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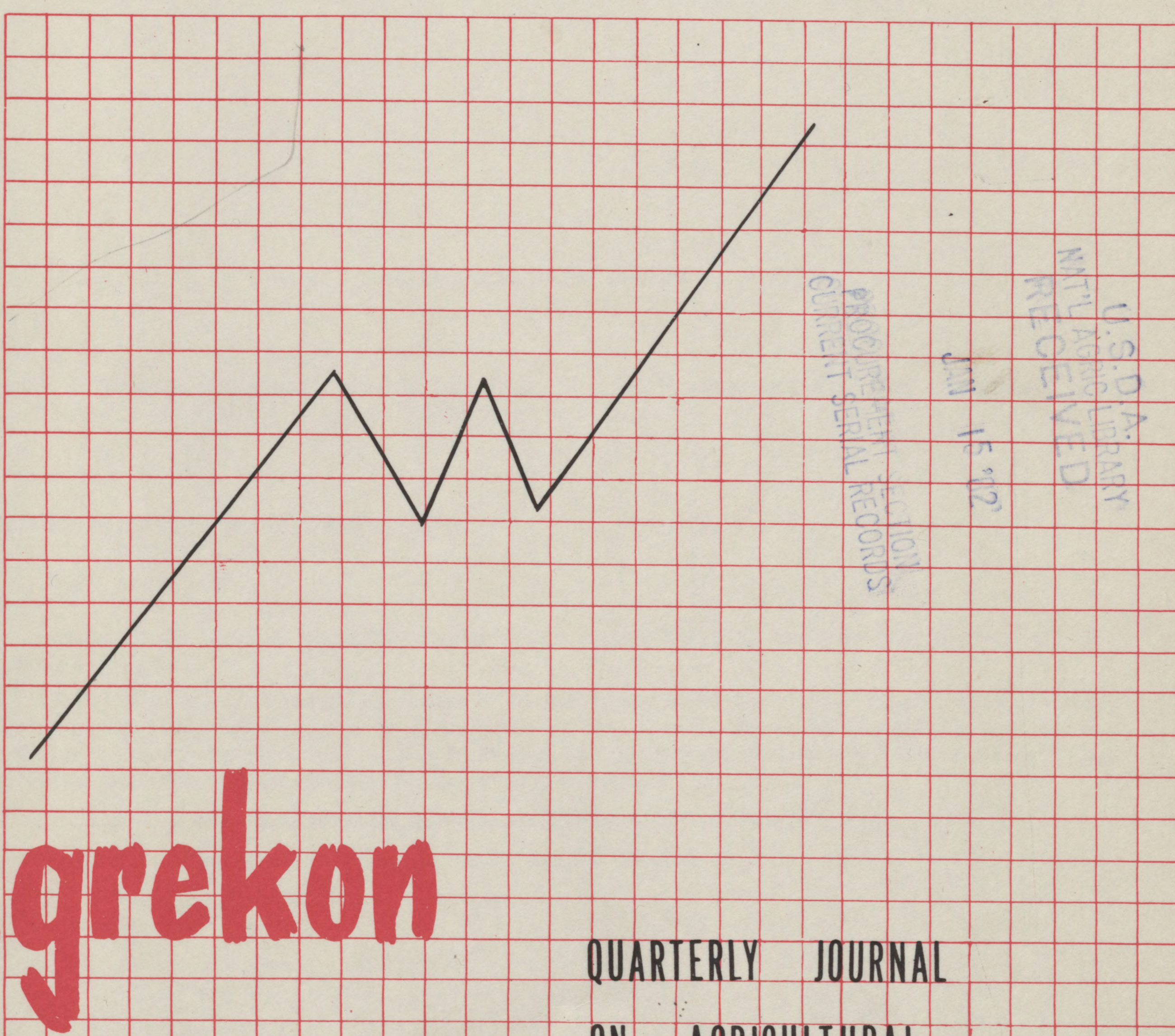

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INTENSIVE FEEDING OF BEEF

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Intensive feeding of cattle is becoming more important and also more profitable in South Africa especially with current high beef prices.

