Effect of replacement rate, production system and beef price on total herd efficiency

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The influence of replacement rate (R), price (c/kg carcass weight) and two production systems on total herd efficiency was investigated. R was assumed to be either 15% (minimum), 19% (point in between) or 23% (maximum). Percentage differences (minimum, point in between, maximum) in beef prices for the period 1984 to 1992 (RSA Livestock and Meat Statistics) were calculated for eight-month-old weaners vs. cull cows and 18-month-old market animals vs. cull cows, respectively. These percentage price differences were used to calculate relative income per hectare (I/ha) for two production systems, namely, an 8/18 month system (steers sold at eight months of age/surplus heifers sold at 18 months of age) and an 18/18 month production system (all market animals sold at 18 months of age). From the results it was clear that maximum R is applicable on systems where cull cows are, on a per-animal basis, of higher value than both eight-month-old weaners and 18-month-old market animals. Comparison between the two production systems based on adjusted I/ha and 20% R (assumed as standard practise in South Africa) has shown the 18/18 month system to be more efficient. This study also indicated that longevity is not important for maximizing efficiency, since R should be maximized.

Die invloed van vervangingstempo (R), verskille in vleispryse (c/kg karkasmassa) en twee produksiestelsels op totale kuddedoeltreffendheid is ondersoek. R was vasgestel op onderskeidelik 15% (minimum), 19% (punt tussenin) en 23% (maksimum). Persentasieverskille (minimum, punt tussenin, maksimum) in vleispryse vir die tydperk 1984 tot 1992 (RSA Vee- en Vleisstatistieke) is vir onderskeidelik agt-maande-speenkalwers vs. 18-maande-markdiere, agt-maande-speenkalwers vs. uitskotkoeie en 18-maande-markdiere vs. uitskotkoeie bepaal. Hierdie persentasie prysverskille is gebruik om berekenings vir relatiewe inkomste per hektaar (I/ha) vir die twee produksiestelsels, naamlik die 8/18-maande-stelsel (speenkalwers verkoop op ouderdom agt maande/surplus verse verkoop op ouderdom 18 maande) en die 18/18-maande-stelsel (alle markdiere op ouderdom 18 maande verkoop), te maak. Maksimum R is van toepassing op stelsels waar uitskotkoeie op 'n per-dier-basis meer werd is as sowel agt-maande-speenkalwers en 18-maande-markdiere. 'n Vergelyking gegrond op aangepaste I/ha en 20% R (beskou as standaard in Suid-Afrika) tussen die twee produksiestelsels, het bewys dat die 18/18-maande-produksiestelsel meer doeltreffend is. Hierdie studie het verder aangedui dat langslewendheid nie belangrik vir die maksimalisering van doeltreffendheid is nie, aangesien R so groot as moontlik moet wees.

Keywords: Production system, replacement rate, total herd efficiency.

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Introduction

Questions on the effect of replacement rate (R) (defined as percentage breeding cows replaced annually) and beef price on total herd efficiency are common in the beef industry. It is also known that a number of factors influence the ability of an animal to convert feed energy to beef over different stages of maturity in its productive lifespan with resulting differences in efficiency. Selection must therefore be based on all the traits contributing to efficiency rather than a specific trait. Single trait selection causes rapid change while creating a biological imbalance which may be detrimental to other components of efficiency (Stewart & Martin, 1983). The simplest possible breeding objective would be to maximize profit. However, this may be difficult due to fluctuations in price according to supply and demand since breeding improvement is a long-term enterprise requiring stable goals (Roux, 1992a).

Reproductive performance is a major determinant of economic success in beef production and shows considerable variability indicating scope for selection (Meyer *et al.*, 1990). According to Roux (1992a) reproductive performance depends on relative costs and output, related to the keeping of different age classes of reproducing animals. Furthermore, it is clear that the importance of replacement rate in herd efficiency depends on reproduction rate (Roux, 1992b).

Monetary value varies greatly in animal products, indicating that animal size and age (value per animal) will play a major role in establishing the most efficient production system.

