A COMPARATIVE STUDY OF

BEEF CATTLE BREEDS

IN NAMIBIA

By

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S	Sanga
N	Nguni
A	Afrikaner
H	Hereford
SG	Santa Gertrudis
SIM	Simmental
BW	Birth Weight
WW	Weaning Weight
CE	Cow Efficiency at Weaning
WR	Calf Crop Weaned
CWC	Cow Weight at Calving
CSC	Body Condition Score at Calving
N	Number of observations
LSMEAN	Least Squares Means
SE	Standard Error
YS	Year of birth
P	Level of Significance
85s	Calves born in summer of 1985
86s	Calves born in summer of 1986
87s	Calves born in summer of 1987
88s	Calves born in summer of 1988

CHAPTER I

INTRODUCTION

Namibia is a country full of contrasts, from sub-tropical climate to semi-arid to desert landscapes. The warmest months are January and February, with maximum temperatures between 20 °C and 36 °C during the day. The daily temperatures during winter are between 18 to 22 ° C, while the minimum temperature ranges between 6 to 10 ° C (Namibia Trade Directory, 1999). This country is categorized as a summer rainfall area; precipitation is sparse, mostly during October and November as well as January to March (Namibia Trade Directory, 1999). This hot environment, along with the sparse and erratic rainfall of Namibia, hampers the production of crops, making farmers largely dependent on extensive livestock farming. The north and central parts of the country are mostly large stock (beef) production areas, while the south is the small stock (mutton and goat) production territory. Droughts are the most common natural disaster Namibia encounters. For farmers to have a profitable livestock production system, farming with the correct type of animals that can thrive under current environmental conditions in Namibia would be a valuable asset.

Production systems can be more efficient if the end performance is preserved or improved and input costs kept to a minimum (Freetly & Cundiff, 1997). By selecting a maternal line best suited for a particular environment and management system, a successful cow-calf production system can be obtained (Freetly & Cundiff, 1997). Variation among breeds in their production characteristics permits us to apply selection appropriately for the production system presented (Freetly & Cundiff, 1998).

The purpose of the present trial was to compare different beef cattle breeds according to reproduction and production. This comparison of different breeds was according to birth, weaning weight and cow efficiency (expressed as calf weaning weight to cow weight at weaning). To evaluate reproductive performance, the effect of body condition score (BCS) at calving on the calving rate (expressed in terms of weaning rate) the next year.

This study should benefit Namibian producers in that it will give a comparison of the genetic material available and assist farmers in selecting the most suitable breed for their production system under existing environmental conditions.

CHAPTER II

LITERATURE REVIEW

Birth Weight

In any livestock production system, birth weight is very important. In a beef cattle production system, the optimum birth weight enables excellent calf viability and growth without calving difficulty.

If birth weight is less than what is favored, calves may be less resistant to diseases, have a slower post-natal growth rate, reduced adult size, lack strength and energy and be more susceptible to colder temperatures (Holland & Odde, 1992 and Ferrell, 1993). Lower birth weights will result in a higher mortality rate (lower calf survival) at and after birth (Ferrell, 1993). Birth weights higher than what is favored, are linked to dystocia which in return will lead to more calf mortalities and calves that are more prone to diseases and lower conception rate of cows (Holland & Odde, 1992 and Ferrell, 1993).

The phenotype of an individual (i.e. the appearance of an individual) is attributed to the individual's inherent genetic composition and the influence of environment (Dickerson, 1969). It can be explained as follows:

$P = G_{sire} + G_{dam} + M + E$

Where:

P = the calf's phenotype

G_{sire} = the genetic contribution from the calf's sire (50%)

G_{dam} = the genetic contribution from the calf's dam (50%)

M = maternal environment

E = sum of the permanent and temporary environment the calf is exposed to.

The fetus is a combination of both the paternal and maternal genetic material (Holland & Odde, 1992 and Ferrell, 1993). The dam contributes half of the calf's genetic make-up, however, her contribution is more than just genetic (Ferrell, 1993).

Birth weight is influenced by many factors; factors can be genetic and environmental in origin. The factors include breeds of the parents, gender of the calf, how old and heavy the dam is, parity, environmental temperatures and nourishment of the cow as well as the number of fetuses (Holland & Odde, 1992 and Ferrell, 1993). The genetics of the fetus however establishes maximum growth ability (Ferrell, 1993). Sawyer et al. (1991) reported that both parent (male & female) breeds significantly influenced birth weight, and that the breed of the mother has a greater effect on birth weight than the breed of the bull. Sire Expected Progeny Differences (EPDs) for birth weight are reliable. A bull that has a low EPD for birth weight will produce calves with lower birth weights when compared with high EPD bulls (Colburn et al., 1997). Reynolds et al. (1990) reported that larger sized bull breeds produced heavier calves than medium sized bull breeds. Offspring produced from bulls of breeds with a higher milk producing level were heavier in birth weight than those sired by bulls from medium milk producing breeds (Reynolds et al., 1990). Larger and heavier breeds of cows (eg. Simford, Wokalup multibreed) produce calves that have higher birth weights when compared to cows from early developing British breeds (Sawyer et al., 1991).

Bos Taurus calves have a greater birth weight than *Bos Indicus* calves (Fordyce et al., 1993 and Freetly & Cundiff, 1998). Gregory et al. (1978), Gregory et al. (1979) and Cundiff et al. (1998) confirmed that calves from Hereford cows were heavier at birth than those of Angus cows. Hereford-Angus and Red Poll crosses had a lower birth weight when compared to Brown Swiss, Gelbvieh, Maine-Anjou and Chianina crosses. However, the Maine-Anjou and Chianina crosses were heavier than the Brown Swiss and Gelbvieh crosses at birth (Gregory, et al. 1978). Brahman crosses were heavier at birth than Hereford-Angus crosses. Sahiwal and Tarentaise did not differ in birth weight, but differences in birth weight were observed among Hereford, Polled Hereford, Angus, Brahman, and Pinzgauer (Gregory et al. 1979).

Notter et al. (1978) categorized cows according to age as a) calved as 2-year-olds and b) calved as 3-year-olds. They concluded that, for both age groups, the offspring from Jersey cross dams were lighter in birth weight than offspring from Charolais, Simmental and South Devon cross cows, while those of Hereford-Angus were intermediate. Calves from 3-year-old Hereford-Angus cross cows were lighter than those from 3-year-old Limousin cross cows. In the 2-year-old group, the calves from Limousin cross cows were not heavier at birth than those of the Hereford-Angus cross cows. In the 2-year-old category, the offspring originating from Hereford and Angus bulls were lighter in birth weight when compared to those originating from Brahman and Holstein bulls. However, for the 2-year-old age group, the Brahman bulls sired calves had the highest birth weights. For the 3-year-old group, the offspring from Hereford and Angus bulls were lighter than those of Maine-Anjou, Chianina and Gelbvieh. A meaningful breed of calf's sire x breed of cow's dam interaction was observed by the authors. Offspring originating from Angus bulls and Hereford grandmothers were lighter at birth when compared to those of Hereford bulls and Angus grandmothers. These differences can be attributed to the direct and maternal genetic influences. Maternal effects can be expressed as genetic (dams differ genetically from one-another) as well as non-genetic (the environment). The grand-dam's contribution to differences in the calf's performance is attributed to the environment (non-genetic) provided to the dam by, for example, milk production and the grand-dam's mothering abilities.

Cundiff et al. (1998) reported that breed of calf's sire significantly influenced birth weight. Calves from Galloway bulls were heavier at birth than calves from Longhorn bulls, but lighter than those from other breeds (Hereford, Angus, Nellore, Piedmontese, Salers, Charolais, Gelbvieh and Pinzgauer). With the exception of the calves from the Shorthorn sire breed, calves from Charolais, Nellore, Pinzgauer, Gelbvieh bulls had greater birth weights than those from Hereford, Angus and Piedmontese. Progeny from Shorthorn and Salers sires were not significantly different in birth weight but were intermediate for birth weight. Selk and Buchanan (1990) found that calves from Limousin bulls were heavier at birth than those from Salers bulls.

The sex of the calf also significantly affects birth weight. It is estimated that bull calves are about 5 to 8 % heavier than heifer calves (Oni et al., 1988 and Holland & Odde, 1992). In general, the birth weight of bull calves exceeds that of the heifer calves (Godley et al., 1966, Harricharan et al., 1976, Gregory et al., 1978, Gregory et al., 1979, Ahunu & Makarechian, 1986, Oni et al., 1988, Reynolds et al., 1990, Sawyer et al., 1991, Fordyce et al., 1993 and Kertz et al., 1997). Holland & Odde (1992) argued that the higher birth weight in male calves could be linked to the production of androgens. In the prenatal stage, androgens exist in both sexes, but bull calves tend to have an increased level of testosterone production. The existence of androgen receptors on muscle cells may aid in higher muscle growth as well as leading to greater birth weight.

The year in which a calf is born can also be a source of variation in birth weight. The differences in birth weight could be attributed to differences in nutrition of the dam due to annual precipitation, as well as the environmental temperature. Oni et al. (1988) found meaningful variation in birth weight associated with year of birth. Precipitation will influence the quantity and quality of food available to the gestating dam (Oni et al., 1998). When there is less food available to the mother (especially during the last third of gestation), the birth weight of the calf will be lower (Ferrell, 1993). Due to better forage conditions when the rainy season commenced, the birth weights of the calves tended to increase because the mother was exposed to higher quality nutrition (Sawyer et al., 1991). Reynolds et al. (1990) suggested that there is much yet to be understood about how environmental effects contribute to variation in birth weight. If calves were born in warmer seasons, their birth weights tended to be lower than those born in cooler seasons. The lowered birth weight observed in the warmer seasons may be due to the change in blood flow to the uterus. When temperatures are high, the blood is diverted towards the skin and respiratory organs to assist in the cooling-off of the animal. The reduction in blood flow towards the uterus may results in fewer nutrients to the fetus and consequently lowered birth weights (Holland & Odde, 1992, Ferrell, 1993 and Colburn et al., 1997). Similarly, Selk & Buchanan (1990) found that spring-born calves were heavier at birth than fall-born calves, because during fall season more blood is diverted for heat dissipation.

In addition to the direct genetic contribution of the mother to the birth weight of the calf, the maternal environment of the mother also influences the calf's birth weight. First calf heifers (approximately 2 or 3 years old) produce calves with lower birth weights, and as the mother increases in age so does the birth weight of her calves (Godley et al., 1966, Harricharan et al., 1976, Ahunu & Makarechian, 1986, Holland & Odde, 1992, Ferrell, 1993 and Fordyce et al., 1993). The birth weight of her calves tended to decrease as the dam attained an age of 9 years and older (Holland & Odde, 1992). Birth weight increased with an increase in age up to approximately 6-7 years of age followed by a decrease in birth weight with a further increase in age (Swanepoel & Heyns, 1988). The same investigators reported that lactating cows and heifers that calved for the first time had calves with lower birth weights when compared to dry cows and heifers that were a year older at first calf. The reason for the lower birth weights of calves of first calf heifers can be attributed to the fact that the heifer is still growing at the time when she gives birth for the first time (Holland & Odde, 1992).

It is estimated that the birth weight of the calf is 7 % (ranges between 5 -10 %) of that of the cow weight. The birth weight of the calf becomes larger as the cow becomes larger in body weight and size. As the dam increases in parity, so does the birth weight of her calves (Ferrell, 1993). However, with very old and heavier dams, birth weights start to decrease (Holland & Odde, 1992). Dams that had one parity had lower birth weight than those dams that had a second or more parities (Kertz et al., 1997). In contrast, Tudor (1972) found parity (categorized as with no calf, with one calf and with two or more calves) did not affect the birth weight of calves. This could be attributed to the small number of animals studied. Gregory et al. (1978) found that calves from 5-year-old cows were heavier than those of 4-year-old dams. This is different from the report by Gregory et al. (1979), in which 4-year-old cows had heavier calves at birth and higher mortality rate than 5-year-old and older cows. In general, birth weight increases with an increase in parity, but decreases at much older ages.

Weaning Weight

The pre-weaning growth and weaning weight of a calf is due to the combined effect of genetics and the environment (refer to model on p.3). The environmental conditions to which the calf is exposed may hamper the expression of the full genetic ability of the animal for growth (Oni & Buvanendran, 1988). Besides the inherent ability of the calf for growth, weaning weight is also a function of the maternal ability of the mother, i.e. the milk production (Reynolds et al., 1990). The breed of the bull also plays a role in the variation in weaning weights of calves. Offspring of sires with greater mature size are heavier at weaning than those of medium sized sires (Reynolds et al., 1990). Calves with highest weaning weight originated from bull breeds that are medium and large in mature size with medium and high milk production levels, respectively (Reynolds et al., 1990). Crossbred calves tend to have a greater rate of growth and weaning weight than straight-bred calves (Sawyer et al., 1991).