The purpose in intensive feeding is not only to increase the weight of the animal, but to improve its grade and slaughter percentage. These factors are studied in this report. Intensive feeding of beef lends itself for an economic analysis of response functions as the environment can be controlled.

Results analysed in this report are of particular significance because of the large number of animals, 301 steers, studied in the experiment. The aim of the experiment was to measure and compare the relative efficiency of feed conversion for different age groups. Economic optimum slaughter stages will be determined. Optimum levels depend on many factors such as type of cattle, age, initial mass and condition, sex and grading system.

NATURE OF FEEDING TRIAL

The trial was conducted at Henderson Research Station, Mazoe, Zimbabwe. Results were obtained over the period commencing January 1970, and ending, October, 1975. Animals under study were predominantly Hereford X Afrikander steers of varying ages which is a popular breed in Zimbabwe. The Hereford parent gives the hybrid the ability to fatten rapidly, a characteristic common to most of the British beef breeds. Whereas the Afrikander component, with its heat tolerance genes, gives the offspring the necessary ability to thrive in harsh ranching conditions.

All animals were fed on an identical ration which was provided *ad libitum*. The diet was of a mixed high-energy content, and therefore results of this analysis are only applicable to intensive beef systems.

At different stages, a randomly selected number of steers from their respective group were slaughtered at an abattoir. For each individual animal mass and carcase grade was recorded.

PROCEDURE OF ANALYSIS

Feed consumption data and gain in carcase mass were recorded for 301 steers and weaners of different age groups. A response function analysis was undertaken on this data in order to determine optimum slaughter weights and optimum feeding periods. In this study, feed is the only variable input and problems such as multicollinearity are thus not encountered. Further the environment is more controlled than in the case of fertilizer trials where weather is an important factor and soils and climate differ in production areas.

Change in grade of beef is important in determining the optimum feeding rate. This was accounted for as animals were slaughtered at intervals and grades and prices recorded. Physical output data could thus be adjusted for quality differences. Meat gained was measured as carcase mass to account for improvement in slaughter percentages.

RESULTS

Input-output data

Feeding results for five groups of animals are shown in Table 1. Starting carcase weight for each group is reported in column 1. Animals were randomly slaughtered after each stage to determine quality of meat and carcase mass. For example in the case of the two and a half year old steers, 10 animals were slaughtered at intervals. Data presented in the table thus refer to mean quantity of feed consumed and mean carcase mass, for respective groups at time of slaughter.

Response function on all groups

A single response function was estimated combining data of all groups by incorporating dummy variables for individual groups.

$$y = 8,2 + 0,0899X_1 - 0,0000048X_1^2 - 10,4X_2 + 1,9X_3 -0,75X_4 - 4,6X_5$$

(t=19,8) (t=2,1) (t=2,5) (t=0,4) (t=0,2) (t=2,1) (1)

R^2 = ,98
df = 25

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* Trial was carried out by the Henderson Research Station, Mazoe, Zimbabwe