The objectives of the study were to evaluate the effects of replacement rate, production system and minimum and maximum price differences in different age groups on total herd efficiency by means of a computer simulation program. Details on inputs needed, assumptions, herd structure and outputs are described by Du Toit (1993). The simulation program was verified as accurate and exceptable by Du Toit *et al.* (1994).

Material and methods

Beef price

Beef prices used (c/kg carcass weight) in the simulation study were for the period 1984 to 1992 (RSA Livestock and Meat

Statistics). The mean annual prices for A and C gradings representative of the type of beef produced from 18-month-old market animals and cull cows, respectively, were used. It was assumed that all marketable weaners were sold to a feedlot. Prices used for weaners over the same period were the mean annual feedlot prices (c/kg body weight). Conversion of the price per kg body weight of weaners to price per kg carcass weight was done by multiplication with 2.04 as assumed by the simulation program.

Minimum and maximum price differences (%) with a point in between were calculated between prices for eight-month-old weaners (converted feedlot prices) vs. 18-month-old market animals (A grading), eight-month-old weaners vs. cull cows (C-grading) and 18-month-old market animals vs. cull cows. Since all prices are expressed in c/kg for carcass weight, adjustments on carcass weight produced were done to accommodate the price differences (per kg) between the different groups of animals in the study. Results are expressed as relative income per hectare (I/ha) in kg per hectare for the two production systems concerned. This was done to obtain results independent of time and price fluctuations.

Simulation runs

A computer simulation program (Du Toit *et al.*, 1994) was used to do eight simulation runs. To construct a theoretical herd, mean values derived from all breeds participating in the National Beef Cattle Performance Testing Scheme (1980–1985) were used. In the absence of actual 18 month data for bulls, it was assumed that average final weights of centrally tested bulls (Phase C) were equal to 18 month (540 day) bull weight for extensive conditions. This was mainly done to enable comparison of an 18 month market system. The validity of using Phase C body weight as an indicator of 18 month weight, is demonstrated with experimental results in Table 1.

Table 1 Comparison of Phase C final weight and 18 month weight under extensive conditions for Nguni and Bonsmara Cattle*

Phase C final weight		18 Month weight	
Nguni *n* = 31	Bonsmara *n* = 54	Nguni *n* = 217	Bonsmara *n* = 71
315	469	304	474

* M.M. Scholtz & L. Bergh, personal communication

Comparing Phase C final weight and 18 month weight, the differences were only +3.6% for Nguni and –1.1% for Bonsmara respectively. Fixed values used for each simulation run are shown in Table 2.

Simulation run numbers one to three assumed R of 15% (minimum), 19% (point in between) and 23% (maximum), respectively, and steers were sold at eight months of age with surplus heifers being sold at 18 months of age (8/18 month production system). Run numbers four to six were done for a system where steers and surplus heifers were being sold at 18 months of age with the same R value levels (18/18 month production system). Simulation numbers seven and eight were done for the 8/18 month and 18/18 month systems, respectively, but with R in both cases assumed to be 20% (assumed to be standard practice in the South African beef industry).

Table 2 Fixed values used in all eight simulation runs

Percentage cows calved	:	79.4
Age at first calving	:	36 months
Average cow weight	:	460 kg
Average weaning age	:	7 months
Average weaning weight	:	201 kg
540 day mass of heifers	:	310 kg
Average of final mass of Phase C growth test results	:	487 kg
Eight month steer weight	:	221 kg
Carrying capacity	:	7 ha/LSU
Simulated farm size	:	5000 ha

Outputs for simulation numbers one to six were calculated on a kg/ha basis and then adjusted for price differences outlined earlier. Results were tabulated in relative income per hectare (I/ha). For the 18/18 month production system additional price differences above the true maximum were used, to establish a turning point in the relationship between price difference and R.