Red Poll and Hereford-Angus cross calves had a lighter 200-day weight when compared to Brown Swiss, Gelbvieh, Maine-Anjou and Chianina crosses. Differences in 200-day weight between Mainie-Anjou, Chianina and Gelbvieh cross calves were minimal, but Gelbvieh crosses were slightly greater. Brown Swiss calves were lighter than Gelbvieh calves at 200-days of age, but were not different from Maine-Anjou and Chianina calves (Gregory et al., 1978). The Brahman had the highest 200-day weight of all the cross calves. The Hereford-Angus cross calves (reciprocal) were lighter at 200-days in relation to Pinzgauer and Tarentaise cross calves. The Tarentaise cross calves exceeded the Sahiwal in 200-day weight (Gregory et al., 1979).

In the study conducted by Notter et al. (1978), crossbred cows (produced through mating of Hereford and Angus cows with Hereford, Angus, Jersey, South Devon, Simmental, Limousin and Charolais bulls) were calved at 2-year-old or at 3-year-old. The 2-year-old cows had offspring sired by Hereford, Angus, Brahman, Devon and Holstein sires, while the 3-year-old cows had offspring sired by Hereford, Angus, Maine-Anjou, Chianina and Gelbvieh sires. Calves originating from Hereford-Angus cross cows had the lowest 200-day weight and pre-weaning growth rate, while calves from the Jersey and Simmental cross cows had the highest 200-day weight and growth rate. In the 2-year old group, the calves originating from the Hereford and Angus bulls grew slower than the calves from Brahman bulls. Progeny form Holstein and Brahman bulls had higher 200-day weights than the Hereford-Angus offspring. In the 3-year old group, the Hereford and Angus bull calves had lower growth rate than calves from Chianina and Gelbvieh bulls. The lowest 200-day weight was observed in the progeny of the Angus and Hereford bulls. The Longhorn crosses had the lightest 200-day weight of all the cross calves. Progeny of the Charolais bulls had the highest 200-day weight, followed by the Nellore, Salers, Shorthorn, Hereford-Angus, Piedmontese, Galloway, reference (bulls originating from the GPE Program) Hereford-Angus bulls (Cundiff et al., 1998).

At weaning, intact male calves had the highest weaning weight followed by castrated males and then by heifer calves (Peacock, et al. 1960, Meade et al., 1963 and Sewell et al., 1963). Bulls and/or steers had a higher weaning weight (Godley et al., 1966, Gregory et al., 1978, Gregory et al., 1979, Reynolds et al., 1980, Leighton et al., 1982, Charles & Riley, 1984, Ahunu & Makarechian, 1986, Reynolds et al., 1990, Sawyer et al., 1991 and Fordyce et al., 1993) and were faster in growth than heifers (Godley et al., 1966, Gregory et al., 1978, Gregory et al., 1979, Leighton et al., 1982, Ahunu & Makarechian, 1986, Reynolds et al., 1990 and Fordyce et al., 1993).

Similarly, Neville Jr. (1962), Rutledge et al. (1971) and Seifert et al. (1974) concluded that female calves were lower in weaning weight than intact males or castrated calves. When bull calves attain puberty, testosterone production is increased. Testosterone has an anabolic effect on skeletal muscle growth. Some muscles have androgen receptors, resulting in a direct effect of testosterone on muscle growth. Dinkel et al. (1990) and Dinkel et al. (1992) concluded that intact males as well as castrated males are heavier and more efficient than females. This difference may be partly attributed to the milk production level of the dam. Melton et al. (1967) found that bull calves suckled more often than heifers, which could result in increased milk production of the cow. Higher milk producing breeds are able to provide more energy to fulfill in the male calf's requirement. Peacock et al. (1960) found that male and castrated male calves were higher in weaning weight than female calves at weaning, but female calves have a higher grade at slaughter. The authors attributed the results of greater weaning weight to the greater growth ability of steers and that those female weaners deposit fat faster than male or castrated weaners.

Offspring from older, adult cows tended to have greater weaning weights and more rapid pre-weaning growth rates than those from first calf heifers (Godley et al., 1966, Carles & Riley, 1984, Ahunu & Makarechian, 1986 and Fordyce et al., 1993). Leighton et al. (1982) indicated that weaning weight of calves become greater as cows becomes older up to 5-6 years of age. Weaning weights of the calves did not increase after the cows reached 6 years of age and started to decrease as the cows become older than 10 years of age. Gregory et al. (1978) reported that progeny of 5 year old dams and older had heavier weights at 200 days than those of 4-year-old dams. However, Gregory et al. (1979) reported that progeny from 5 year olds and older were lighter than those of 4 year olds. Weaning weight of calves from first calf heifers (approx. 2 year old heifers) was significantly lower when compared to that of older cows (Peacock et al., 1960, Sewell et al., 1963 and Meade et al., 1963). Reynolds et al. (1980) reported that older cows produced heavier calves at weaning. These results agree with those of Swanepoel & Heyns (1988), who reported a meaningful increase in weaning weight of Hereford calves as the dams increased in age and parity. When the authors related the weaning weight of Afrikaner calves with increased age and parity of the dam, a slight non-significant improvement in weaning weight was observed.

Neville Jr. (1962), Sewell et al. (1963), and Rutledge et al. (1971) associated the greater weaning weights obtained by calves from older dams with greater milk production older cows. As the cow increases in age, so does the milk production, with maximum production at about 6 years of age (Sewell et al. 1963). Dams with a higher parity had heavier weaners than first calf heifers, because of the higher milk production with older cows Oni & Buvanendran (1988).

The year of birth has an influence on weaning weight of calves. The effect of year is modulated through the environment. Precipitation and temperature are the primary factors, however, management, (Meade et al., 1963) of the animals also plays a role. Rainfall (amount and dispersal) influenced the vegetation growth (Peacock et al., 1960, Meade et al., 1963 and Sewell et al., 1963). The year effect, as dictated by precipitation and food availability, causes variations in weaning weights and rate of pre-weaning growth (Reynolds et al., 1990). Neville Jr, (1962) associated the effect of years with the quality of feedstuffs, and in this case, poor quality was correlated with low weaning weights.

Godley et al. (1966) verified that birth weight was responsible for 5 - 8 % of the differences in weaning weight. The greater the birth weight, the greater the weaning weight (Neville Jr. 1962, Sewell et al., 1963 and Godley et al., 1966). Rutledge et al. (1971) concluded that the greater the weight of the calf at birth, the greater the milk requirement of the calf or the greater the ability of the calf to drink milk. Bull calves are heavier at birth, and they tend to suckle more frequently which in turn stimulates the cow to produce more milk (Melton, et al. 1967). With heavier birth weights, heavier weaning weights would be possible.

Reproduction

Reproduction is one of the important factors that determine the success of a cattle production system. A cow needs to produce a calf a year. Several factors influence the reproduction of the cowherd. The variation among breed groups in the number calves of born indicates that breeds differ in reproductive ability (i.e. conception rate and prenatal survival ability), while weaning rate indicates that breed groups differ, in addition to the previously mentioned factors, postnatal survival ability is also a factor

(Cundiff et al., 1985). Breed has a meaningful effect on reproduction (Warnick et al., 1960). Breeds of British origin had greater reproductive ability than breeds originating from Brahman. Lactation status and maturity of the dam are factors that will affect re-breeding potential. The best results in re-breeding are obtained when a cow is 4 years or older and not producing milk (Warnick et al., 1960).

Pregnancy percentage is influenced by the time that the cow calves in the calving season as well as the nutritional environment provided. If there is more food available, the weight and condition of the cow will be greater as will the pregnancy percentage. A reduction in the food supply to cows before calving causes a reduction in body weight and condition, a longer anestrous period after calving, less cows in heat, decrease in conception and pregnancy rate, as well as lowered birth weights (Bellows and Short, 1978). If cows calve early in the calving season, there is a greater chance that they will rebreed (Selk, et al., 1988). Pang et al. (1998) confirmed that cows had a lower body condition score when they calved late in the calving season. Cows with lower weights tended to have a higher estrogen production, and estrogen exerts a negative feedback on the hormones (LH and FSH) responsible for ovulation and follicle growth (Boyd et al., 1987). Cundiff et al. (1985) concluded that if the nutrient demand of large sized superior milk producers is not provided, the postpartum anestrous period lengthens and less cows conceive.

Body condition of a cow gives us information about the status of her energy reserves. Cows experience several stress conditions such as gestation, parturition and milk production after conception. To be successful in all these conditions and to re-breed, the cow needs energy. Supplying extra energy in the form of feedstuffs would be expensive. To meet the energy demand (at times when the demand is high) the cow would catabolize her fat reserves to provide energy (Selk et al., 1986). The better the condition of a cow at calving, the greater the chance is that she will conceive. Pang et al. (1998) reported that after experiencing a winter period, the body condition of a female before parturition is the best indication of her energy reserves. Selk et al. (1986), Selk et al. (1988) and Spitzer et al. (1995) confirmed that body condition of the cow at calving is the best predictor of the cow's reproductive ability (i.e., re-breeding and postpartum anestrous interval). A greater body condition score at calving resulted in a larger number of cows in heat and pregnant within the 2 to 3 month mating season.

The endocrine system is influenced by changes in nutrient supply to the cow. Rasby et al. (1986, 1991) concluded that cows with lower body condition scores tend to have smaller ovaries and corpora lutea. This weight decrease may influence the production and secretion of those hormones that are involved in follicle growth and ovulation. Richards et al. (1986, 1989) demonstrated the effect of reduced nutritional levels on reproduction of cows. When cows were exposed to reduced nutrient levels, body condition declined and that consequently influenced the cycling ability of the cows. If cows declined in body condition to 3.5 and below (where a condition score of 1 = emaciated and a condition score of 9 = obese; Wagner et al., 1988), estrus cycles cease. However, when the cows were given adequate nutrition after restriction, estrus resumed. Reduced nutrition influenced the frequency and concentration of LH pulses. Luteinizing Hormone in return is responsible for ovulation as well as luteinization.

Spitzer et al., (1995) indicated that greater body condition score of cows at calving resulted in larger birth weights. Weaning weight of calves from cows with medium weight gains after calving were lighter when compared to calves from cows that had higher weight gains. Greater body condition resulted in greater 205-day weaning weight, but the reproductive performance of heifers at different body condition scores was not significantly different. Wettemann et al. (1986) concluded that percentage of heifers pregnant at calving was affected by body condition at calving. However, birth weight of calves was not significantly affected by the body condition of the heifer at calving.

When heifers calving for the first time were allowed to increase weight after they calved, the postpartum anestrous period was shorter and the percent pregnant increased (Morrison et al., 1986). The greater the body condition score, the greater the percentage of cows pregnant (Rae et al. 1993). Parity had a meaningful influence on pregnancy percentage. Cows that reached parity four and higher tended to have a greater pregnancy percentage. Tinker et al. (1989) investigated how females from different biological types, produced from Angus and Hereford cows, influence reproduction. They suggested that one should consider the biological types of cattle as well as the breed of dam's sire to obtain an advantage in reproduction. Breed of sire of dam had a meaningful effect on luteal activity (LA). Cows from Jersey bulls had the highest LA with the Hereford x Angus cows the least LA. The Simmental and Brown Swiss sired cows were intermediate in LA.

Cow Efficiency

In earlier days, cow efficiency was measured in terms of the calf weight to cow weight ratio (Dinkel & Brown, 1978). However, Dinkel & Brown (1978) argued that this method was prejudice in that it would be more favorable to small cows. The authors suggested that calf-weaning weight is the most desirable indicator of cow efficiency. How efficient the cow produces her calf could be calculated by the ratio of calf weight at weaning to total TDN consumption of the cow plus calf (Dinkel & Brown, 1978; Dinkel et al., 1992).

Dinkel et al. (1992) investigated the influences of breed of dam x sex interaction on weaning weight and efficiency. The efficiency ratio (as calculated by the ratio of weaning weight to the total TDN consumption of cow plus calf) was higher for male than female calves. Dinkel and Brown (1978) reported that a larger-sized dam had an efficiency ratio of 12.6 kg of TDN per kg calf produced compared to the 11.3 kg TDN consumed to produce 1 kg calf weight in a smaller sized dam. This information agrees with López de Torre et al. (1992) that smaller cows will be more productive than large dams. The authors argued that animals that reach maturity quicker, however at a lower weight would be more efficient, because they will be able to produce more weaners as well as more weaning weight over their productive life span.

The largest expense a production system encounters is feed costs. The ideal would be to increase gain, but to keep feed cost to the minimum. However, the more the animal grows, the bigger it becomes and more food will be required for maintenance (Klosterman, 1972). Maintenance costs increased as an animal increased in size (Klosterman, 1972, Andersen, 1978). Andersen (1978) stipulated that larger animals are usually those that produce more milk as well as meat. This agrees with Ferrell & Jenkins (1982) who reported that high lactation cows had a "high maintenance requirement per unit metabolic size" when compared to low lactation cows. Klosterman (1972) argues that there is no ideal size. This supports opinions of Dickerson (1978) and Andersen (1978) that ideal size of cattle depends on the production system practiced, the surroundings the animal is exposed to, and the area where cattle are produced as well the trends of the industry.

