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# THE RELATIONSHIP BETWEEN SIZE AND EFFICIENCY IN THE BEEF COW

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*OPSOMMING*: DIE VERWANTSKAP TUSSEN GROOTTE EN DOELTREFFENDHEID IN VLEISRASKOEIE

Die verskil in doeltreffendheid tussen klein (<420 kg), middelmatig (455–490 kg) en groot tipe (>525 kg) graad Afrikanerkoeie is bepaal ten opsigte van reproduksievermoë van koei, oorlewing en groei van nageslag en totale winsgewendheid. Koei-doeltreffendheidsindekse (K.D.I.) is bereken deur die kalf se speengewig by 260 dae, gekorrigeer vir maand van geboorte en ouderdom van koei, uit te druk as 'n persentasie van die koei se metaboliese gewig. K.D.I. is omgekeerd eweredig tot grootte van koei. 'n Positiewe en kurvilinêre verwantskap bestaan tussen grootte van koei en grootte van kalf by speen. Kalfpersentasie en oorlewingspersentasie van nageslag het toegeneem met toename in koeigrootte. Groot tipe koeie was 41 % swaarder as klein tipe koeie maar het slegs 29 % meer voedingstowwe benodig vir onderhoud.

Soortgelyk benodig middelmatig groot koeie 15 % meer voedingstowwe maar is 21 % swaarder. Die massa van twee en drie jaar oud verse en die voor slagting, karkasmassa en karkasgraad van die osnageslag van koeie van verskillende grootte is vergelyk. Die winsgewendheid van stelsels waarin klein, middelmatig en groot tipe koeie gebruik is, is bepaal. Die stelsels is op 'n grootvee-ekwivalent van 988 grootvee-eenhede per 6 000 ha vergelyk. Groot en middelmatig groot koeie was meer doeltreffend as klein koeie in terme van vleisproduksie per koei, per grootvee eenheid van 454 kg, en per hektaar. Die bruto-wins van stelsels waarin groot en middelmatig groot koeie gebruik is, en waarin klein koeie gelyk aan 100 gestel word, was 126,9 en 111,5 respektiewelik.

*SUMMARY*

The efficiencies of small (<420 kg), medium (455–490 kg) and large (>525 kg) size grade Africander cows were compared for reproductive performance of cow, survival rates, growth of progeny and overall profitability. Cow efficiency index (C.E.I.) calculated by expressing the 260-day weaning mass of the calf corrected for month of birth and age of dam, as a percentage of the dam's metabolic size, is inversely related to cow size. The relationship of cow and calf mass is positive and curvilinear. Calving percentages and survival rates of progeny improved with an increase in size of cow. Large cows were 41 % heavier than small cows but required only 29 % more nutrients for maintenance. Likewise medium cows required 15 % more nutrients but were 21 % heavier. Mass of female progeny at 2 and 3 years of age and preslaughter mass, carcass mass and carcass grades of steers from the various categories were compared. The economic efficiencies of small, medium and large size cows were assessed, based on an equivalent number of 988 livestock units per area of 6 000 ha. Large and medium size cows were more efficient producers than small cows in terms of beef produced per cow, per livestock unit of 454 kg and per hectare. Relative to small cows = 100, the gross margin for medium size cows was 111,5 and for large cows 126,9.

A summary by Petty & Cartwright (1966) of recent studies reporting genetic correlations indicate that the genetic relationships among production traits governed by additive gene action are high. Selection for such traits as growth rate and final mass has both a cumulative effect on size overtime and, as a correlated response, improvement in efficiency of feed utilisation. Large cows may be 40% heavier than small cows but require only 30% more nutrients for maintenance and production. In addition, there is a strong positive genetic correlation between rate of gain and mature size so that faster gaining cattle tend to become larger at maturity. Therefore with continued selection for rate of gain, progeny will be larger at specific ages with successive generations. In the light of these well-established principles, it seems reasonable to assume that large cows should have a greater net efficiency than small cows. However, the conclusions drawn from several recent investigations are conflicting.

Kress, Hauser & Chapman (1969) examined the value of using large or small cows as breeding stock and discussed the economics with regard to fixed costs per cow, the relative merits of the progeny and measures of reproductive performance. They concluded that in all instances large cows were more profitable. In similar studies, Cartwright, Ellis, Kruse & Crouch (1964) and Singh, Schaller, Smith & Kessler (1970) associated greatest net productivity with cows of intermediate size. Long, Fitzhugh & Cartwright (1971) in a simulation study, compared small, medium and large cows for several genetic and environmental variables and concluded that in terms of nett effect small cows had the greatest overall efficiency. The mear mass of small, medium and large cows in all these studies were remarkably similar.

Nichols & Whiteman (1966) reporting on studies with sheep, found that the regression of lifetime production measures on ewe body size were very small, indicating that larger ewes produced only slightly more lamb and wool during their lifetime than did smaller ewes.