Outputs for simulation numbers seven and eight were pooled to compare the efficiency of the two production systems. This included economic outputs for both production systems without the effect of price differences, as well as outputs where the combined price differences between eight-month-old weaners vs. 18-month-old surplus heifers and 18-month-old market animals vs. cull cows were included.

Results and discussion

Results for I/ha for the 8/18 month and 18/18 month production systems are given in Tables 3 and 4 respectively.

The relative price difference among 8 month weaners, 18 month market animals and cull cows had a dramatic effect on I/ha. Using R of 15% as an example, the increase in I/ha was

Table 3 Relative income per hectare (I/ha) for different replacement rates (R) and beef prices for an 8/18 month production system

	Price differences			
	Theoretical zero	Actual minimum	Point in between	Actual maximum
	0&0*	15&16*	34&19*	52&22*
15	1.00#	1.11	1.18	1.26
R(%) 19	1.03	1.12	1.20	1.27
23	1.05	1.14	1.21	1.28

#: I/ha of 1.00 = 8.37 kg/ha (adjusted for price differences)

*: Indicates percentage price difference per kg beef (on c/kg basis) between eight-month-old steers and cull cows and percentage price difference per kg beef between 18-month-old market animals and cull cows. For example: 52&22 indicates that eight-month-old steers were on a c/kg beef basis 52% more expensive than cull cows while 18-month-old market animals were on the same basis 22% more expensive than cull cows

Table 4 Relative income per hectare (I/ha) for different replacement rates (R) and beef prices for an 18/18 month production system

		Price differences						
		Theoretical zero	Actual minimum	Point in between	Actual maximum	Additional price differences		
		0@	16@	19@	22@	35@	45@	55@
	15	1.00#	1.13	1.15	1.17	1.28	1.36	1.44
R(%)	19	1.02	1.14	1.16	1.18	1.28	1.36	1.43
	23	1.04	1.15	1.17	1.19	1.29	1.36	1.43

#: I/ha of 1.00 = 10.71 kg/ha (adjusted for price differences)
*: A1, A2 & A3 indicating
@: Indicates percentage price difference per kg beef (on c/kg basis) between 18-month-old market animals and cull cows. For example: 22 indicates that 18-month-old market animals were on a c/kg beef basis 22% more expensive than cull cows

26% for the maximum price difference (theoretical zero vs. actual maximum).

In Table 4 it is shown (at actual maximum price difference) that I/ha increased with 17%, 18% and 19% for R values of 15%, 19% and 23%, respectively. This trend was similar to the 8/18 month production system, as depicted in Table 3, but the increase was smaller for the 18/18 month system. It is important to note that the simulation does not make provision for lower average weaning weights due to a higher percentage of lighter calves from young cows at a high level of R. This is likely to have biased results related to R in both production systems in favor of systems with the highest R.

It is important to note that actual price differences did not have an effect on the tendency of improved I/ha as R increased for both production systems (Tables 3 and 4). It can therefore be concluded that an increased R had a constant positive influence, though small, on both biological efficiency (theoretical zero) and economical efficiency for both systems. The reason is that, although cull cows were of lower value on a per kg basis for carcass weight than both eight month old weaners and 18 month old market animals, they were on average valued 99% and 28% more on a per animal basis. This is in agreement with the principles of Roux (1992a) and Taylor *et al.* (1985), namely, that R should be as large as possible for maximum herd efficiency where the value of an old female on a per animal basis exceeds that of a young female.

The importance of replacement rate in herd efficiency depends on the level of reproduction rate (Roux & Meissner, 1984; Taylor *et al.*, 1985; Roux, 1992b) which permits higher turn-off and greater selection intensity. Relative importance of replacement rate can also be low for various reasons, the most important probably being increased turn-off age. The later the turn-off age the less important reproduction rate, and therefore replacement rate, as an economic trait (Hetzel & Seifert, 1986; Herd *et al.*, 1991).