TABLE 1 - Average gain and feed consumption in kg/head

	Starting carcase mass (kg)	Trial data						
2½ year old steers	190,4							
Feeding days		0	28	56	91	126	168	
Feed consumed (kg)		0	316,9	730,4	1 188,9	1 700,2	2 176,7	
Gain in carcase (kg)		0	35,5	65,5	101,0	132,7	164,9	
Price of meat (R/kg)			2,18	2,18	2,18	2,18	2,09	
Heavy 1½ year old steers	140,4							
Feeding days		0	28	56	84	112	140	
Feed consumed (kg)		0	237,3	586,7	885,7	1 249,9	1 592,7	
Gain in carcase (kg)		0	27,5	63,4	90,0	113,3	143,1	
Price of meat (R/kg)			1,86	2,18	2,18	2,18	2,18	
Light 1 ½ year old steers	116,8							
Feeding days		0	28	56	84	112	140	
Feed consumed (kg)		0	280,1	611,5	927,6	1 261,0	1 491,6	
Gain in carcase (kg)		0	36,5	67,7	84,6	120,1	127,9	
Price of meat (R/kg)			1,76	2,18	2,17	2,18	2,18	
Heavy weaners	111,2							
Feeding days		0	28	56	84	112	140	168
Feed consumed (kg)		0	171,4	401,8	706,1	906,8	1 185,8	1 509,9
Gain in carcase (kg)		0	19,7	40,7	70,8	83,2	103,8	126,6
Price of meat (R/kg)			1,81	2,18	2,18	2,18	2,18	2,18
Light weaners	86,5							
Feeding days		0	35	70	105	140	175	210
Feed consumed (kg)		0	204,2	499,7	830,1	1 094,0	1 360,7	1 709,7
Gain in carcase (kg)		0	25,2	57,8	89,2	107,4	124,5	144,4
Price of meat (R/kg)			1,59	2,07	2,18	2,18	2,18	2,18

y = gain in carcase mass per animal in kg, mass converted to top grade using prices
X_1 = quantity of feed consumed in kg per animal
X_2 = 1 if group 1 (2½ year old steers)
X_3 = 1 if group 2 (heavy 1½ year old steers)
X_4 = 1 if group 3 (light 1½ year old steers)
X_5 = 1 if group 4 (heavy weaners)

If $X_2 = X_3 = X_4 = X_5 = 0$; then group 5 (light weaners)

In this response function, gain in carcase mass was converted to top grades by utilising beef prices to account for changes in beef quality during the trial.

According to equation 1,98 per cent of the variation in weight gain was attributed to feed intake and group differences, which gives confidence in the model. t-Values of the feed variable are highly significant (t=19,8) giving further confidence in the model. Although the production function indicates diminishing returns (X^2 being negative), the very high t-value for X_1 and the lower t-value for X_2 implies the weight gain increased largely in a linear fashion in relation to feed intake over the duration of the trial. The dummy variables permit us to make group comparisons because groups can now be ranked in terms of their feed conversions. The 2½ year old steers (X_2)put on the least weight for an equivalent amount of feed consumed for the five groups. Differences in weight gain for the same quantity of feed consumed were not significant for the other four groups. The five groups are ranked in Table 2 in terms of feed conversion from best to worst as follows: heavy 1½ year old steers, light weaners, light 1½ year steers, heavy weaners and 2½ year steers. Table 2 shows that for the average amount of feed consumed during the trial, the light weaners gained 10,4 kg per animal more than the 2½ year old steers. Other data are interpreted in a similar way.

In an alternative model, number of days on feed was included as a variable to allow for the cost of housing cattle. This variable was significant but because of intercorrelations between feed intake and feeding days it is difficult to separate their influences and this factor was not further explored.

Response functions on individual groups

In Table 3, response functions are reported for individual groups. All variables are highly significant, R^2 are close to one and the low constant terms further stress the importance of feed. All functions indicate diminishing returns, i.e. the conversion rate of feed into beef falls at higher levels of feed.

In order to determine optimum slaughter weight, prices of beef and feed are required. Beef prices of top grades increased from about R1,18 during January 1980 to about R2,18 during November 1980 on a slaughter weight basis.

The high energy ration used in the trial was of the following composition: seventy per cent ground maize, ten per cent "super ten beef concentrate" and twenty per cent milled "star" grass. The following prices were used:

Purchase price of maize (includes railage and cost of bags), Nov. 1980 R148,90 per ton

Super ten beef concentrate (July 1980) R246,80 per ton

TABLE 2 - Group differences in kg per animal of meat for mean feed intake

Groups	Carcase mass (kg) per animal
2½ year old steers	0,
Heavy weaners	5,8
1½ year old steers	9,7
Light weaners	10,4
Heavy 1½ year old steers	12,4

TABLE 3 - Production function data on feed consumed and carcase mass: unadjusted carcase data*