Buttram & Willham (1989) investigated the influence of size (small, medium and large) and management (season of calving and time of weaning) on first to third parity cows. They concluded that small sized females are more efficient in their reproduction (i.e., calving percentages) than larger sized females. Medium sized females were intermediate. Large, late-developing frame females have a greater need for food and would attain sexual maturity at heavier weights. Failure to meet that requirement could be detrimental to the cycling ability of the female and consequently cause a reduction in calving percentage. Klosterman (1972) and Buttram & Willham (1989) suggested that small sized, early developing breeds can be utilized efficiently under extensive conditions, because they have lower maintenance requirements and that the larger sized, late developing breeds would be most suitable in intensive production systems.

Stocking rate

Stocking rate is important and if applied incorrectly could result in deterioration of pastures and animals. Varying stocking rates affected animal performance more than vegetation. During the dry periods of the year, food usually becomes sparse. If a high stocking rate is applied, additional feedstuffs need to be provided (Seligman et al., 1989).

Cows on a low stocking density tended to produce calves with greater birth weights and when lactating cows were exposed to supplementation, the calves increased in birth weight (Gaertner et al., 1992). Cows on high and medium stocking densities produced lighter weaner calves than cows on low stocking densities. The differences in weaning weights of females and castrated males were lower at higher stocking densities (Gaertner et al., 1992). Quality and quantity of forage enhances animal performance. Also, the positive relationship between birth and weaning weight resulted in an increase in weaning weight. Seligman et al. (1989) found that weaning weight of the calf, as well as dam, was less at higher stocking rates. These results agree with those of Gutman et al. (1990) and Hart et al. (1988). Also, the fewer animals per ha, the lower the supplementations as well as the weaned weight per ha. The authors (Gutman et al., 1990) found that the percentage of cows conceiving varied among years, but increased with lower stocking rates. These results confirm the observation by McMeekan (1959) as cited by Gutman et al. (1990) that "stocking rate is probably the most powerful weapon influencing efficiency (of animal production) on a per acre basis".

Meat production per hectare (ha) is an important component of an extensive grazing production system. In extensive, harsh situations it is more logical and economical to change the type of grazing animal than the environment. Mezzadra et al. (1992) reported that under higher stocking rates, large frame animals produced less meat per ha and on an individual basis. The opposite is true when low stocking densities are applied. At high stocking rates small frame animals will produce more meat on a per ha as well as an individual basis. The opposite is true for large frame animals. Under conditions in which less forage is available, small frame animals are more flexible due to their lower maintenance needs (Mezzadra et al., 1992). In a trial conducted by Joandet (1969), small-frames Angus calves had less weaning weight than the large-framed Charolais calves. However, when focused on the kilograms weaned per ha, the Angus breed weaned more kilograms per ha than the Charolais. A larger number of rapid growing calves per unit of grazing land were obtained when small maternal lines with large paternal lines were utilized (Molinueva ,1969). This implies that the small dam lines permit a larger carrying capacity on the pasture.

CHAPTER III

BEEF BREED CHARACTERIZATION IN NAMIBIA

ABSTRACT

Six beef cattle breeds were characterized according to birth weight, weaning weight, cow efficiency (expressed as the ratio of calf weight at weaning to cow weight at weaning) and reproductive performance in Namibia. The breeds were categorized according to frame size, in that Simmental & Santa Gertrudis represented the large frame group, Afrikaner & Hereford represented the medium frame group, and the Sanga and Nguni breeds comprised the small frame group. General linear models were used to generate least squares means for birth weight, weaning weight, cow efficiency and reproduction (measured in terms of calf crop weaned), cow weight and body condition at calving. Cow weight and body condition at calving were related to calf crop weaned by use of regression variables. Orthogonal contrasts were used to evaluate effects of parity. Preplanned non-orthogonal contrasts were used to compare breed main effect and Bonferroni t-tests were used to conduct the multiple comparisons.

At birth, small frame breeds were lighter than large and medium frame breeds. At weaning, calves of large frame breeds were heavier than calves of small frame breeds. The medium frame breeds were intermediate for birth and weaning weights. Bull calves were heavier than heifer calves at both birth and weaning. Birth and weaning weights of calves increased with increasing parity. First and second parity cows were more efficient at weaning than third or more parity cows. Small frame cows were more

efficient at weaning than medium frame cows. At weaning, cows producing bull calves were more efficient than cows producing heifer calves. Regression of calf crop weaned on cow weight at calving was positive (0.12%; $P < .05$) for Hereford breed, negative (0.13%; $P < .05$) for Sanga breed and approached significance at the Simmental breed (0.08%; $P < .10$). Cow weight at calving increased with an increase in parity. At calving the large frame breeds were the heaviest and the small frame breeds the lightest, while the medium frame breeds were intermediate. The Hereford breed was very sensitive to changes in environmental conditions. Small frame type animals seemed to be the most suitable for Namibian conditions.

INTRODUCTION

Cattle producers are exposed to many different types of cattle breeds. This gives the producer the opportunity to match specific types of cattle with specific kinds of environmental conditions such as climate, nutrition and management to obtain maximum beef production (Notter et al., 1978). Characterizing the different types of cattle would assist producers in selecting the breeds of cattle most suitable for their particular production environment (Notter et al., 1978). Variation in performance traits of breeds allows the producer to increase the efficiency of beef production through breeding systems (Cundiff et al., 1998).

Agriculture is one of the important economic sectors in Namibia. It contributes approximately 10 % to the country's GDP, is a major provider of labor and adds to the income from foreign exchange (Namibia Trade Directory, 1999). Eighty percent of the total beef and lamb produced is exported. The lamb is exported mostly to Southern African countries, while beef is exported mostly to Europe and Africa (Namibian Trade Directory, 1999). Livestock farming in Namibia is practiced as either commercial or communal (subsistence) farming. In commercial farming systems, beef cattle are mostly produced to export to overseas countries and therefore contribute greatly to the country's economy (Lepen, 1994). The farming practices in the commercial section are in line with those of developed countries. Beef producers practice pure breeding and/or crossbreeding. *Bos Indicus* breeds and their crosses are mostly used as mothers in the crossbreeding systems (Lepen, 1994). The communal farmer utilizes cattle for various reasons such as a source of milk for the household. In most of the times cattle are used as a financial source.

With sparse rainfall and dry conditions in Namibia, utilization of the most suitable types of cattle would be advantageous to the producers and country's economy. Therefore, the objective of the present study was to characterize six different breeds of cattle, which were categorized according to frame size, in a Namibian production environment.

MATERIALS AND METHODS

Environment

This interbreed trial was conducted at Omatjenne Research station in Namibia, Southern Africa. Omatjenne lies approximately 25 km west of Otjiwarongo, in the Otjozondjupa region, on the 20,5 ° Southern latitude and 16,6 ° Eastern longitude. It has an altitude of 1380 meters above sea level. This is categorized as a summer rainfall area, with an average annual rainfall of approximately 430 mm. The rainfall season usually commences in October and lasts until April, with the highest precipitation during January and February (Appendix A). Omatjenne is classified as thorn-bush savanna, and has palatable bushes, shrubs and perennial grass species. Due to the high nutritional value of the grass coverage, the veld type can be referred to as Sweet-veld. The soil type varies from sand to dolomite and lime.

Experimental Animals

This present study commenced in 1977 with the Afrikaner, Hereford, Simmental, Santa Gertrudis and Sanga breeds. The breeds utilized in this trial were those that performed the best in a previous trial conducted at Omatjenne. Breeds were categorized into three groups according to their frame size. Large frame breeds included Simmental and Santa Gertrudis, medium frame breeds were the Afrikaner and Hereford, and the small frame breed was the Sanga. Crosses between *Zebu* x humpless Hamitic longhorn cattle were used to produce Sanga type of cattle in Central and East Africa. Black tribes moved to the Southern Africa along with their Sanga cattle (Schoemann, 1989). In Namibia, all these indigenous cattle (from the Caprivi, Kavango, and Owamboland areas) are referred to as Sanga (Schoemann, 1989).

The cows of the Afrikaner, Hereford and Simmental breeds were selected from the animals of the former trial. Santa Gertrudis cows were from an existing herd at Omatjenne Research Station. Sanga cows came from the existing herd (since 1968) at the research station. The bulls of the Hereford breed were collected from the breeder associations in Namibia. The Santa Gertrudis bulls were either purchased or borrowed from breeders in Namibia. The Simmental bulls were selected from the studs at Uitkomst Research Station and Neudamm Agricultural College as well as from various performance tested herds in Namibia. The Afrikaner bulls were selected from the existing Afrikaner stud. The Sanga cattle originated from a closed herd brought from the Owamboland region, Namibia, in 1968. In 1984 the closed herd was opened for the first time, and bulls from the Kavango region were introduced into the herd. Sanga bulls were selected from exiting herd and pedigrees were used to avoid inbreeding. The Nguni breed, a small frame breed, entered the trial at the end of 1983. Four Nguni cows and two Nguni bulls were transferred from Irene Research Station in South Africa. By 1984, forty Nguni cows and heifers, from KwaZulu Natal, South Africa entered the trial. Because the Nguni cows needed to acclimatize to the Namibian environment, their weights were only recorded by January 1985. The year 1984 and 1985 were excluded because cows originated from different countries. Some commercial and stud farmers in Namibia contributed also to the building of the groups of the different breeds. By October 1989, the majority of the Herefords and Santa Gertrudis were sold at the annual Omatjenne auction. In January 1990, the entire Nguni herd was transferred to the Sonop Research Station in northern Namibia.

TABLE 1

THE NUMBER OF CALVES BORN FOR EACH BREED, PARITY (P), YEAR OF BIRTH (YS) AND SEX

Breed	Sanga						Nguni						Afrikaner						Hereford						Santa Gertrudis						Simmental					
	P_1		P_2		$P_{\geq 3}$		P_1		P_2		$P_{\geq 3}$		P_1		P_2		$P_{\geq 3}$		P_1		P_2		$P_{\geq 3}$		P_1		P_2		$P_{>3}$		P_1		P_2		$P_{\geq 3}$	
YS	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
85s	7	3	3	2	5	15	7	6	5	4	3	5	3	2	1	2	7	4	5	1	1	2	7	6	5	1	3	-	6	7	4	7	2	1	2	5
86s	5	3	4	3	12	8	-	-	6	7	6	10	1	4	5	4	3	10	2	4	2	4	8	7	2	4	2	4	4	5	-	2	5	4	6	4
87s	-	-	4	4	11	11	-	1	-	1	13	9	1	1	3	4	8	10	-	-	-	5	11	5	-	-		3	7	9	1	-	1	1	7	5
88s	-	-	4	6	11	17	-	-	5	6	14	8	-	2	2	1	12	9	1	-	7	1	12	6	1	-	4	3	8	7	-	1	3	3	8	6

P_1 = Parity 1, P_2 = Parity 2, $P_{\geq 3}$ = Parity 3 and more
M = Male, F = Female
YS = Year of birth

Selection and culling criteria

Selection and culling in the cowherd took place annually, shortly before the joining of the cows with the bulls. Older cows were culled according to reproductive performance and age. If an older cow missed a calving season, the decision on whether she would be culled or not was based on the performance (eg. weaning ratio) of all of her previous calves. Replacement heifers were selected according to growth performance, which encompassed weaning, yearling, 18 month and 24 months weight ratios and a subjective evaluation of femininity. Extreme ratios were avoided. Heifers were to calve at 3 years of age. If they did not conceive the first time, the heifers were culled. Conception was determined via rectal palpation. Rectal examinations occurred after the mating season (i.e., about June – July). The bulls used in the Hereford, Santa Gertrudis, Simmental and Nguni herds were selected from outside herds. Afrikaner bulls came from the stud that was at Omatjenne. Since the Sanga herd was a closed herd (from 1968 until 1984), the bulls were selected from within the herd. Pedigrees were used to avoid the occurrence of inbreeding. Bulls three years of age and older were considered candidates for mating. Selection of the bulls was based on performance, which included weaning, yearling, 18-month weight ratios, body conformation, subjective evaluation of masculinity and functional sexual organs.

Stocking rate

Biomass stocking rate can be explained as the stocking of a pasture with kg animal biomass according to the kg plant biomass available. Usually a pasture survey would be conducted to measure DM production, i.e. the available grass yield (in kg/ha). By using the available grass yield (kg/ha), the carrying capacity (kg/ha) can be calculated. In formula notation, the calculated carrying capacity (kg/ha) = [50 % of available grass yield] / [{3% intake x 365 days} / 1 kg animal biomass] = [Total available grass yield / 21.9] (Lubbe, 1999, Personal communication). The DM production from these hectares was used to determine the total amount of animal biomass (kg/ha) to be carried, and consequently the number of cows (Lubbe, 1999, Personal communication). As a result a small frame breed (i.e. lower in biomass) will have more individuals in order to have an equal total weight at mating for each breeds.