A turning point in I/ha for R was reached at an approximate price difference of 45% between 18-month-old steers/surplus heifers vs. cull cows (Table 4). At this point R had no effect on I/ha and by implication 18-month-old steers and surplus heifers were thereafter of higher value on a per animal basis. This is in agreement with the findings of Roux (1992a) which indicate that R should be as small as possible in a case where a premium is paid for tender young meat. Klosterman (1972) and Newman *et al.* (1990) stated that in a production system where beef derived from cull cows is of similar value to that of calves, the larger frame breed groups might be more profitable because of the salvage value of the cow. Long *et al.* (1975) concluded that, in some situations of limited nutrient resources, differences in salvage value among different cow size might be less important than Klosterman (1972) suggested.

The simulated number of cows (using the fixed values of Table 2) for the three different measures of R and for the two production systems are given in Table 5 for simulation numbers one to six.

Table 5 Number of breeding females in a herd for the different replacement rates (R) and production system

		Production system	
		8/18	18/18
	15	386	329
R(%)	19	379	324
	23	372	319

It can be seen in Table 5 that the number of breeding females in a herd decreases for both the production systems with a corresponding increase in R. The reason for this decrease in breeding female numbers is that more replacement heifers need to be kept.

In Table 6 the results in I/ha are given for the two production systems.

Values expressed in Table 6 as deviations from 1.00 were adjusted for their corresponding price differences. In comparing the two production systems, the differences are only caused by price differences between eight-month-old weaners and 18-month-old market animals. Price differences were taken as 19% between 18-month-old market animals vs. cull cows. The turning point for price differences between these two groups, where an 8/18 month production system becomes more efficient than an 18/18 month system, was calculated as 81%.

Reasons for the 18/18 month production system being more efficient may be the following: Maximum overall efficiency for slaughtering occurs in the maturity range between 0.4 to 0.7 which is most relevant to the beef industry (Taylor *et al.*, 1985). Roux (1992a) also suggests that cattle should be marketed at a point when their body weights tend to be temporarily stationary in early maturity. No great loss would be incurred (Taylor *et al.*, 1985; Roux, 1992a) when slaughtering takes place somewhat earlier or somewhat later than the optimum stage (0.7) of maturity (Taylor *et al.*, 1985).

Table 6 Relative income (I/ha) per production system, when R was assumed to be 20% for both systems

	Production system	
Price differences	8/18	18/18
0 & 0	1.00#	1.26
0 & 19	1.11	1.44
–2 & 19	1.12	1.44
11 & 19*	1.16	1.44
23 & 19	1.21	1.44
81@ & 19	1.44	1.44

#: I/ha of 1.00 = 8.65 kg/ha (adjusted for price differences)
*: Indicates percentage price difference per kg beef (on c/kg basis) between eight-month-old steers and 18-month-old market animals and percentage price difference per kg beef between 18-month-old market animals and cull cows. For example: 11&19 indicates that eight-month-old steers were on a c/kg beef basis 11% more expensive than 18-month-old market animals while 18-month-old market animals were on the same basis 19% more expensive than cull cows
@: Indicates the turning point in percentage price difference per kg beef between eight-month-old steers and 18-month-old market animals. The turning point is reached at a percentage price difference between the mentioned groups of 81% where an 8/18 month system should theoretically become more profitable than an 18/18 month system

Conclusions

Calculated turning points for price differences indicate that for the simulated production systems it would be almost impossible for an 8/18 month system to be more efficient than an 18/18 month system. The highest recorded price differences between animal types (52%) for which turning points were calculated, did not even approximate the calculated turning points (81%).

As proved by Roux (1992a), maintaining the highest possible R values to maximize efficiency should be pursued. Salvage value of cows (per head) was also a determining factor for optimal R in terms of maximum efficiency (Long *et al.*, 1975; Fitzhugh, 1978; Roux, 1992a).

In contrast to popular belief, this study indicated that longevity is not important for maximizing efficiency, since R should be maximized. Stewart & Martin (1981) and Taylor *et al.* (1985) found that the higher the average cow age, the less efficient the system became. Hetzel & Seifert (1986) also found longevity to be of little economic importance.

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