In the present study, 14 years' (1958–1971) performance records of grade Africander cows and their progeny were used. All animals involved are part of a long-term study in progress at Matopos Research Station concerned with genotype x environment interaction in beef cattle. They are grazed on a ranch unit of 6 002 ha, which comprises gently undulating open grassland to broken wooded savannah. The mean annual rainfall of 650 mm is of poor reliability. The wet season (summer) usually starts in mid-November and continues until March, with virtually no rain at other times of the year. Overall carrying capacity is 6,07 ha per livestock unit (1 L.U. – 454 kg). Rotational grazing is practised.

Single size herds of 25 cows are bred over a three monthly breeding season from mid-December to mid-March. Calves are weaned at 9 to 11 months of age during the first week of October. All male progeny not retained as bulls are castrated at the same time in June each year. Steer progeny are slaughtered in August at 33 months of age after a finishing period. Heifers are bred at the age of three years and 20% breeding cows are replaced annually. Culled cows are sold for slaughter in May and surplus heifers are sold as breeding stock in February. Based on grading on hoof, it is fair to assume that they would grade Chiller 2 on average had they been slaughtered. This paper reports the results of a study to determine the relationship between size and efficiency in beef cows from field data.

## Procedure

*Choice of small, medium and large cows*

The choice of size of cow was based on the frequency distribution of the uncorrected May mass of 1 100 cows fed a supplement in winter to maintain bodymass (fed), and of 886 not fed cows on the same grazing. May mass was chosen since it is least affected by foetal development and is prior to winter seasonal stress. The distribution was symmetrical with 25% of the cows having a mass less than 420 kg, 50% having a mass of 421 to 524 kg, and 25% having a mass greater than 525 kg. In order to clearly distinguish between cows of small, medium and large size, animals in the class intervals 421 to 454 kg and 491 to 524 kg, 12% in each instance, were omitted (Fig. 1).

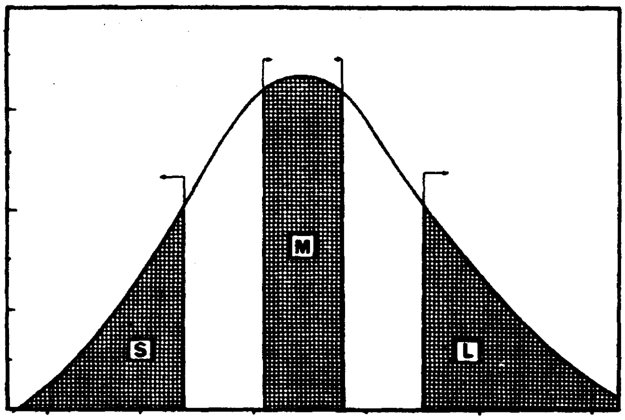


**Fig. 1.** *Frequency distribution of uncorrected May mass of cows (1958–1972). Shaded areas represent those animals used in the study*

Of the remaining animals only the data of fed cows that weaned a calf, 596 in all, were used. Their distribution by age is given in Table 1. Examination of the distribution of the uncorrected data by age and year showed that the majority of small cows occurred in the initial years and most

**Table 1**

*Distribution by age and size of grade Africander cows fed supplements in winter*

| Age (years) | Small < 420 kg | | Medium 455 – 490 kg | | Large > 525 kg | | Total | |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | No. | % |
| 4 | 30 | 16,4 | 45 | 17,8 | 29 | 18,0 | 104 | 17,4 |
| 5 | 22 | 12,0 | 40 | 15,7 | 20 | 12,5 | 82 | 13,8 |
| 6 | 23 | 12,6 | 38 | 15,0 | 26 | 16,3 | 87 | 14,6 |
| 7 | 26 | 14,2 | 27 | 10,7 | 18 | 11,3 | 71 | 11,9 |
| 8 | 26 | 14,2 | 21 | 8,3 | 22 | 13,8 | 69 | 11,6 |
| 9 | 21 | 11,5 | 26 | 10,3 | 16 | 10,0 | 63 | 10,6 |
| 10 | 17 | 9,3 | 22 | 8,7 | 16 | 10,0 | 55 | 9,2 |
| 11 | 6 | 3,3 | 13 | 5,1 | 5 | 3,1 | 24 | 4,0 |
| 12 | 5 | 2,7 | 10 | 4,0 | 3 | 1,9 | 18 | 3,0 |
| 13 | 6 | 3,3 | 7 | 2,8 | 4 | 2,5 | 17 | 2,9 |
| 14 | 1 | 0,5 | 3 | 1,2 | 1 | 0,6 | 5 | 0,8 |
| 15 | 0 | 0,0 | 1 | 0,4 | 0 | 0,0 | 1 | 0,2 |
| | 183 | 100,0 | 253 | 100,0 | 160 | 100,0 | 596 | 100,0 |
| Per cent of total | 30,70 | | 42,45 | | 26,85 | | | |

of the large cows in the latter years. Yearly variations were considered a random effect and in the analysis of variance included in the error. Yearly variations would also partly have been eliminated through correction to 7 years of age, since the correction was based on the data pooled over years. No account was taken of the possible movement of a cow from one group to another over years since each cow record was considered as an independent observation within years.