Initially each breed had an allocated number of 30 cows. From 1984 comparisons between the different breeds were done on approximately 17 kg cow bio-mass/ha/year Lepen, (1994). This resulted in different numbers of animals per breed. 7704 ha (hectares) were allocated to the animals in the trial (cows utilize 4923 ha of the total, i.e. 64 % of the total area). A total area (ha) was allocated to each breed. The Afrikaners received 828 ha, the Herefords 823 ha, Sangas 826 ha, Santa Gertrudis 830 ha, Simmental 818 ha and the Nguni's 798 ha.

The pasture types were evaluated, and the camps grouped according to the different pasture types. A camp of each pasture type was allocated to each breed to assure that each breed had a camp of all the different pasture types. The camp allocations were done at random. Five camps were allocated to each of the six breeds. Plants were investigated according to composition and coverage. The grazing period was approximately 2 week and the camp had the chance to rest for about 60 days. The rotations were not fixed. If the animals needed to be moved, they were moved to the camp that had the best grazing at that time. All the animals in the trial received a winter lick as supplementation (Appendix B), which supplied mostly salt, phosphorus and calcium.

Management of animals

The calving season was from October until December. Pregnant cows were checked 2-3 times per week for new arrivals to ensure that the calves were not older than 4-5 days when recorded. The newborns were usually tagged and weighed within 2 to 4 d after birth. There is a lot of bush and shrubs in Omatjenne and some cows tended to hide their calves after giving birth, which sometimes prevented obtaining a birth weight. Mating season commenced in mid-January and ended approximately mid-April. Natural mating was used. Two bulls were used per mating season in each breed. The bulls were used for two consecutive mating seasons. All bulls used in the mating season underwent a fertility test (including a semen test, scrotal circumference measurement and soundness test) and tests for several venereal diseases (eg. vibriosis, trigamoniases). A state veterinarian conducted these tests.

Weaning was at approximately 7 months of age. If drought conditions occurred, calves were sometimes weaned at approximately 6 mo of age, which allowed cows to build body reserves. It was more economical to feed the calves directly than *via* their mothers. Shortly after weaning, some of the bull calves were selected to participate in the Phase C of the Performance Test Scheme. Phase C is one of the five phases practiced in the Beef Cattle Performance Test Scheme. Only stud bulls can participate in this phase and it is conducted at a central test station. In phase C the growth potential (average daily gain and growth per day of age), feed efficiency and body measurements of each bull is measured and recorded. In 1987 calves were weaned at 2 different ages, one group at 7 mo and the other at 9 mo. The reason for this was (a) to investigate the effect of late weaning (9 months) on the fertility of the cow and (b) to see whether there was an increase in kg meat per ha produced. The calves from the heifers mated in the winter (August – October) were weaned in January the following year. All weaning weights were adjusted to 205 d.

The steers were placed on normal grass pasture. Normal pasture entails grass species such as *Anthephora pubescens, Aristida meridionaleis, Brachiaria nigropedata, Cenchrus cilliaris, Eragrostis porosa, Fingerhuthia africana, Heteropogon contortus, Schmidtia pappophoroides and Stipagrostis uniplumis.* Steers were weighed every 28 d and rotated between six camps (20 ha each) on a 2-wk basis. The steers had ad libitum access to supplementation in the form of a winter-lick (Appendix B). The steers were slaughtered at either 18 or at 27 mo of age at the Meatco abattoir in Windhoek. The individuals to be slaughtered at either age were identified at random. Carcass weight, grading information, eye-muscle measurement and fat thickness were recorded, but were not part of the present study.

The heifers were mated at 24 to 26 mo of age to calve at 3 yr of age. Mating of heifers coincided with the mating season of the cows. However, in 1986 until 1988, some of the heifers were mated at 18 to 20 mo (about mid-August until October) of age and calved by June of the next year. In 1989 the mating period was about 1.5 mo in length, from mid-August until September 30. Approximately 12-15 % more heifers than needed were mated.

Adult animals were weighed 3 times per year. Weighing occurred before entering the mating season (mid-January), at the end of the mating season (mid-April) and before calving (i.e. about August/ September). Condition score of the cows on a scale of 1 to 5 were also recorded. The following key was used (Appendix C): 1 (very thin), 3 (average), 5 (very fat). All calves were weighed at birth, pre-weaning (at end of mating season), and at weaning. The yearling, 15-, 18-, 24- and 27-mo weights of the steers were also recorded.

Statistical Analyses

Due to data availability, analyses were conducted to compare the six breeds over a 4-yr period from 1985/86 until 1988/89. All data were analyzed with ordinary least squares (SAS, 1999). Weaning weight was adjusted to 205 d. Parity was categorized as first, second and third or more (Gallo et al., 1996, Morales et al., 1989 and Tharmaraj et al., 1989). Cow efficiency at weaning was defined as calf weaning weight divided by the cow weight at weaning.

The model for birth weight (BW) and weaning weight (WW) was:

$Y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + \alpha\beta_{ij} + \alpha\gamma_{ik} + \alpha\delta_{il} + \beta\gamma_{jk} + \beta\delta_{jl} + \gamma\delta_{kl} + \alpha\beta\delta_{ijl} + \alpha\beta\gamma_{ijk} + \beta\gamma\delta_{jkl}$

$+ e_{ijklm}$, where

Y_{ijklm} = the birth weight of the m^{th} calf, of the l^{th} year of birth, of the k^{th} parity, of the j^{th} sex, of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

β_j = main effect of the j^{th} sex,

γ_k = main effect of the k^{th} parity,

δ_l = main effect of the l^{th} year of birth,

$\alpha\beta_{ij}$ = interaction effect of the i^{th} breed with the j^{th} sex,

$\alpha\gamma_{ik}$ = interaction effect of the i^{th} breed with the k^{th} parity,

$\alpha\delta_{il}$ = interaction effect of the i^{th} breed with the l^{th} year of birth,

$\beta\gamma_{jk}$ = interaction effect of the j^{th} sex with the k^{th} parity,

$\beta\delta_{jl}$ = interaction effect of the j^{th} sex with the l^{th} year of birth,

$\gamma\delta_{kl}$ = interaction effect of the k^{th} parity with the l^{th} year of birth,

$\alpha\beta\delta_{ijl}$ = interaction effect of the i^{th} breed, of the j^{th} sex, of the l^{th} year of birth.

$\alpha\beta\gamma_{ijk}$ = interaction effect of the i^{th} breed, of the j^{th} sex, of the k^{th} parity,

$\beta\gamma\delta_{jkl}$ = interaction effect of the j^{th} sex, of the k^{th} parity, of the l^{th} year of birth,

e_{ijklm} = random error; assume $e_{ijklm} \sim N(0, \sigma^2)$.

All the terms above were included in the model for weaning weight, except for the interaction effect of the j^{th} sex with the k^{th} parity ($\beta\gamma_{jk}$), the interaction effect of the i^{th} breed of the j^{th} sex of the l^{th} year of birth ($\alpha\beta\delta_{ijl}$), the interaction effect of the i^{th} breed of the j^{th} sex of the k^{th} parity ($\alpha\beta\gamma_{ijk}$) and the interaction effect of the j^{th} sex of the k^{th} parity of the l^{th} year ($\beta\gamma\delta_{jkl}$).

The model for cow efficiency (CE) at weaning was:

$Y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + \alpha\beta_{ij} + \alpha\gamma_{ik} + \alpha\delta_{il} + \beta\gamma_{jk} + \beta\delta_{jl} + \gamma\delta_{kl} + \alpha\beta\delta_{ijl} + e_{ijklm}$, where

Y_{ijklm} = the cow efficiency at weaning of the m^{th} calf, of the l^{th} year of birth, of the k^{th} parity, of the j^{th} sex, of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

β_j = main effect of the j^{th} sex,

γ_k = main effect of the k^{th} parity,

δ_l = main effect of the l^{th} year of birth,

$\alpha\beta_{ij}$ = interaction effect of the i^{th} breed with the j^{th} sex,

$\alpha\gamma_{ik}$ = interaction effect of the i^{th} breed with the k^{th} parity,

$\alpha\delta_{il}$ = interaction effect of the i^{th} breed with the l^{th} year of birth,

$\beta\gamma_{jk}$ = interaction effect of the j^{th} sex with the k^{th} parity,

$\beta\delta_{jl}$ = interaction effect of the j^{th} sex with the l^{th} year of birth,

$\gamma\delta_{kl}$ = interaction effect of the k^{th} parity with the l^{th} year of birth,

$\alpha\beta\delta_{ijl}$ = interaction effect of the i^{th} breed of the j^{th} sex of the l^{th} year of birth,

e_{ijklm} = random error; assume $e_{ijklm} \sim N(0, \sigma^2)$.

Calving rate (WR) was defined as whether a cow weaned a calf when exposed to a bull the previous year. If a cow weaned a calf a '1' was assigned and in case no calf was weaned, a '0' was assigned. WR was regressed on cow weight at calving (CWC) and body condition at calving (CSC). CWC in the summer 1985 was related to a weaning rate in 1987. Similarly, CWC in the summers 1986 and 1987 was related to weaning weights in 1988 and 1989, respectively. CSC in summer 1986 and 1987 was related to weaning weight in 1988 and 1989, respectively. The effect of breed, parity and year of birth (YS) on cow weight at calving (CWC) and body condition at calving (CSC) were also investigated.

The model for calf crop weaned (WR) was:

$Y_{ijkl} = \mu + \alpha_i + \gamma_j + \delta_k + \alpha\gamma_{ij} + \alpha\delta_{ik} + e_{ijkl}$, where

Y_{ijkl} = WR of the l^{th} calf weaned, of the k^{th} year of birth, of the j^{th} parity, of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

γ_j = main effect of the j^{th} parity,

δ_k = main effect of the k^{th} year of birth,

$\alpha\gamma_{ij}$ = interaction effect of the i^{th} breed with the j^{th} parity,

$\alpha\delta_{ik}$ = interaction effect of the i^{th} breed with the k^{th} year of birth,

e_{ijkl} = random error; assume $e_{ijkl} \sim N(0,\sigma^2)$.

The model for WR including CWC as a regression variable was:

$Y_{ijkl} = \mu + \alpha_i + \gamma_j + \delta_k + \beta(A_{ijkl} - \bar{A}) + \alpha\delta_{ik} + \beta(A_{ijkl} - \bar{A})\alpha_i + e_{ijkl}$, where

Y_{ijkl} = WR of the l^{th} calf weaned of the k^{th} year of birth of the j^{th} parity of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

γ_j = main effect of the j^{th} parity,

δ_k = main effect of the k^{th} year of birth,

$\beta(A_{ijkl} - \bar{A})$ = regression coefficient of Y variable on A (CWC) variable,

$\beta(A_{ijkl} - \bar{A})\alpha_i$ = interaction effect of the i th breed with regression coefficient of Y variable on A (CWC) variable,

$\alpha\delta_{ik}$ = interaction effect of the i^{th} breed with the k^{th} year of birth,

e_{ijkl} = random error; assume $e_{ijkl} \sim N(0,\sigma^2)$.

The model for WR with CSC as a regression variable was:

$Y_{ijkl} = \mu + \alpha_i + \gamma_j + \delta_k + \beta(A_{ijkl} - \bar{A}) + \alpha\delta_{ik} + \beta(A_{ijkl} - \bar{A})\alpha_i + e_{ijkl}$, where

Y_{ijkl} = WR of the l^{th} calf weaned of the k^{th} year of birth of the j^{th} parity of the i^{th} breed,

μ = overall mean

α_i = main effect of the i^{th} breed,

γ_j = main effect of the j^{th} parity,

δ_k = main effect of the k^{th} year of birth,

$\beta(A_{ijkl} - \bar{A})$ = regression coefficient of Y variable on A (CSC) variable,

$\beta(A_{ijkl} - \bar{A})\alpha_i$ = interaction effect of the i th breed with regression coefficient of Y variable on A (CSC) variable,

$\alpha\gamma_{ij}$ = interaction effect of the i^{th} breed with the j^{th} parity,

$\alpha\delta_{ik}$ = interaction effect of the i^{th} breed with the k^{th} year of birth,

e_{ijkl} = random error; assume $e_{ijkl} \sim N(0,\sigma^2)$.

When there was a significant breed x regression interaction, within breed regressions were included for either CWC or CSC. The model for the regression of WR on CWC or CSC nested within breed was:

$Y_{ijkl} = \mu + \alpha_i + \gamma_j + \delta_k + \beta(\alpha_i) + \alpha\delta_{ik} + e_{ijkl}$, where

Y_{ijkl} = WR of the l^{th} calf weaned of the k^{th} year of birth of the j^{th} parity of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

γ_j = main effect of the j^{th} parity,

δ_k = main effect of the k^{th} year of birth,

$\beta(\alpha_i)$ = regression of WR on CWC or CSC $[\beta(A_{ijkl})]$ nested within i^{th} breed,

$\alpha\delta_{ik}$ = interaction effect of the i^{th} breed with the k^{th} year of birth,

e_{ijkl} = random error; assume $e_{ijkl} \sim N(0,\sigma^2)$.