	R^2	Constant term	X	X^2
2½ year old steers	0,997	2,7	+0,093 (t=13,9)	-0,0000088 (t=3,0)
Heavy 1½ year old steers	0,997	1,04	0,113 (t=13,8)	-0,000016 (t=3,2)
Light 1½ year old steers	0,986	2,2	0,116 (t=7,0)	-,0,000021 (t=1,9)
Heavy weaners	0,999	0,84	0,107 (t=23,1)	-0,000016 (t=5,4)
Light weaners	0,999	0,54	0,126 (t=41,3)	0,000025 (t=14,1)

*X and Y measured in kilograms

"Star" grass price of a 36 kg bale (July 1980) R 1,60 per bale

The weighted price per kg = (0,7)(14,89) + (0,1)(24,68) + (4,45)(0,20)

=13,781 per kg.

Optimums of slaughter weight and feed consumptions are derived by equating marginal costs of feed and marginal revenue of beef produced $(\frac{dy}{dx} = \frac{Px}{Py})$ and are presented in Table 4.

Using a price of beef of R2,18 per kg as prevailed during November 1980 and a price of feed of R0,1378 per kg, optimum feedings days are shown in Table 4 to vary from 108 - 165 days for different age groups. If prices of beef of R1,235 per kg (January 1980) and prices of feed of R0,1043 (July 1980) are used, optimum feeding days varied between 39 - 108 days which were considerably lower. The optimum feeding level appears to be sensitive to beef and feed prices. The reason for this is that the response function, converting beef into meat, is fairly linear over the intensive feeding period. This is clear from Table 3 where the linear term has very high t-values in relation to the quadratic term.

The conclusion is drawn that the substantial increase in beef prices during 1980, increased the level at which it is still profitable to feed, greatly. On the other hand during the beginning of 1980, the beef:feed price ratio was a bit unfavourable explaining why optimum feeding days were low at that time.

According to Mr. J. van Ryssen, Department of Animal Science, University of Natal, the length of feeding period varies from one month for old cows and oxen to six months for light weaner calves. Mr. B. Tarr from Tongaat uses a feeding period of 100 - 120 days for testing purposes. According to Mr. Jan Pretorius a large commercial feedlot owner and farmer, Pietermaritzburg his feeding period extends over 90 - 100 days for weaners.

Feed conversion

Table 5 shows the amount of concentrate feed required for one kg gain in carcase weight. Feed conversion data are calculated from actual data and not from response functions. Data for all groups show that feed conversion is the best during the initial feeding period and that it worsens after that. During the first 28 days of feeding 8 to 9 kgs of feed were required for 1 kg of carcase gain but after about 84 days approximately 12,5 kg of feed were required for the same gain in carcase weight. Carcase mass is expressed here as the kilogram weight gain and is not adjusted for grade quality changes.

Approximate meat prices are shown in Table 5 for animals slaughtered at various feeding stages. Two of the animals of the 2½ year steers were downgraded after 168 days of feeding for excess fat. Seven steers of the heavy 1½ year group were downgraded after 28 days of feeding due to insufficient degree of fat cover. Insufficient fat cover was also initially observed for other groups. Prices indicated in Table 5 are a reflection of the Zimbabwean grading system as the trial was carried out in that country.

The MR:MC ratio measures marginal revenue as a ratio of marginal cost taking into account possible downgrading of animals. For example in the case of the 2½ year steers, during the first 28 days of feeding, R1 spent on feed increased the value of meat output by R1,78 while between days

TABLE 4 - Optimum slaughter weight and feeding days, Nov. 1980, with data for January 1980 shown between brackets*

	Optimum live slaughter weight carcase mass (kg)	Optimum feed intake (kg)	Optimum feeding days (days)	Margin per Steer (R)
2½ year old steers	308(288)	1 433(508)	108(39)	57,6
Heavy 1½ year old steers	280(232)	1 576(918)	139(87)	88,0
Light 1½ year old steers	233(195)	1 269(769)	113(70)	77,8
Heavy weaners	227(180)	1 352(710)	153(85)	66,4
Light weaners	208(177)	1 282(857)	165(108)	89,0

*Optimum slaughter weight = initial carcase mass + gain in carcase weight. Price of beef taken as R2,18/kg and feed concentrate as R0,1378 per kg (Nov. 1980)

29 and 56, R1 spent on feed increased the value of meat output by only R1,15. The economic optimum slaughter weight as derived in Table 4 is where the MR ÷ MC ratio is 1.0.