*Calving percentage and survival rates*

Calving percentages were calculated by expressing the number of calves actually born to small, medium and large cows as a percentage of cows put to the bull. As only records of cows that actually weaned a calf could be used, weaning percentages was estimated as the percentage of animals that survived to 20 months of age. Survival rates and all other production data of progeny were assessed within each of the herds of small, medium and large cows.

*Calculation of cow efficiency indices (C.E.I.)*

All cow mass data were adjusted for age to 7 years using multiplicative adjustment factors. The mean adjusted May mass of small cows was 392,8 kg; of medium sized cows 473,6 kg; and of large cows 552,0 kg. Weaning mass of male and female calves were adjusted within sex for age to 260 days using the calf's own average daily gain from birth to weaning, and, for month of birth to December and to a dam age of 7 years by multiplicative adjustment factors. Two cow efficiency indices were calculated. In the first, the corrected weaning mass of the calf is expressed as a percentage of its dam's metabolic size in May (C.E.I.-metabolic) and in the second, corrected weaning mass is expressed as a percentage of the dam's bodymass in May (C.E.I.-actual). Thus,

$$\text{C.E.I. (metabolic)} = \frac{\text{Weaning mass}}{\text{Cow mass}^{0,75}} \times \frac{100}{1} \text{ and,}$$

$$\text{C.E.I. (actual)} = \frac{\text{Weaning mass}}{\text{Cow mass}} \times \frac{100}{1}$$

*Feed requirements*

(i) **Cow and calf unit**

Cows nursing calves received on average 9,0 kg maize silage and 1,0 kg cottonseed meal daily to maintain bodymass from about June to November each year. The mean winter feeding period was 144 days. The aggregate of the amounts fed to cows and calves separately after weaning until the end of the season was added to the preweaning quantities to assess the requirement per cow and calf unit for the season.

In terms of nutrients fed, the actual daily amounts averaged 3 067,23 g T.D.N. and 393,91 g D.P. per cow and calf unit over the 12 year period. In order to adjust the supplement to cow size the theoretical daily T.D.N. and D.P. requirements were calculated for each cow by the formulae (Crampton, 1956);

$$\text{T.D.N. (g)} = \frac{140\,(\text{cow mass})^{0,75}}{4,38} ;$$

$$\text{D.P. (g)} = \frac{146\,(\text{cow mass})^{0,75} \times 6,25 \times 3,4}{1\,000}$$

Using the weighted means obtained for each of the three cow size categories, the nutrient requirements of medium and large size cows, relative to small = 100, were 115,1 and 129,1 respectively. Thus, the actual amounts fed were decreased by 15,1% and increased by 14,0% to arrive at the nutrient requirements for small and large cow and calf units respectively.

The cost of this feed per cow and calf unit was estimated as follows:

$$Y = (a \times b \times 144) + (c \times d \times 144)$$

where,

Y = cost for 144 days in R$,

a = percentage of total D.P. intake derived from cottonseed meal,

b = price per kilogram of D.P. in cottonseed meal,

c = percentage of total T.D.N. intake derived from maize silage,

d = price per kilogram of T.D.N. in maize silage.

For example, the feed cost of a cow and calf unit of medium size is:

$$= \left[\left(\frac{74,09}{100} \times 0,3939\right) \times 0,2176 \times 144\right] + \left[\left(\frac{69,73}{100} \times 3,0672\right) \times 0,0079 \times 144\right]$$

= $11,56. (All prices taken as at 1st April 1973).

(ii) **Young stock**

The various age groups of progeny were fed a supplement of cottonseed meal only. Animals at 20 months and 32 months of age at the start of winter are expected to gain about 10 and 7%, respectively, of their maximum summer mass over the feeding period. To achieve these growth rates, animals at 20 months required daily 298,7 g D.P. Similarly, animals at 32 months required 394,9 g D.P. daily over the winter feeding period of 144 days (authors' unpublished data).

To obtain the requirements for the progeny of the small, medium and large size cows, these amounts were adjusted according to the mean mass of small and large animals when medium size animals equal 100. For example, the daily D.P. requirement for the 20 months old progeny of small cows may be determined from information given in Tables 5 and 6:

$$\text{D.P.(g)} = \frac{\text{Mean mass of small x nutrient requirement of medium}}{\text{Mean mass of medium}}$$

$$= \frac{268{,}52 \times 298{,}73}{280{,}44}$$

$$= 286{,}03.$$

This approach assumes a positive linear relationship between size and nutrient requirements and was adopted in order to utilise data on nutrient requirements obtained in the field.