The model for the cow weight at calving (CWC) was:

$Y_{ijkl} = \mu + \alpha_i + \gamma_j + \delta_k + \alpha\gamma_{ij} + \alpha\delta_{ik} + e_{ijkl}$, where

Y_{ijkl} = CWC of the l^{th} calf, of the k^{th} year of birth, of the j^{th} parity, of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

γ_j = main effect of the j^{th} parity,

δ_k = main effect of the k^{th} year of birth,

$\alpha\gamma_{ij}$ = interaction effect of the i^{th} breed with the j^{th} parity,

$\alpha\delta_{ik}$ = interaction effect of the i^{th} breed with the k^{th} year of birth,

e_{ijkl} = random error; assume $e_{ijkl} \sim N(0,\sigma^2)$.

The model for the condition score at calving (CSC) was:

$Y_{ijkl} = \mu + \alpha_i + \gamma_j + \delta_k + \alpha\gamma_{ij} + e_{ijkl}$, where

Y_{ijkl} = CSC of the l^{th} calf, of the k^{th} year of birth, of the j^{th} parity, of the i^{th} breed,

μ = overall mean,

α_i = main effect of the i^{th} breed,

γ_j = main effect of the j^{th} parity,

δ_k = main effect of the k^{th} year of birth,

$\alpha\gamma_{ij}$ = interaction effect of the i^{th} breed with the j^{th} parity,

e_{ijkl} = random error; assume $e_{ijkl} \sim N(0,\sigma^2)$.

For BW, WW, CE, WR, CWC and CSC, orthogonal contrasts (Parity 1 vs parity 2 and Parity 1 & 2 vs parity 3) were used to compare the parity main effect. For BW, WW, CE, WR, CWC and CSC, five preplanned non-orthogonal [(a) Indigenous breeds vs exotic breeds, (b) Sanga & Nguni vs Simmental & Santa Gertrudis, (c) Sanga & Nguni vs Afrikaner & Hereford, (d) Sanga & Nguni vs Afrikaner, and (e) Simmental vs Santa Gertrudis & Hereford, (table 2)] contrasts were used for the breed main effects. The Bonferroni *t* test was used for these multiple comparisons of means for the different breeds at birth, weaning, cow efficiency, WR, CWC and CSC (Kuehl, 2000).

TABLE 2

COEFFICIENTS OF CONTRASTS WRITTEN
FOR THE BREED MAIN EFFECT

CONTRASTS	COEFFICIENTS					
	Afrikaner (A)	Hereford (H)	Nguni (N)	Sanga (S)	Santa Gertrudis (SG)	Simmental (SIM)
1 Indig vs Exotic	0.333	-0.333	0.333	0.333	-0.333	-0.333
2. S & N vs SIM & SG	0	0	0.5	0.5	-0.5	-0.5
3. S & N vs A & H	-0.5	-0.5	0.5	0.5	0	0
4. S & N vs A	-1	0	0.5	0.5	0	0
5. SIM vs SG & H	0	-0.5	0	0	-0.5	1

RESULTS AND DISCUSSION

Birth Weight

There was a breed x sex x year of birth effect ($P < .001$) on birth weight (tables 3 and 4). Over all the years and for each breed, bull calves were usually heavier or weighed the same at birth as heifer calves (table 3). For both sexes and for all breeds, differences in birth weight during poor grazing conditions were less. The lightest birth weights for both sexes were recorded during the summer of 1987 (table 3), which corresponds with the lowest annual precipitation. Differences in birth weight between male and female calves were more pronounced in the summers of 1885 and 1988. The summers of 1985 and 1988 had the greatest precipitation, which could have contributed to the greater birth weights for bull calves. Among the heifer calves, heifer calves from the summer of 1986 had the greatest birth weight over all the years. Year of birth could have its effect through annual precipitation by influencing the quality and quantity of the pasture (Oni et al. 1988). The least total annual rainfall (351 mm) was in 1987/88, while 1985/86 had the greatest total annual rainfall (670 mm). If the mother is exposed to inadequate nutrition, fewer nutrients are available for transfer to the fetus across the placenta and birth weights are less (Ferrell, 1993). When calves are born in periods when forage is abundant, birth weight is increased because the mothers are exposed to better quality food (Sawyer et al., 1991). However, the year effect is random and difficult to explain.

The breed x year of birth effect on birth weight ($P < .0001$; table 4) was due to the magnitude of difference, not the direction of differences. Rankings of some of the breeds for birth weight changed across years (figure 1). In each of the four years, (a) calves from exotic breeds (Simmental, Hereford and Santa Gertrudis) were heavier ($P < .05$) at birth than the calves from breeds indigenous to Africa (Sanga, Nguni and Afrikaner), (b) calves from Sanga and Nguni breeds were lighter ($P < .05$) at birth than calves from large (Santa Gertrudis and Simmental) and medium (Afrikaner and Hereford) frame breeds, (c) Afrikaner calves were heavier ($P < .05$) at birth than the Sanga and Nguni calves, while the Simmental calves were heavier ($P < .05$) at birth than Santa Gertrudis and Hereford calves.

The differences between breeds agree with the study by Reynolds et al. (1990) who illustrated that high milk producing and larger sized bull breeds will produce offspring with greater birth weight. Sawyer et al. (1991) indicated that larger and heavier cow breeds would produce heavier calves than earlier developing British breeds. Notter et al. (1978) found that offspring from Simmental, Charolais and South Devon cross cows were heavier than those from Hereford-Angus cows. Cundiff et al (1998) indicated that offspring from Galloway bulls were heavier than Longhorn, but lighter than other breed such as the Hereford, Charolais, Angus etc. At birth, bull calves were heavier ($P < .0001$) than heifer calves (table 3). This agrees with Godley et al. 1966, Gregory et al. (1978 and 1979), Ahunu & Makarechian (1986), Reynolds et al. (1990), Fordyce et al. (1993).

Parity influenced birth weight of calves. Birth weight of calves from second parity cows was larger than calves from first parity cows ($P < .02$; table 5). Offspring from third parity or more cows were heavier at birth than the calves from both first and second parity cows ($P < .001$). This agrees with studies by Gregory et al. (1978), Swanepoel & Heyns (1988), Holland & Odde (1992), Ferrell (1993) and Kertz (1997).

TABLE 3

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF BIRTH WEIGHT FOR THE BREED X SEX X YEAR OF BIRTH (YS) INTERACTION, BREED AND SEX MAIN EFFECTS

		85s	86s	87s	88s	Breed Main Effect
Sanga	M	32.77 ± 1.09	31.16 ± 0.94	24.50 ± 1.70	32.91 ± 1.62	28.58 ± 0.53
	F	27.99 ± 1.10	30.06 ± 1.14	23.06 ± 1.66	26.19 ± 1.43	
Nguni	M	31.48 ± 1.10	30.99 ± 1.52	26.37 ± 2.10	33.29 ± 1.66	30.04 ± 0.60
	F	29.09 ± 1.06	30.14 ± 1.33	26.93 ± 1.55	32.04 ± 1.61	
Afrikaner	M	36.53 ± 1.35	35.98 ± 1.50	34.91 ± 1.48	38.40 ± 1.78	35.31 ± 0.54
	F	33.83 ± 1.46	34.23 ± 1.01	33.06 ± 1.39	35.52 ± 1.36	
Hereford	M	38.82 ± 1.24	38.86 ± 1.29	37.03 ± 2.07	38.38 ± 1.29	36.29 ± 0.63
	F	36.72 ± 1.51	37.58 ± 1.07	34.08 ± 1.86	28.86 ± 2.02	
Santa Gertrudis	M	40.10 ± 1.11	40.38 ± 1.47	29.09 ± 2.31	37.18 ± 1.41	35.39 ± 0.65
	F	34.11 ± 1.76	34.96 ± 1.13	32.68 ± 1.81	34.62 ± 1.78	
Simmental	M	45.93 ± 1.50	44.84 ± 1.63	50.38 ± 1.68	50.33 ± 1.90	45.34 ± 0.60
	F	40.24 ± 1.28	47.03 ± 1.32	42.45 ± 2.13	41.51 ± 1.47	
SEX MAIN EFFECT	M	36.69 ± 0.45				
	F	33.62 ± 0.43				

TABLE 4

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF BIRTH WEIGHT FOR THE SEX X YEAR OF BIRTH (YS) AND BREED X YEAR OF BIRTH (YS) INTERACTION

		85s	86s	87s	88s
BREED	Sanga	30.38 ± 0.77	30.61 ± 0.74	23.78 ± 1.19	29.55 ± 1.08
	Nguni	30.28 ± 0.76	30.56 ± 1.01	26.65 ± 1.30	32.67 ± 1.16
	Afrikaner	35.18 ± 0.99	35.11 ± 0.90	33.99 ± 1.02	36.96 ± 1.12
	Hereford	37.77 ± 0.98	38.22 ± 0.84	35.55 ± 1.39	33.62 ± 1.20
	Santa Gertrudis	37.11 ± 1.04	37.67 ± 0.93	30.89 ± 1.47	35.90 ± 1.13
	Simmental	43.08 ± 0.99	45.94 ± 1.05	46.41 ± 1.36	45.92 ± 1.20
SEX	M	37.61 ± 0.52	37.04 ± 0.64	33.71 ± 1.28	38.42 ± 1.11
	F	33.66 ± 0.62	35.67 ± 0.50	32.04 ± 1.14	33.13 ± 0.98

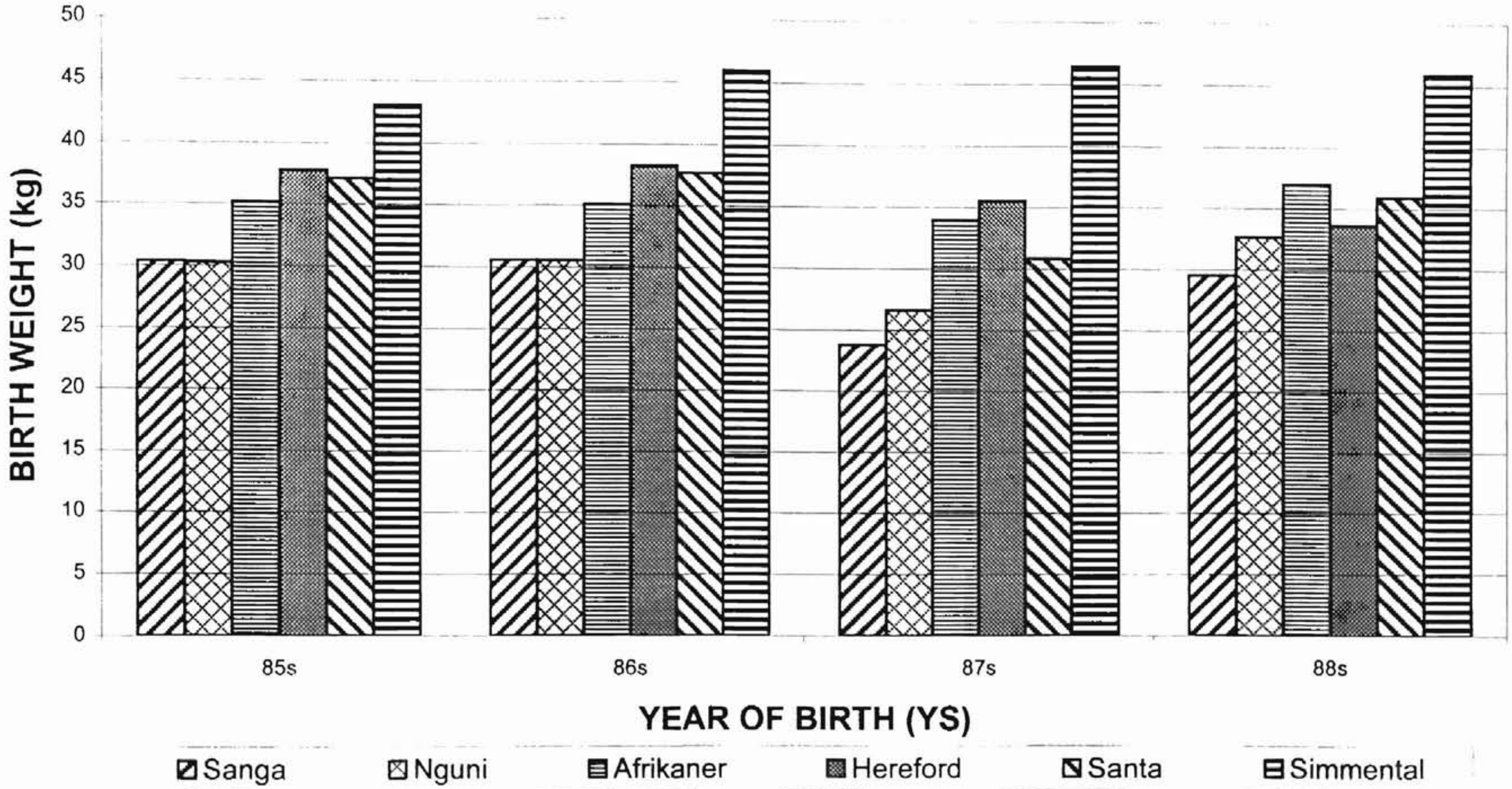
TABLE 5

ESTIMATE, STANDARD ERROR (SE), t-VALUE AND LEVEL OF SIGNIFICANCE (P) OF CONTRASTS FOR BIRTH WEIGHT FOR THE BREED AND PARITY MAIN EFFECTS

