15.11.70	3,06	–0,17	0,06			
15.12.70	6,18	2,70	0,08	8,75	5,25	0,22
15.1.71	7,18	3,70	0,09	14,93	11,17	0,25
15.2.71	7,25	3,86	0,11	9,00	5,50	0,21
15.3.71	6,06	2,67	0,10	9,96	6,45	0,30
15.10.71	9,25	5,75	0,12	7,68	4,30	0,15
15.11.71	12,25	8,56	0,15	8,62	5,12	0,16
15.12.71	7,75	4,36	0,12	10,68	7,06	0,26
15.1.72	10,12	6,54	0,17	13,18	9,46	0,24
15.2.72	7,18	3,70	0,20	6,40	3,03	0,18
15.3.72	6,31	2,94	0,14	6,37	3,00	0,21
Average from 15.12.70 to 15.3.72	7,95	4,47	0,12	9,55	6,03	0,21

Conclusions

The greatest response in respect of improved live mass gains of steers on summer veld was obtained with the provision of a protein supplement. However, the response was erratic and had no statistical significant influence on different carcass parameters. The response to the strategic supplementation on maize meal was disappointing. When the rather contradicting results of other research workers in this field in South Africa in respect of measured growth responses with energy versus protein are considered, it appears that additional research should be done before the supplementary feeding of animals grazing summer veld can be recommended. Results obtained further conclusively indicated that marketable carcasses could not be produced from Friesland steers in the age group ± 18 months which had been grazed on summer veld with strategic supplementation of either energy and or protein

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References

ALDER, F.E., HEAD, M.J. & BERTING, J.F.R., 1956. Carbohydrate supplements for beef cattle on grass/clover and grass/lucerne mixtures. *Proc. Br. Soc. Anim. Prod.* 3, 79 Edinburgh : Oliver & Boyd.

ALTONA, R.E., ROSE, C.J. & TILLEY, T.J., 1960. Urea as supplementary protein for milk feeds. *S. Afr. J. agric.* Sci. 3, 69.

BREDON, R.M., LYLE, A.D. & SWART, C.E., 1970. The use of oesophageal fistulated cattle on summer veld in East Griqualand. *Proc. S. Afr. Soc. Anim. Prod.* 9, 163.

CASTLE, M.E. & WALKER, R.F.R., 1959. The outdoor rearing of Ayrshire calves on pasture with and without supplementary feeding. *J. Br. Grassld Soc.* 14, 88.

CLANTON, D.C., HILDEBRAND, R.L. & JONES, L.E., 1971. *Supplements for yearling cattle on summer range.* Nebraska beef cattle report. Univ. Nebraska, 218, 7.

CONWAY, A., 1968. Grazing management in relation to beef production. V. Effect of feeding supplements to beef cattle on pasture at two intensities of stocking. *Ir. J. agric. Res.* 7, 105.

DODSWORTH, T.L. & BALL, C., 1962. Studies on the feeding of supplements to beef cattle on grass. *Anim. Prod.* 4, 221.

FORBES, T.J., RAVEN, A.M. & ROBINSON, K.L., 1966. Observations on the utilization of grass grazed by young beef cattle with and without barley supplementation. *J. Br. Grassld. Soc.* 21, 167.

FORBES, T.J., RAVEN, A.M., IRWIN, J.H.D. & ROBINSON, K.L., 1967. The utilization of grass fed indoors to young beef cattle with and without barley supplementation. *J. Br. Grassld. Soc.* 22, 158.

HART, R.H., BOND, J., CARLSON, G.E. & RUMSEY, T.R., 1971. Feeding corn or molasses to cattle on orchard grass pasture. *Agron. J.* 63, 397.

KREFT, H.W., 1966. Urea and Biuret as nitrogen supplements for cattle. *Proc. S. Afr. Soc. Anim. Prod.* 5, 66–70.

LESCH, S.F., PRELLER, J.H. & VAN SCHALKWYK, A.P., 1968. Wintervoeding en beesvleisproduksie. *Boerd. S. Afr.* 44 (No 3), 60.

MAY, J.M., 1952. Extended and corrected tables of the upper percentage points of the studentized range. *Biometrika* 39, 192.

McDONALD, I.W., 1971. Animal production: Quo Vadis. *S. Afr. J. Anim. Sci.* 1, 149.

MUSANGI, R.S., HOLMES, W. & JONES, J.G.W., 1965. Barley supplementation and voluntary feed intake of fattening beef cattle under restricted and unrestricted grazing conditions. *Proc. Nutr. Soc.* 24, i.

PERRY, T.W., HUBER, D.A., MOTT, G.O., RHYKERD, C.L. & TAYLOR, R.W., 1972. Effect of level of pasture supplementation on pasture dry lot and total performance of beef cattle. 2. Spring plus summer pasture. *J. Anim. Sci.* 34, 647.

PIETERSE, P.J.S., 1967. Feeding systems for meat production. *Fmg. S. Afr.* 43 (No 4), 43.

PIETERSE, P.J.S. & PRELLER, J.H., 1965. Voorlopige resultate met byvoedings aan vleisbeeste op somerveld. *Hand. S. Afr. Ver. Diereprod.* 4, 123.

PRELLER, J.H., LESCH, S.F. & KRUGER, A.J.J., 1967. *Beesvleisproduksie – Eenheidsproef.* Jaarlikse vorderingsverslag H-Ps 67.