(iii) **Pen feeding of steers**

Steers in feed-lot were not individually fed and only average daily intake was determined. Accordingly, adjustment for intake to size was not made. Average daily nutrient intake during the feed-lot period was 6 004 g T.D.N. and 737,8 g D.P.

*Constants used in economic programmes and calculation of total cow equivalents*

In order to compare the economic efficiency of the three herds, production data were used together with the information given in Table 2. Herd composition (Table 7) was estimated by using the calving percentages and survival rates given in Table 3 and a cow ratio of 30%. This value was derived from an analysis of herd compositions over all years which showed that on average 30% of the total number of animals within a herd were breeding cows.

The total number of cow equivalents (Table 7) were derived by adjusting the carrying capacity of 988,47, L.U./6 000 ha to the mean cow size of each herd. The number of cow equivalents for the herd of small cows are:

$$\text{Cow equivalents} = \frac{\text{Carrying capacity x mass of L.U.}}{\text{Mean cow mass of herd}}$$

$$= \frac{988{,}47 \times 454}{392{,}8}$$

$$= 1\,142{,}6$$

*Statistical analysis*

Where necessary, the data were analysed by the method of analysis of variance for non-orthogonal data described by Scheffe (1961).

**Results**

*Fertility and survival rate*

There is a tendency for calving percentages and survival rates to improve with an increase in size of cow. Large and medium size cows have a higher ($P < 0{,}01$) calving rate than small cows (Table 3). Survival rates for progeny at any age are directly related to dam size; significantly ($P < 0{,}01$) more calves from large cows survived to 20 months and 2½ years of age compared with small and medium size cows. Survival rate to the age of 3 years was similar for heifers from both medium and large size cows. No explanation can be offered for the difference between sexes for the progeny of medium size cows in survival to 2½ years of age.

*Weaning mass and cow efficiency indices*

Efficiency indices were inversely related with cow size and calf weaning mass. Small cows with a mean mass of 392,8 kg have metabolic and normal efficiency indices of 170,1 and 38,2 respectively, whereas these values for large cows (mean mass of 552,2 kg) were 139,2 and 28,7 (Table 4). The differences between herds were significant at $P = 0{,}01$.

The relationship of cow and calf mass appears to be positive and curvilinear. The mean weaning mass increased significantly ($P < 0{,}05$) from 150 kg for the calves of small cows to 161,5 kg for the progeny of medium size cows. The calves of large cows recorded 3,3 kg less at weaning than those of medium size cows but the difference was not significant.

*Live mass at two and three years of age, slaughter mass and slaughter grades*

Two-year-old heifers from medium size cows were significantly ($P < 0{,}01$) heavier in December than either heifers from large or small size cows. Heifers from small cows did not differ significantly from those of large cows. At 3 years of age the progeny of all three groups differed from one another significantly ($P < 0{,}01$) with heifers from medium size cows maintaining their earlier superiority over heifers from small and large size cows, the latter group being lightest. Two-year-old steers from medium and large cows were of similar body mass, with both groups heavier than those from small cows ($P < 0{,}01$). On entering the feed-lots medium size and large steers were still heavier by 30 kg and 60 kg respectively, than small steers. Small and medium size steers gained faster (0,8 kg/day) in feed-lot than did large steers (0,6 kg/day).

Preslaughter mass at 33 months of age differed between all groups ($P < 0{,}01$). No significant differences was apparent between hot carcass mass of steers from medium and large cows but carcasses from both these groups were heavier ($P < 0{,}01$) than those of steers from small cows. Hot carcass mass (H.C.M.) and cold dressed mass (97% of H.C.M.) are inversely related to dressing-out percentage. Despite the lower ($P < 0{,}01$) dressing percentage of steers from large cows, all these carcasses graded within the top two grades compared to 6,5 and 4,4% of the carcasses from small and medium groups, respectively, which were down-graded to Chiller 3.

Table 2

*Constants used in assessing profitability of herds of small, medium and large size cows*

| Item | | | Unit |
|---|---|---|---|
| Area (ha) | | | 6 000 |
| Mass of livestock unit (kg) | | | 454 |
| Carrying capacity (ha/L.U.) | | | 6,07 |
| Average feeding period over 12 years (days) | | | 144 |
| * Slaughter price of cows grading Good Average Quality (G.A.Q.) in May (cents/kg Cold Dressed Mass) | | | 36,81 |
| Slaughter price of heifers grading Chiller 2 in February (cents/kg C.D.M.) | | | 43,06 |
| Slaughter price of steers in August (cents/kg C.D.M.): | Chiller 1 | | 45,83 |
| | Chiller 2 | | 43,75 |
| | mean | | 44,79 |
| | Chiller 3A | | 42,14 |
| Price of cottonseed meal: | a) | per tonne (R$) | 70,06 |
| | b) | per kg D.P. (R$) | 0,2176 |
| Price of maize silage | a) | per tonne (R$) | 5,44 |
| | b) | per kg T.D.N. (cents) | 0,7878 |
| Feed-lot cost of steers per 100 days (R$) | | | 30,00 |
| Cost per L.U. of: | a) | labour (R$) | 1,00 |
| | b) | tractor (R$) | 0,15 |
| | c) | medicine, dip, etc (R$) | 0,60 |
| | d) | miscellaneous (R$) | 1,54 |
| Cows as percentage of total L.U. in a herd | | | 30 |