MAIN EFFECT	CONTRAST	ESTIMATE	SE	t-Value	Pr > |t|
BREED	Indig vs Exotic	-7.69	0.4490	-17.13	
	S & N vs SIM & SG	-11.05	0.5421	-20.39	
	S & N vs A & H	-6.49	0.5361	-12.11	
	S & N vs A	-5.99	0.6529	-9.19	
	SIM vs SG & H	9.50	0.7304	13.00	
	Bonferroni t *			2.58	< 0.05
				2.33	< 0.10
PARITY	1 vs 2	-2.10	0.8982	-2.34	0.0196
	1 & 2 vs ≥3	-1.74	0.5116	-3.41	0.0007

Indig = Indigenous, S = Sanga, N = Nguni, SIM = Simmental, SG = Santa Gertrudis, A = Afrikaner, H = Hereford
* = Bonferroni t is the critical value for the given probability

Figure 1.   Breed x Year of Birth (YS) Interaction for Birth Weight



50
45
40
35
30
25
20
15
10
5
0
BIRTH WEIGHT (kg)
85s
86s
87s
88s
YEAR OF BIRTH (YS)
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

Weaning weight

There was a breed x parity interaction ($P < .01$) for weaning weight (table 6). Rankings for some of the breeds for weaning weight changed across parities (figure 2). With respect to the preplanned contrasts, any breed x parity effect was due to the difference in magnitude, not in the sign of the contrast. In each of the three parity categories, (a) calves from exotic breeds (Simmental, Santa Gertrudis and Hereford) were heavier ($P < .05$) at weaning than the calves from breeds indigenous to Africa (Sanga, Nguni and Afrikaner), (b) calves from small frame breeds (Sanga and Nguni) were lighter ($P < .05$) at weaning than calves from large frame breeds (Simmental and Santa Gertrudis) and (c) Simmental calves were heavier ($P < .05$) at weaning than Santa Gertrudis and Hereford calves. At parity 2 and ≥3 categories, the calves from small frame breeds (Sanga and Nguni) were lighter ($P < .05$) at weaning than the calves from medium frame breeds (Afrikaner and Hereford). Calves from second and third or more parity Afrikaner cows were heavier ($P < .05$) at weaning than similar parity Sanga and Nguni calves. This agrees with Notter et al. (1978) who reported that for 2 or 3-year old dams, the progeny from smaller frame bull breeds were lighter at weaning than those from large sized breeds.

There was a breed x year of birth interaction ($P < .0001$) for weaning weight (table 6). Rankings of some of the breeds for weaning weights changed across years (figure 3). With respect to the preplanned contrasts, any breed x year of birth effect was due to the magnitude of difference, not the sign of contrasts. In each of the four years, (a) calves from indigenous breeds were lighter at weaning ($P < .05$) than calves from exotic breeds, (b) calves from small frame breeds (Sanga and Nguni) were lighter ($P < .05$) than those from large frame breeds (Simmental and Santa Gertrudis) and (c) Simmental calves were heavier ($P < .05$) at weaning than the Santa Gertrudis and

Hereford calves. In each of first three years (85s, 86s and 87s), calves from small frame breeds (Sanga and Nguni) were lighter ($P < .05$) at weaning than calves from medium frame breeds (Afrikaner and Hereford), and Afrikaner calves were heavier ($P < .05$) at weaning than Sanga and Nguni calves. In the fourth year (88s), calves from small frame breeds (Sanga and Nguni) did not differ in weaning weight ($P > .10$) from calves of medium frame breeds (Afrikaner and Hereford), and Afrikaner calves did not differ in weaning weight ($P > .10$) from Sanga and Nguni calves.

The weaning weights of calves from first parity cows were lighter ($P < .05$) than calves from second parity cows (table 8). The offspring from cows with three parities or more were heavier ($P < .05$) at weaning when compared to calves from both first and second parity cows (table 8). The findings in the present study agree with studies conducted by Peacock et al. (1960), Meade et al. (1963), Sewell et al. (1963), Gregory et al. (1978) and Oni & Buvanendran (1988). Weaning weight is a function of milk production and as the cow increases in age, so does the milk production (Sewell et al. 1963). Rutledge et al. (1971) reported that as the cow's weight increases, so does her milk production. This indicates that the older the cow becomes, the more milk she will produce and the greater the weaning weight of her calf. Therefore, cows with three or more parities produced heavier weaners.

Calves from breeds indigenous to Africa (Sanga, Nguni and Afrikaner) were lighter ($P < .05$; table 8) at weaning than calves from exotic breeds (Simmental, Santa Gertrudis and Hereford). Progeny from small frame breeds (Sanga and Nguni) were lighter ($P < .05$) at weaning than those originating from both medium (Afrikaner and Hereford) and large (Simmental and Santa Gertrudis) frame breeds (table 8). Afrikaner calves were heavier ($P < .05$) than Sanga and Nguni calves at weaning, while the Simmental calves were heavier ($P < .05$) than the Hereford and Santa Gertrudis calves at weaning (table 8). Overall, the large frame breeds (Simmental & Santa Gertrudis) were the heaviest at weaning, while the small frame breeds (Nguni and Sanga) were the lightest. The medium frame breeds (Afrikaner and Hereford) were intermediate for weaning weight (table 6). This agrees with some of the findings of Notter et al. (1978) and Cundiff et al. (1998).

Neville (1962) concluded that the quality of available food plays a role. When periods of poor quality feeding exist, weaning weights decrease. Poorer grazing conditions influenced the forage availability to the mother, which could have resulted in lighter birth weights, and consequently affected weaning weight. Sewell et al. (1963) and Godley et al. (1966) reported that birth weight is responsible for 5 to 8 % of the differences in weaning weight. The authors indicated that heavier birth weights resulted in heavier weaning weights. Nutritional environment also influences the performance of the calf to weaning. There was a tendency for greater weaning weight when calves were born in a period when forage was abundant. In the present study, the greatest precipitation was in 1985/86 (670 mm) (Appendix A). Milk production should have then been greater which in turn would have resulted in heavier weaning weight. Since weaning weight is partly a function of the mother's milk production ability, the heavier weaning weights obtained by the higher milk-producing breeds such as the Simmental could be explained. The opposite is true with the lower milk producers such as the Sanga and Nguni breeds. This agrees with Reynolds et al. (1990) who reported that calves with highest weaning weight originated from bull breeds that are medium and large in mature size with medium and high milk production levels, respectively.

There was a breed x sex interaction ($P < .05$) for weaning weight (table 6). Large frame Simmental and Santa Gertrudis bull calves were the heaviest at weaning, while the small frame Nguni and Sanga bull calves were the lightest. The medium frame Afrikaner and Hereford bull calves were intermediate for weaning weight. The heifer calves had the same pattern. There was a tendency for a sex x year of birth interaction

(P < .10; table 7). Across all years, the bull calves exceed the heifer calves in weaning weight. Bull and heifer calves born in the summer of 1987 were the heaviest at weaning, followed by those calves born in the summer of 1985. Bull calves born in the summer of 1988 were lighter than bull calves born in the summer of 1985, but heavier than those of born in the summer of 1986. The heifer calves born in the summer of 1986 were lighter at weaning than those born in the summer of 1988. If calves were exposed to a long dry rainy season before the following wet season commences, weaning weight tended to decrease (Fordyce et al., 1993).

TABLE 6

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF WEANING WEIGHT FOR THE BREED X PARITY, BREED X YEAR OF BIRTH (YS), BREED X SEX INTERACTIONS AND BREED MAIN EFFECT

		Sanga	Nguni	Afrikaner	Hereford	Santa Gertrudis	Simmental
Parity	1	170.25 ± 7.26	176.88 ± 8.08	190.59 ± 5.98	175.99 + 8.68	213.63 ± 7.26	239.86 ± 6.90
	2	166.69 ± 3.94	177.31 ± 3.97	194.92 ± 4.67	192.86 ± 6.70	233.36 ± 5.03	264.39 ± 5.16
	≥3	175.53 ± 2.49	175.87 ± 2.72	195.84 ± 2.77	208.57 ± 4.09	228.11 ± 3.04	254.25 ± 3.36
YS	85s	168.52 ± 4.05	169.63 ± 3.91	190.92 ± 5.07	207.61 ± 5.04	228.47 ± 4.98	261.05 ± 4.94
	86s	169.90 ± 3.93	180.64 ± 5.11	193.16 ± 4.36	181.64 ± 4.35	228.28 ± 4.67	232.27 ± 5.23
	87s	170.55 ± 6.04	181.85 ± 6.27	206.37 ± 5.15	189.64 ± 6.74	223.54 ± 7.26	267.74 ± 6.95
	88s	174.32 ± 5.94	174.62 ± 6.03	184.69 ± 5.45	191.01 ± 13.71	219.85 ± 5.87	250.28 ± 5.91
SEX	M	184.79 ± 3.37	185.50 ± 3.64	201.46 ± 3.59	200.23 ± 5.10	240.60 ± 3.97	261.36 ± 4.00
	F	156.85 ± 3.55	167.87 ± 3.60	186.11 ± 3.33	184.71 ± 5.55	209.47 ± 3.99	244.31 ± 3.84
BREED MAIN EFFECT		170.82 ± 2.82	176.68 ± 3.03	193.78 ± 2.67	192.48 ± 4.54	225.03 ± 3.12	252.83 ± 3.02

Figure 2. Breed x Parity Interaction for Weaning Weight

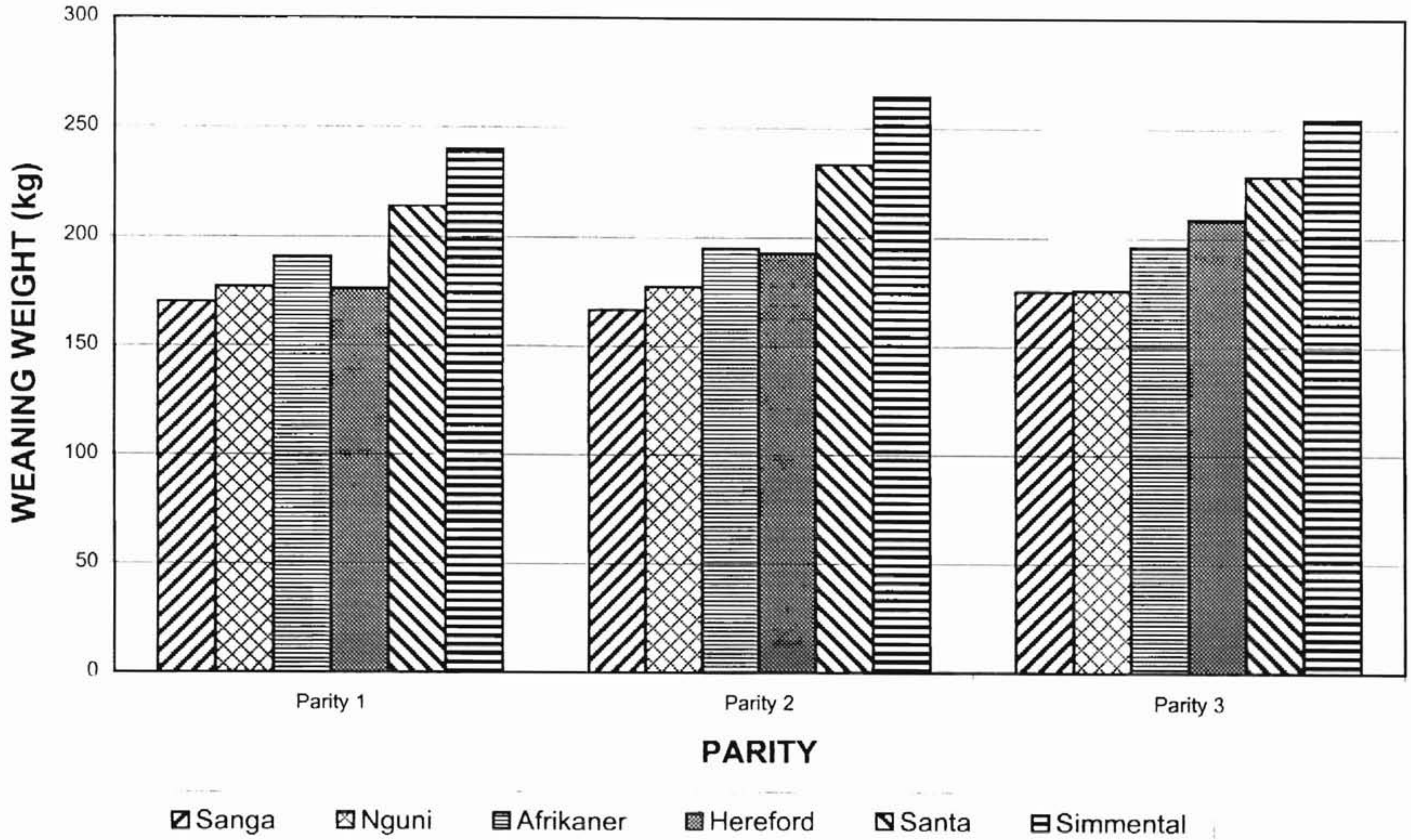

WEANING WEIGHT (kg)
300
250
200
150
100
50
0
Parity 1
Parity 2
Parity 3
PARITY
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