Table 4 indicates the maximum profit that is possible per animal from intensive feeding using cost and price data. By increasing the turnover in the feedlot, the profit per animal would be lower but total profit would be more. Table 4 thus shows the maximum number of days an animal should be kept in a feedlot. The absolute minimum period that an animal should be kept in a feedlot is indicated in Table 6. The latter table reports meat production as a ratio of feed consumption at each production stage, which is the fimiliar economic concept of Average Product. For example in the case of the 2½ year steers after 56 days feeding total weight gain is 65,6 kg, feed consumption is 730,4 kg (refer Table 1) and the average product is 65,5 ÷ 730,4 = 0,090 (refer Table 6). The average product reflects kg of meat produced with 1 kg of feed at each production stage.

In some of the groups, a grade improvement occurred during the initial stages of feeding as can be seen from meat prices in Table 1. The weight gain data are consequently adjusted for this quality change using meat prices. For example in the case of "heavy 1½ year steers", after 28 days of feeding the average product is (27,5 x 1,86/2,18)/237,3 = 0,099 (refer Table 6).

Economic theory shows that if production is profitable, then a resource must be applied at least to the maximum of its average product, *irrespective of product (meat) and factor (feed) prices.* If this is applied to Table 6, then animals in groups 2, 3 and 4 should *not* be slaughtered before 56 days and animals in group 5 not before 70 days. Animals in group 1 can be slaughtered after 28 days. This is the *minimum* period that animals should be intensively fed. To put it differently. In the case of "Light 1½ year steers" after 28 days, 1 kg of feed produced 0,105 kg of meat (grade adjusted) while after 56 days 1 kg of feed produced 0,111 kg of meat. It must be more profitable to produce 0,111 kg of meat than 0,105 kg of meat from 1 kg of feed irrespective of the price of beef or the price of feed. Specific days of slaughter in this trial were chosen by researchers and the analysis of Table 6 must be seen as a comparison between slaughter stages; there is no magic about the specific numbers say 56 days.

CONCLUDING COMMENTS

Intensive feeding of cattle has become more important in South Africa. Animal Scientists and farmers know that under intensive feeding conditions, the animal not only gains weight, but a grade improvement occurs while slaughter percentage also improves. All these factors were considered by researchers at the Henderson Research Station in Mazoe, Zimbabwe. Animals were randomly slaughtered at different stages and carcase weight recorded to account for improvement in slaughter percentage under intensive feeding conditions. The exceptionally good results as measured by statistically levels of significance must be attributed to the very large number of animals (301 steers) on which this experiment was based. The animals were predominantly Hereford X Afrikander steers of varying ages.

It was found that in all age groups except for the 2½ year steers that the feed conversion (average product) adjusted for grade improvement, improves after the first feeding stage (28 days). The feed conversion fell after 56 days. According to economic theory a feeder must *at least* feed up to the point where the feed conversion is maximum (See Table 6), irrespective of meat and feed prices. This is under the provision that feeding in the first place is profitable. If animals are fed beyond the point of the maximum feed conversion ratio, then profits per animal will still increase, although total profits may fall. In Table 4 the maximum profit

TABLE 5 - Feed conversion ratio; kilogram of feed required to produce 1 kg of carcase mass, unadjusted data*