* Grades in decreasing order of excellence: Chiller 1, Chiller 2, Chiller 3A and B, G.A.Q.

Table 3

*Calving percentage of small, medium and large size cows and survival rates of heifers and steers from birth to 20 months, 2½ and 3 years of age. (Survival rate expressed as a percentage of the number of animals weaned.)*

| | | Cow size | | | L.S.D. | |
|---|---|---|---|---|---|---|
| | | Small | Medium | Large | P = 0,05 | P = 0,01 |
| | | (%) | (%) | (%) | (%) | (%) |
| Calving percentage | | 83,1 | 86,7 | 87,6 | 2,50 | 3,30 |
| Survival to 20 months: | ♂ | 97,6 | 95,5 | 100,0 | | |
| | ♀ | 95,0 | 99,3 | 100,0 | | |
| Mean | | 96,3 | 97,4 | 100,0 | 1,77 | 2,33 |
| Survival to 2½ years: | ♂ | 96,3 | 95,5 | 100,0 | | |
| | ♀ | 94,1 | 99,3 | 100,0 | | |
| Mean | | 95,1 | 97,4 | 100,0 | 2,05 | 2,69 |
| Survival to 3 years: | ♀ | 92,1 | 98,5 | 98,1 | 4,07 | 5,35 |

**Table 4**

*Mean cow efficiency indices and weaning mass of calves of grade Africander cows of small, medium and large size*

| | Cow size | | | L.S.D. | |
|---|---|---|---|---|---|
| | Small | Medium | Large | P<0,05 | P<0,01 |
| Mean cow mass (kg) | 392,8 | 473,6 | 552,2 | | |
| Cow mass relative to small = 100 | 100,0 | 120,6 | 140,6 | | |
| Mean weaning mass (kg): ♂ | 153,0 | 165,9 | 164,4 | 8,3 | 10,9 |
| ♀ | 147,0 | 157,2 | 152,1 | 8,3 | 10,9 |
| Mean | 150,0 | 161,5 | 158,2 | | |
| Mean C.E.I. (metabolic): ♂ | 173,4 | 163,6 | 144,3 | 8,2 | 10,8 |
| ♀ | 166,8 | 154,8 | 134,1 | 8,2 | 10,8 |
| Mean | 170,1 | 159,2 | 139,2 | | |
| Mean C.E.I. (actual): ♂ | 39,0 | 35,1 | 29,8 | 1,8 | 2,3 |
| ♀ | 37,5 | 33,2 | 27,7 | 1,8 | 2,3 |
| Mean | 38,2 | 34,1 | 28,7 | | |

**Table 5**

*Mean live mass of males and females at 20 months, 2 and 3 years of age, in December, and mean slaughter mass, carcass mass and slaughter grades of steers of small, medium and large size cows*

| | Cow size | | | L.S.D. | |
|---|---|---|---|---|---|
| | Small | Medium | Large | P = 0,05 | P = 0,01 |
| Mean mass of 20-month-old steers (kg) | 281,7 | 298,1 | 285,1 | | |
| Mean mass of 20-month-old heifers (kg) | 257,5 | 266,9 | 244,7 | | |
| Mean | 268,5 | 280,4 | 267,6 | 4,58 | 6,03 |
| Mean mass of 2-year-old heifers (kg) | 277,1 | 308,1 | 280,0 | 8,33 | 10,97 |
| Mean mass of 3-year-old heifers (kg) | 364,8 | 376,5 | 354,5 | 8,78 | 11,56 |
| Mean mass of 2-year-old steers (kg) | 315,4 | 336,5 | 328,5 | 9,66 | 12,71 |
| Mean mass on entering the feed-lots (kg) | 406,0 | 436,4 | 467,9 | 6,37 | 8,39 |
| Mean pre-slaughter mass of steers at 33 months of age (kg) | 488,3 | 509,2 | 522,3 | 7,11 | 9,37 |
| Mean gain per day in feed-lot (kg/day) | 0,80 | 0,78 | 0,64 | 0,04 | 0,06 |
| Mean hot carcass mass (kg) | 271,9 | 280,6 | 283,0 | 4,41 | 5,80 |
| Mean cold dressed mass (kg) | 263,4 | 272,1 | 274,5 | 4,28 | 5,63 |
| Mean dressing percentage | 54,0 | 53,4 | 52,6 | 0,36 | 0,47 |
| * Percentage carcasses in each grade: | | | | | |
| Chiller 1 and 2 | 93,5 | 95,6 | 100,0 | 3,75 | 4,94 |
| Chiller 3 | 6,3 | 4,4 | – | N.S. | |