Figure 3. Breed x Year of Birth (YS) Interaction for Weaning Weight

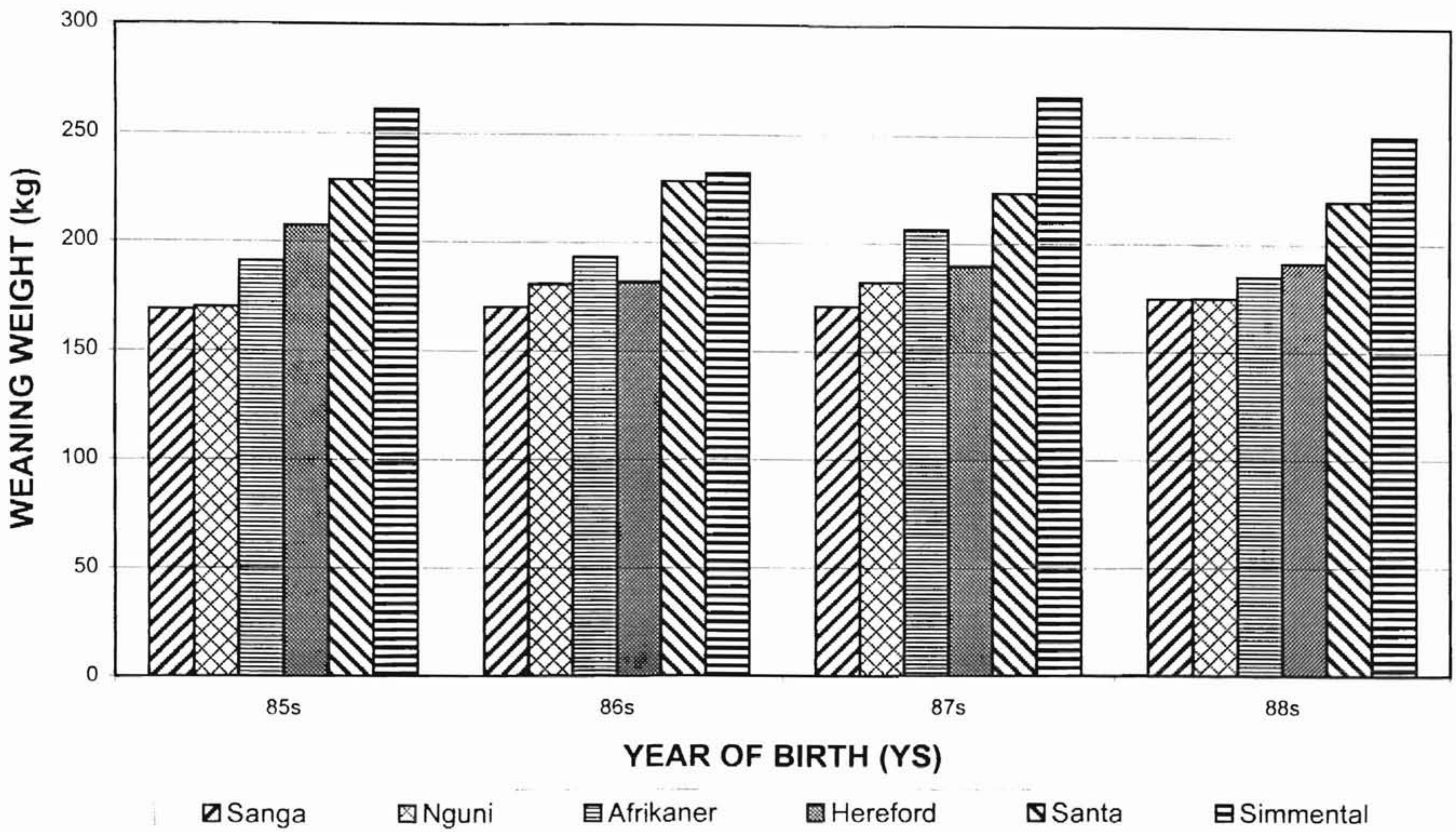

300
250
200
150
100
50
0
WEANING WEIGHT (kg)
85s
86s
87s
88s
YEAR OF BIRTH (YS)
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

TABLE 7

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF WEANING WEIGHT FOR THE SEX X YEAR OF BIRTH (YS) INTERACTION AND SEX MAIN EFFECT

	85s	86s	87s	88s	SEX MAIN EFFECT
M	214.03 ± 2.61	204.61 ± 2.87	217.41 ± 4.63	213.24 ± 4.81	212.32 ± 1.95
F	194.70 ± 2.89	190.69 ± 2.47	195.82 ± 4.42	185.02 ± 4.87	191.56 ± 1.93

TABLE 8

ESTIMATE, STANDARD ERROR (SE), t-VALUE AND LEVEL OF SIGNIFICANCE (P) OF CONTRASTS FOR WEANING WEIGHT FOR THE BREED AND PARITY MAIN EFFECTS

MAIN EFFECT	CONTRAST	ESTIMATE	SE	t-Value	Pr > |t|
BREED	Indig vs Exotic	-42.97	2.4576	-17.49	
	S & N vs SIM & SG	-65.18	2.7004	-24.14	
	S & N vs A & H	-19.38	3.1572	-6.14	
	S & N vs A	-20.03	3.2633	-6.14	
	SIM vs SG & H	44.08	3.9264	11.23	
	Bonferroni t *			2.58	< 0.05
				2.33	< 0.10
PARITY	1 vs 2	-10.39	4.6862	-2.22	0.0271
	1 & 2 vs ≥3	-6.63	2.6489	-2.50	0.0126

Indig = Indigenous, S = Sanga, N = Nguni, SIM = Simmental, SG = Santa Gertrudis, A = Afrikaner, H = Hereford
* = Bonferroni t is the critical value for the given probability.

Cow Efficiency

There was a tendency for a breed x sex x year of birth interaction (P < .10) for cow efficiency at weaning (tables 9 and 10). For each of the years and for all breeds, the cows with bull calves were more efficient at weaning than the cows with heifer calves (table 9). For each sex, breed of dam influenced the ranking of cows for cow efficiency. Breed rankings of cows with bull calves were: S, SG, N & SIM, A, H; and of cows with heifer calves were: SG, SIM & N, A, S, H. Dinkel et al. (1990 and 1992) reported a significant dam breed x sex interaction for cow efficiency. Bull calves from Simmental-Hereford cows were more efficient than calves from Angus-Hereford cows (Dinkel et al. 1990 and 1992). The author argued that breeds with greater milk production were able to supply the additional energy required by bull calves without the cows consuming more energy.

There was a breed x parity interaction ($P < .05$) for cow efficiency at weaning (table 10). Rankings for some breeds for cow efficiency at weaning changed across parities (figure 4). Across parity categories, (a) cows from breeds indigenous to Africa (Sanga, Nguni and Afrikaner) did not differ ($P > .10$) from cows of exotic origin (Simmental, Santa Gertrudis and Hereford) in efficiency at weaning, (b) Sanga and Nguni cows did not differ ($P > .10$) from the Simmental and Santa Gertrudis cows in efficiency at weaning, and (c) Simmental cows were not different ($P > .10$) from the Santa Gertrudis and Hereford cows in efficiency at weaning. At third or more parity category, the Sanga and Nguni cows were more efficient at weaning ($P < .05$) than the Afrikaner cows. At parity 1 and ≥ 3 categories, the Sanga and Nguni cows were more efficient at weaning ($P < .05$) than the Afrikaner and Hereford cows. Measuring cow efficiency in terms of calf weight to cow weight ratio favors the smaller cows (Dinkel and Brown, 1978). Dinkel et al. (1992) reported a significant effect of cow age on efficiency.

There was a breed x year of birth interaction ($P < .0004$) for cow efficiency at weaning (table 10). Rankings of some breeds for cow efficiency at weaning changed across years (figure 5). In each of the three years, (a) cows from indigenous breeds (Sanga, Nguni and Afrikaner) were not different ($P > .10$) from exotic breeds (Simmental, Santa Gertrudis and Hereford) for cow efficiency at weaning, and (b) small (Sanga and

Nguni) and large (Simmental and Santa Gertrudis) frame breeds were not different (P > .10) for cow efficiency at weaning. Sanga and Nguni cows were more efficient at weaning (P < .05) than the Afrikaner and Hereford cows in 86s, but the breeds did not differ in 85s and 87s (P > .10). Sanga and Nguni cows were more efficient at weaning (P < .05) than the Afrikaner cows in 86s, but not in years 85s and 87s (P > .10). Simmental cows were more efficient at weaning (P < .05) than the Santa Gertrudis and Hereford cows only in 87s.

First parity cows were not different (P > .10) in efficiency at weaning when compared with the second parity cows (table 11). Third or more parity cows were less efficient (P < .0001) at weaning than the first and second parity cows (table 11). Cows of breeds indigenous to Africa (Sanga, Nguni and Afrikaner) were not different (P > .10) in efficiency at weaning than cows from exotic origin (Simmental, Santa Gertrudis and Hereford). Large frame cows (Simmental and Santa Gertrudis) did not differ (P > .10) in efficiency at weaning when compared to the small frame cows (Sanga and Nguni). Medium frame cows (Afrikaner and Hereford) were less efficient at weaning (P < .05) than the small frame cows (Sanga and Nguni). Sanga and Nguni cows were not different (P > .10) than the Afrikaner cows in efficiency at weaning. The Simmental cows were not different (P > .10) from the Santa Gertrudis and Hereford cows in efficiency at weaning. This agrees with Dinkel and Brown (1978) who reported that when efficiency is expressed in terms of calf weaning weight to cow weight ratio, the smaller animals would be favored.

TABLE 9

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF COW EFFICIENCY AT WEANING FOR THE BREED X SEX X YEAR OF BIRTH INTERACTION