2½ year old steers: days	28	56	91	126	168	
Feed conversion	8,9	13,8	12,9	16,1	14,8	
Meat price	2,18	2,18	2,18	2,18	2,09	
MR ÷ MC	1,78	1,15	1,23	0,98	1,02	
Heavy 1½ year old steers: days	28	56	84	112	140	
Feed conversion	8,6	9,7	11,2	15,7	11,5	
Meat price	1,86	2,18	2,18	2,18	2,18	
MR ÷ MC	1,57	1,63	1,41	1,00	1,4	
Light 1½year old steers: days	28	56	84	112	140	
Feed conversion	7,7	10,6	18,7	9,4	29,6	
Meat price	1,76	2,18	2,17	2,18	2,18	
MR ÷ MC	1,66	1,49	0,84	1,68	0,53	
Heavy weaners: days	28	56	84	112	140	168
Feed conversion	8,7	11,0	10,1	16,2	13,6	14,2
Meat price	1,81	2,18	2,18	2,18	2,18	2,18
MR ÷ MC	1,51	1,44	1,57	0,98	1,16	1,11
Light weaners : days	35	70	105	140	175	210
Feed conversion	8,1	9,1	10,5	14,5	15,6	17,5
Meat price	1,59	2,07	2,18	2,18	2,18	2,18
MR ÷ MC	1,42	1,62	1,51	1,09	1,01	0,90

*Feed conversion = kg feed consumed/kg weight gain. Weight gain data are measured as kg gain in weights and are not adjusted for grade changes

MR ÷ MC = marginal revenue ÷ marginal cost

TABLE 6 - Accumulated meat production divided by accumulated feed consumption, kg meat/kg feed*

2½ year steers: days	28	56	91	126	168	
Meat production ÷ feed consumption	*0,112*	0,090	0,085	0,078	0,073	
Heavy 1½ year steers : days	28	56	84	112	140	
Meat production ÷ feed consumption	0,099	*0,108*	0,102	0,091	0,090	
Light 1½ year steers : days	28	56	84	112	140	
Meat production ÷ feed consumption	0,105	*0,111*	0,091	0,095	0,086	
*Heavy weaners :*days	28	56	84	112	140	168
Meat production ÷ feed consumption	0,096	*0,101*	0,100	0,092	0,088	0,084
Light weaners : days	35	70	105	140	175	210
Meat production ÷ feed consumption	0,090	*0,110*	0,107	0,098	0,091	0,084

*This measured the average product. In this case meat carcase data are adjusted in relation to the top grade price. Meat relative prices are taken to be a reflection of meat quality

point per animal from intensive feeding is derived. For example the maximum profit for a 2½ year steer is obtained after 108 days of feeding using current price and cost data. If animals are fed beyond the days calculated in Table 4, then the additional cost of feeding exceeds the additional revenue of weight gain. By selling animals at an earlier stage than shown in Table 4, the profit per animal would be lower but total profit could be more because of the larger turnover. The point where profit per animal is maximum as reported in Table 4 must be looked upon as the absolute maximum economic carcase slaughter weight. *Economic analysis thus demarcates a minimum period of feeding* (Table 6) *and a maximum period of feeding* (Table 4).

The length of the feeding period will be determined by type of cattle, age, initial mass and condition, sex, ration and grade price differentials. Animal scientists believe that a period of adaptation is required before cattle raised from the veld could be fed a high concentrate ration. According to Mr. Brian Tarr, Tongaat, this is not necessary any more with modern feeding methods. Dr. James Kitching from Epol recommends a one week adaptation period.

The grading system could however have an important effect on the optimum feeding period. In this study no grade improvement was found after about 56 days of feeding. If prices for super and prime grades are being increased in future then optimum feeding priods may be increased.

One important aspect of the study was to compare feed conversion of different age groups of animals. Table 2 and equation 1 indicated that the 2½ year old steers were *over the feeding* period the worst convertors. This statement needs qualification and the reader is again referred to Table 6 which shows that during the first 28 days the 2½ year old steers were the *best* convertors. However, after 28 days of feeding the conversion rate for the 2½ year old steers falls dramatically and becomes significantly lower than the other age groups. This is in accordance with current knowledge that older animals can be finished off quicker. After 56 days the heavy 1½ year old steers, light 1½ year old steers and light weaners showed best conversions. After 90 - 126 days of feeding, light weaners were marginally the best convertors.