* Grades in decreasing order of excellence: Chiller 1, Chiller 2, Chiller 3A and B

*Feed requirements*

The estimated nutrient requirements and the actual nutrients supplied daily, adjusted for the three herds by the differences between the estimated amounts, are given in Table 6. Although large cows are 40,6% heavier than small cows (Table 4), they require only 29,1% more nutrients. Likewise, medium cows require 15,1% more nutrients but are 20,6% heavier.

*Composition of herds and annual disposals*

Although the potential number of L.U. on each 6 000 ha was identical for all cow categories (988 L.U.), no group realised this potential when the numbers of animals composing a herd were expressed on a L.U. basis. Increase in size of animal failed to compensate for the fewer animals in the medium and large groups. On this basis less grazing is utilised as cow size increases. These figures are adjusted to equivalent numbers of L.U. in Table 13. The number of animals disposed of annually, at a 20% replacement rate, is given in Table 8.

*Costs of production and returns*

Feed cost per animal unit and total feed cost for an average feeding period of 144 days are given in Table 9. Feed cost is directly related to nutrient requirement. Gross income per herd and per animal unit are given in Table 10. In estimating the gross margins for the three herds, the cost per L.U. of labour, tractor, medicines, dip and miscellaneous items was added to the feed cost to obtain the total variable cost (Table 11).

The gross margins for the three herds small, medium and large (Table 11) and the production figures given in Table 12 are based on 793, 705 and 602 L.U. respectively (Table 7). The differences between these numbers of L.U. and the potential 988 L.U. were used to adjust the costs and returns for herds of small, medium and large size cows when the available grazing of 6 000 ha is fully utilised (Table 12). This information is presented in Table 13 and allows a more valid comparison to be made of the production efficiency of the herds on a livestock equivalent basis.

Large and medium size cows are more efficient producers in terms of beef produced per cow and per L.U. The herd of large size cows produced 87,6 kg beef per L.U. compared with the 79,6 kg of medium and 74,3 kg of small size cows. These variables will remain the same when herds are compared on a livestock equivalent basis but production per hectare will change (Table 13). Based on an equivalent number of 988 L.U. per area of 6 000 ha, the herds composed of medium and small size cows produced 1,31 and 2,17 kg less beef per hectare, respectively, than the herd of large size cows. Relative to small = 100, the gross margin for the herd of medium size cows is 111,52 which is 15,38% less than for the herd of large size cows.

## Discussion

*Cow size in relation to fertility and survival of progeny*

Knox (1957) compared the efficiency of compact and large size Hereford cows, weighing 423 and 483 kg respectively (these sizes correspond to those of small and medium cows in the present study) and found that in terms of kilograms of calf weaned, the average annual production was 13% greater for large cows. Also, that large cows had a significantly higher reproduction rate and weaned 12,2% more calves than did compact cows.

However, Koger (1968) reports that genetic size is unrelated to reproductive performance and that good or poor reproduction is characteristic of both large and small cows. With reference to the work of Knox (1957), Koger (1968) points out that the difference in genetic size may not have been responsible for the differences in fertility but that compactness may have been associated with a physiological balance unfavourable to reproduction. Nevertheless, whatever the causative factors, larger cows exhibited greater fertility. In the present study, the difference in survival to weaning age of the progeny of small and medium size cows was not significant but survival rates from birth to weaning, 2½ and 3 years of age were significantly higher ($P < 0,01$), for the progeny of large cows compared with small cows. In general, the results confirm Knox's findings inasmuch that a definite positive relationship exists between dam fertility, survival of progeny, and dam size. Using the metabolic size of the dam for estimating efficiency has no apparent advantage over the cow's normal size, except that metabolic size is also employed in estimating nutrient requirement.

*Performance of progeny*

From the performance of progeny at older ages, it seems that the distinctive advantage which smaller cows have over larger cows in C.E.I. is offset by the lower mass of their progeny at 2 and 3 years of age. Both heifers and steers from small dams were lighter at 20 months, 2 and 3 years of age. The adverse maternal effect of obese dams included in the herd of large size cows persisted in the growth of their female progeny to the age of 3 years. The fact that steers from large cows weighed, on entering the feed-lots, 32 kg (P 0,05) more than steers from medium cows yet were, at 2 years of age 8 kg lighter, shows that large steers grew more rapidly through the summer growing period than did either medium or small steers.

In this regard, Long *et al.* (1971) and Kress *et al.* (1969) have shown a definite genetic correlation between rate of gain during the growing stages and mature size so that faster gaining cattle tend to become larger at maturity. Also, steers gaining faster in feed-lot are expected to have less finish at slaughter. Whilst the carcasses of large steers had lower dressing percentages than those of small steers (Table 5) their mean dressing percentage was still sufficiently high for them not to be downgraded for lack of finish. Small steers achieved a higher rate of gain than large steers, but graded poorer. Analysis of carcass data (unpublished results) show that carcasses from small steers were down-graded for lack of conformation and not finish.

*Cow size in relation to weaning mass, efficiency index and reproduction*

The results from most studies in which the efficiency of production of cows of various sizes have been compared show that when efficiency is assessed in terms

**Table 6**

*Estimated daily nutrient requirements and amounts fed relative to size of animal*

| | | Cow size | | |
|---|---|---|---|---|
| | | Small | Medium | Large |
| | | (g) | (g) | (g) |
| Mean estimated amounts required per cow | T.D.N. | 2 819,3 | 3 245,0 | 3 640,5 |
| | D.P. | 273,7 | 315,0 | 353,4 |
| Requirement relative to small = 100 | | 100,0 | 115,1 | 129,1 |
| Mean amounts fed per cow and calf unit | T.D.N. | 2 604,1 | 3 067,2* | 3 497,6 |
| | D.P. | 334,4 | 393,9* | 449,2 |
| Daily supply of D.P. to: | 20-month-old animals | 286,0 | 298,7* | 285,0 |
| | 32-month-old animals | 376,8 | 395,0* | 391,4 |
| Mean winter feeding period (1958–1972) | | | 144 days | |

* These amounts represent the actual mean amounts fed daily per animal

**Table 7**

*Composition of herds of small, medium and large size cows*

| Number of animals | Cow size | | |
|---|---|---|---|
| | Small | Medium | Large |
| Potential number of cow equivalents | 1 142,60 | 947,51 | 812,67 |
| Number of cows (30% of potential) | 342,78 | 284,25 | 243,80 |
| Number of calves | 284,92 | 246,56 | 213,64 |
| Number of 20-month-old animals | 274,39 | 240,18 | 213,64 |
| Number of 2½-year-old steers | 133,89 | 112,53 | 106,82 |
| Number of 3-year-old heifers | 124,68 | 120,58 | 104,77 |
| Total number of animals | 1 160,65 | 1 004,10 | 882,67 |
| Number of L.U. of 454 kg | 793,15 | 704,66 | 602,00 |

**Table 8**

*Annual disposal of animals*

| | Cow size | | |
|---|---|---|---|
| | Small | Medium | Large |
| Culled cows (20% of breeding herd) | 68,56 | 56,85 | 48,76 |
| Surplus heifers (20% replacement) | 56,12 | 63,73 | 56,01 |
| Feed-lot steers (2½-years old) | 133,89 | 112,53 | 106,82 |
| Total | 258,57 | 233,11 | 211,59 |

**Table 9**

*Total feed cost and feed cost per animal unit for an average 144-day feeding period*

| Type of animal | | Cow size | | |
|---|---|---|---|---|
| | | Small | Medium | Large |
| | | (R$) | (R$) | (R$) |
| Cow and calf: | mean | 9,82 | 11,56 | 13,19 |
| | relative to medium = 100 | 85,24 | 100,00 | 114,50 |
| | total | 3 366,40 | 3 286,83 | 3 215,72 |
| 20-month-old animals: | | | | |
| | mean | 8,96 | 9,36 | 8,93 |
| | total | 2 457,66 | 2,248,08 | 1 907,87 |
| 32-month-old heifers: | | | | |
| | mean | 11,80 | 12,38 | 12,27 |
| | total | 1 472,20 | 1 493,26 | 1 285,40 |
| Feed-lot steers for 100 days: | | | | |
| | mean | 30,00 | 30,00 | 30,00 |
| | total | 4 016,70 | 3 375,90 | 3 204,60 |
| Total | | 11 312,96 | 10 404,07 | 9 613,59 |

**Table 10**

*Gross annual income per herd and per animal unit*

| Income source | | Cow size | | |
|---|---|---|---|---|
| | | Small | Medium | Large |
| | | (R$) | (R$) | (R$) |
| Culled cows: | per cow | 72,29 | 87,17 | 101,63 |
| | total | 4 956,53 | 4 955,39 | 4 955,60 |
| Surplus heifers: | per heifer | 78,54 | 81,06 | 76,30 |
| | total | 4 407,74 | 5 165,99 | 4 273,69 |
| Steers: | per steer | 117,52 | 121,56 | 122,95 |
| | total | 15 735,19 | 13 678,73 | 13 133,36 |
| Total | | 25 099,46 | 23 800,11 | 22 362,65 |
| Relative to small = 100 | | 100,00 | 94,82 | 89,10 |

**Table 11**

*Gross margin for herds of small, medium and large size cows*

| Item | Cow size | | |
|---|---|---|---|
| | Small | Medium | Large |
| | (R$) | (R$) | (R$) |
| Gross income | 25 099,46 | 23 800,11 | 22 362,65 |
| Total variable cost | 13 922,42 | 12 722,40 | 11 594,17 |
| Gross margin | 11 177,04 | 11 077,71 | 10 768,48 |
| Gross margin relative to small = 100 | 100,0 | 99,11 | 96,34 |

**Table 12**

*Beef produced and cost of production per hectare and per livestock unit*

| Item | Cow size | | |
|---|---|---|---|
| | Small | Medium | Large |
| Total cold dressed beef produced (kg) | 58 968,10 | 56 078,67 | 52 712,50 |
| Beef produced/cow/100 cows bred (kg) | 172,03 | 197,27 | 216,21 |
| Beef produced/ha (kg) | 9,83 | 9,35 | 8,79 |
| Feed cost/kg beef produced (cents) | 19,18 | 18,55 | 18,24 |
| Variable cost/kg beef produced (cents) | 23,61 | 22,69 | 22,00 |
| Beef produced/L.U. (kg) | 74,35 | 79,58 | 87,56 |
| Gross margin/L.U. (R$) | 14,09 | 15,72 | 17,89 |

**Table 13**

*Beef production and gross margins for herds of small, medium and large size cows, based on an equivalent number of livestock units (988,47 L.U./6 000 ha)*

| Item | Cow size | | |
|---|---|---|---|
| | Small | Medium | Large |
| Actual number of L.U. | 793,15 | 704,66 | 602,00 |
| Potential number of L.U. | 988,47 | 988,47 | 988,47 |
| Difference (L.U.) | 195,32 | 283,51 | 386,17 |
| Difference as a percentage | 19,77 | 28,69 | 39,08 |
| Total cold dressed beef produced (kg) | 73 490,14 | 78 640,40 | 86 525,54 |
| Beef produced/ha | 12,25 | 13,11 | 14,42 |
| Gross income (R$) | 31 280,42 | 33 375,74 | 36 707,82 |
| Total variable cost (R$) | 17 350,93 | 17 841,09 | 19 031,57 |
| Gross margin (R$) | 13 929,49 | 15 534,65 | 17 676,25 |
| Relative to small = 100 | 100,00 | 111,52 | 126,90 |

of size of calf produced at weaning, smaller cows are more efficient. On the other hand, size of cow has an overriding influence on weaning mass so that larger cows within a breed generally produce calves with heavier weaning mass. The lower weaning mass realised by the progeny of large cows compared with medium size dams (Table 4) is probably due to the inclusion of fat cows, as distinct from skeletally large cows, into the herd of larger size dams. This observation is supported by evidence from the present herd where cows exceeding 546 kg have calves markedly lower in weaning mass than do cows weighing 456-545 kg (authors' unpublished data). These results confirm the evidence advanced by Klosterman, Sanford & Parker (1968) that efficiency is negatively related to fatness. Kress *et al.* (1969) also clearly distinguish between skeletally large cows and fat cows. The latter were less efficient producers of calves, whereas skeletally large and small cows were approximately equal with a possible advantage for large cows.

*Production and economic consideration in terms of nutrient requirements*

Brody & Cunningham (1936) reported that "profit per unit of feed consumed, like profit per unit of milk produced tends to be independent of body mass". They also assert that "profit per cow increases as body mass increases while profit per unit body mass decreases as body mass increases. Thus, larger cows produced less unit body mass but their maintenance requirements are less per unit body mass and hence they are just as efficient as, or possibly more efficient than, smaller cows in producing weaning mass of calf". On the other hand, Long *et al.* (1971) suggest that the maintenance requirements of smaller cows were sufficiently reduced to more than compensate for the lowered efficiency associated with the slower growth of their progeny. They consequently concluded that smaller cows were the most efficient.

The results from the present study in every way support those of Brody & Cunningham (1936) except that large cows produced more per unit of body mass. Likewise, production per unit area, per cow and per L.U., and profit per L.U. increased as body mass increased. It is evident, however, that in comparing the efficiency of herds of various cow sizes, all variables need to be examined simultaneously in order to assess whether poor production in one phase is not offset by superior production in another. Thus, whilst from a biological point of view large cows may, for example, be preferred to small cows, the desirable cow size in terms of overall net efficiency, may change with location and system of production. Since feed cost represents a major portion of the total costs of production, the effect of the efficiency of feed utilisation on the profitability of a system would be less with a wide ratio of nutrient cost to price of beef than a narrow ratio.

From an appraisal of available information and, in particular, the results of the present study, it may be concluded that in terms of net effect large cows have the greatest overall efficiency. This result may be ascribed to their lower requirement of feed per unit of body size, higher fertility and the higher survival rates and superior growth performance of their progeny.

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