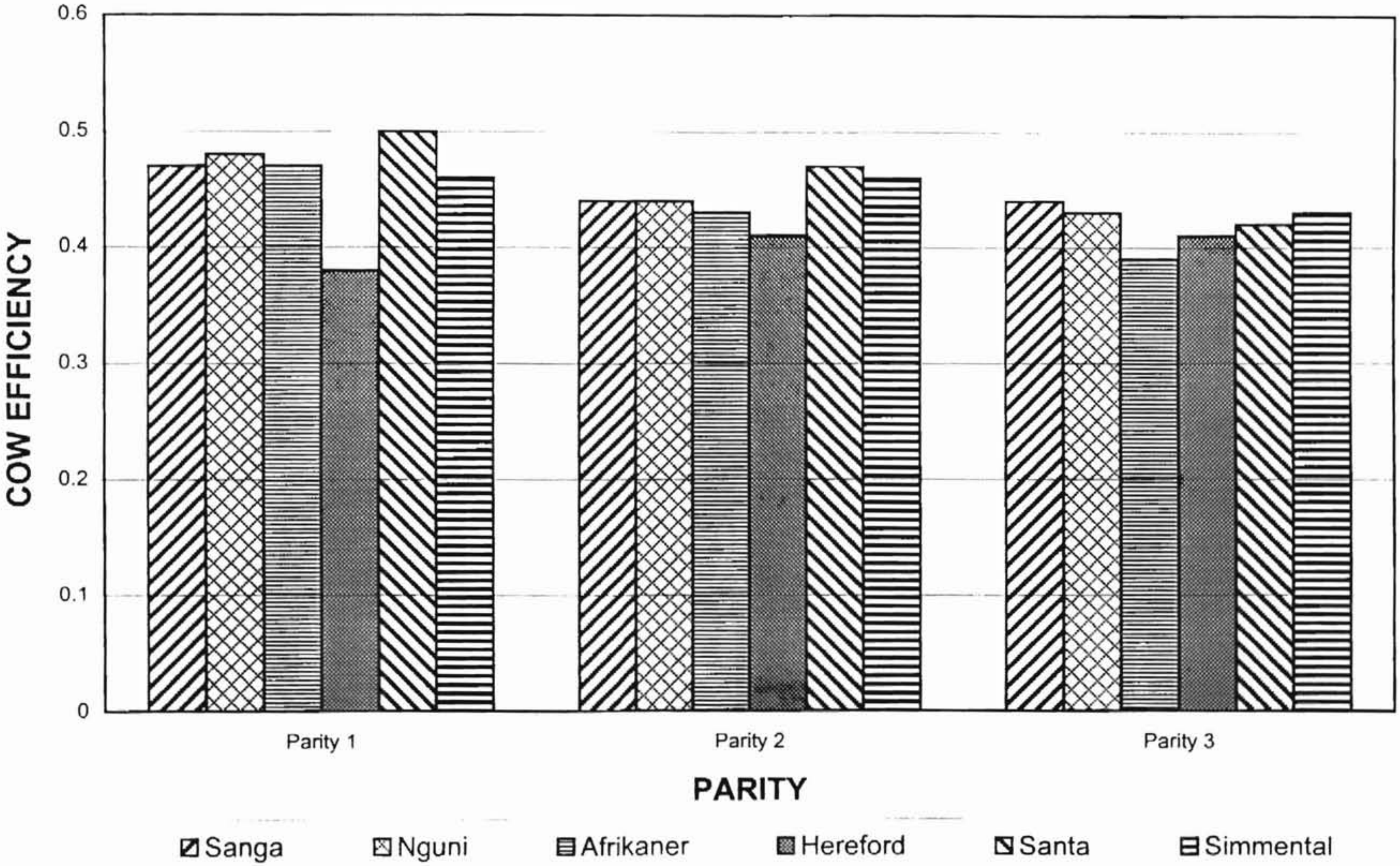
		85s	86s	87s
Sanga	M	0.50 ± 0.017	0.48 ± 0.013	0.49 ± 0.020
	F	0.37 ± 0.016	0.44 ± 0.017	0.42 ± 0.020
Nguni	M	0.42 ± 0.016	0.50 ± 0.019	0.48 ± 0.023
	F	0.42 ± 0.015	0.45 ± 0.017	0.44 ± 0.021
Afrikaner	M	0.43 ± 0.018	0.42 ± 0.020	0.48 ± 0.019
	F	0.40 ± 0.020	0.41 ± 0.014	0.44 ± 0.018
Hereford	M	0.44 ± 0.018	0.40 ± 0.018	0.42 ± 0.025
	F	0.40 + 0.021	0.37 ± 0.015	0.37 ± 0.024
Santa Gertrudis	M	0.46 ± 0.016	0.51 ± 0.022	0.48 ± 0.031
	F	0.46 ± 0.024	0.45 ± 0.016	0.44 ± 0.022
Simmental	M	0.46 ± 0.021	0.43 ± 0.021	0.51 ± 0.023
	F	0.40 ± 0.017	0.42 ± 0.018	0.48 ± 0.029

TABLE 10

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF COW EFFICIENCY AT WEANING FOR THE BREED X PARITY, BREED X YEAR OF BIRTH (YS) AND BREED X SEX INTERACTIONS

		Sanga	Nguni	Afrikaner	Hereford	Santa Gertrudis	Simmental
PARITY	1	0.47 ± 0.019	0.48 ± 0.021	0.47 ± 0.018	0.38 ± 0.023	0.50 ± 0.021	0.46 ± 0.020
	2	0.44 ± 0.013	0.44 ± 0.014	0.43 ± 0.014	0.41 ± 0.017	0.47 ± 0.019	0.46 ± 0.017
	≥3	0.44 ± 0.008	0.43 ± 0.009	0.39 ± 0.009	0.41 ± 0.009	0.42 ± 0.010	0.43 ± 0.011
YS	85s	0.43 ± 0.011	0.42 ± 0.011	0.42 ± 0.014	0.42 ± 0.014	0.46 ± 0.015	0.43 ± 0.014
	86s	0.46 ± 0.011	0.48 ± 0.014	0.42 ± 0.012	0.38 ± 0.012	0.48 ± 0.014	0.43 ± 0.015
	87s	0.45 ± 0.017	0.46 ± 0.018	0.46 ± 0.014	0.39 ± 0.019	0.46 ± 0.021	0.50 ± 0.020
SEX	M	0.49 ± 0.010	0.47 ± 0.012	0.44 ± 0.011	0.42 ± 0.013	0.48 ± 0.014	0.47 ± 0.013
	F	0.41 ± 0.011	0.44 ± 0.010	0.42 ± 0.011	0.38 ± 0.012	0.45 ± 0.013	0.44 ± 0.013

Figure 4. Breed x Parity Interaction for Cow Efficiency



0.6
0.5
0.4
0.3
0.2
0.1
0
COW EFFICIENCY
Parity 1
Parity 2
Parity 3
PARITY
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

Figure 5. Breed x Year of Birth (YS) Interaction for Cow Efficiency

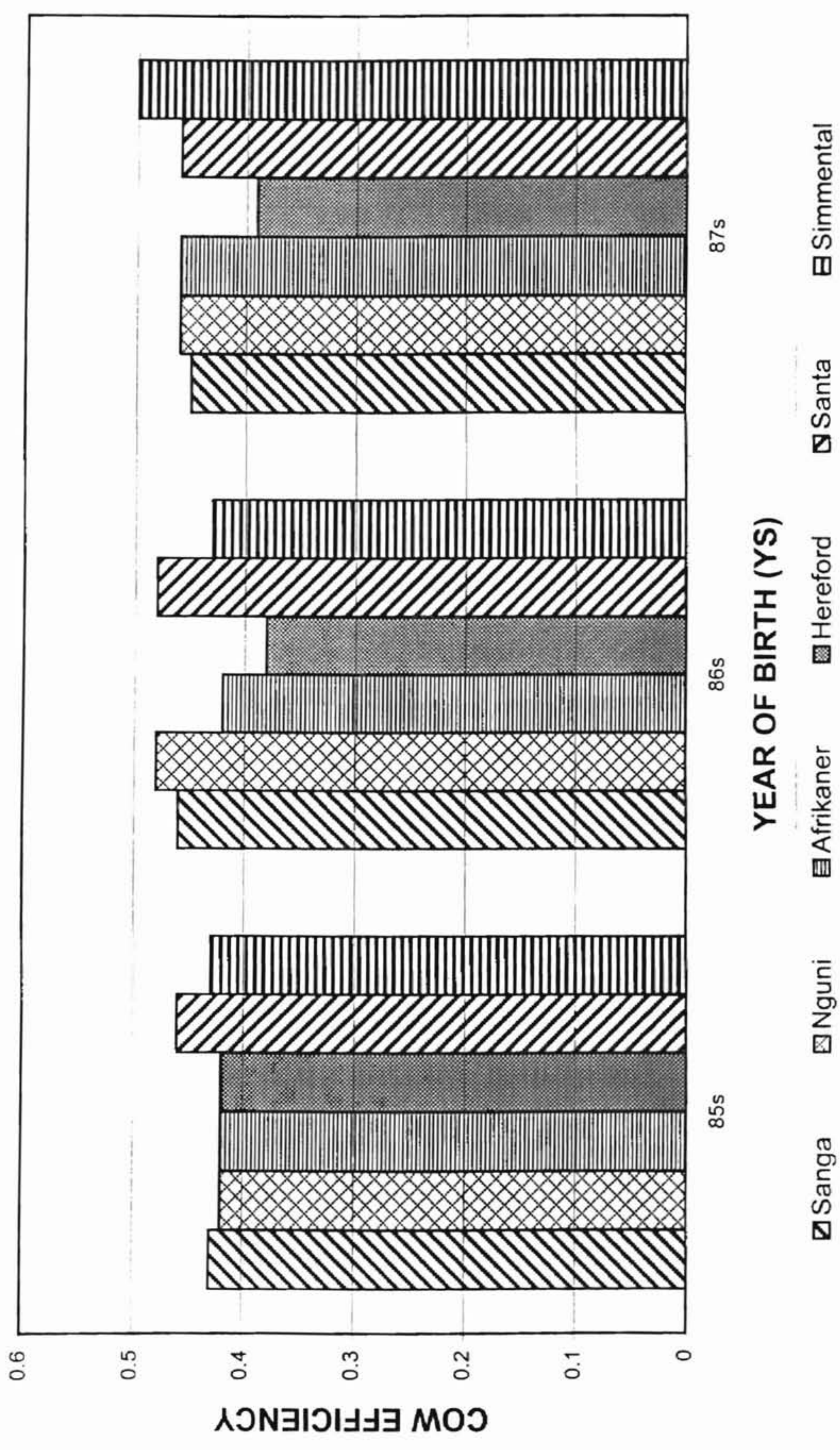

COW EFFICIENCY
0.6
0.5
0.4
0.3
0.2
0.1
0
85s
86s
87s
YEAR OF BIRTH (YS)
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

TABLE 11

ESTIMATE, STANDARD ERROR (SE), t-VALUE AND LEVEL OF SIGNIFICANCE (P) OF CONTRASTS FOR COW EFFICIENCY AT WEANING FOR THE BREED AND PARITY MAIN EFFECTS

MAIN EFFECT	CONTRAST	ESTIMATE	SE	t-Value	Pr > |t|
BREED	Indig vs Exotic	0.0056	0.0069	0.82	
	S & N vs SIM & SG	-0.0070	0.0085	-0.83	
	S & N vs A & H	0.0360	0.0080	4.53	
	S & N vs A	0.0206	0.0096	2.15	
	SIM vs SG & H	0.0193	0.0114	1.69	
	Bonferroni t *			2.58	< 0.05
				2.33	< 0.10
PARITY	1 vs 2	0.0181	0.0130	1.39	0.1653
	1 & 2 vs 3	0.0301	0.0077	3.92	0.0001

Indig =Indigenous, S = Sanga, N = Nguni, SIM = Simmental, SG = Santa Gertrudis, A = Afrikaner, H = Hereford
* = Bonferroni t is the critical value for the given probability

Reproduction

Calving percentage was calculated as the ratio of the number of cows exposed to the number of cows calved. Tables 12 represent the data for the average calving percentages.

TABLE 12

AVERAGE CALVING PERCENTAGES FOR EACH BREED FROM SUMMER 1985 UNTIL SUMMER 1988

BREED	AVERAGE CALVING PERCENTAGE
Sanga	92.05
Nguni	86.43
Afrikaner	80.85
Hereford	87.03
Santa Gertrudis	84.60
Simmental	80.13

In the present analysis reproduction was evaluated as calf crop weaned (WR). There was a tendency for a breed x parity interaction ($P < .10$) for WR (table 13). Rankings of some breeds changed for WR across parity categories (figure 6). Across all parities, (a) cows from indigenous breeds (Sanga, Nguni and Afrikaner) did not differ ($P > .10$) from cows of exotic origin (Simmental, Santa Gertrudis and Hereford) in WR, (b) Simmental and Santa Gertrudis cows did not differ ($P > .10$) from Sanga and Nguni cows in WR, (c) Simmental cows did not differ ($P > .10$) from Santa Gertrudis and Hereford cows in WR, (d) Afrikaner and Hereford cows did not differ ($P > .10$) from Sanga and Nguni cows in WR, and (e) Afrikaner cows did not differ ($P > .10$) from Sanga and Nguni cows in WR.

Cow weight at calving (CWC) and cow body condition at calving (CSC) were related to calf crop weaned (WR) the subsequent year. Regressions of WR on CWC or CSC were not significant ($P > .10$; table 14), but the relative magnitude of the estimated regressions was consistent with reports by Selk et al. (1988), Rae et al. (1993) and Spitzer et al. (1995) who indicated that cow body condition was the most suitable indicator of cow fertility.

Cows from exotic breeds had greater WR ($P < .05$; table14) than cows from indigenous breeds. Simmental and Santa Gertrudis cows did not differ ($P > .10$) from Sanga and Nguni cows in WR. Afrikaner and Hereford cows did not differ ($P > .10$) from Sanga and Nguni cows in WR. Afrikaner cows did not differ ($P > .10$) from Sanga and Nguni cows in WR, while Simmental cows were not different ($P > .10$) from Santa Gertrudis and Hereford cows in WR (table 14). There was a CWC x breed interaction ($P < .05$) for WR. The regression of WR on CWC was positive ($P < .05$) for Hereford, and negative ($P < .05$) for Sanga cows, but only approached significance for the Simmental breed ($P < .10$; table 15). For every unit increase in CWC, the WR of the Hereford breed increased by 0.12 %, while the Sanga breed decreased in WR by 0.13% with every unit increase in CWC. The Simmental breed increased in WR by 0.08% ($P < .10$) per unit increase in CWC.

TABLE 13

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF WR FOR THE BREED X PARITY INTERACTION

	PARITY 1	PARITY 2	PARITY ≥3
Sanga	1.00 ± 0.09	0.97 ± 0.05	0.83 ± 0.03
Nguni	0.48 ± 0.18	1.00 ± 0.05	0.98 ± 0.03
Afrikaner	1.00 ± 0.08	1.00 ± 0.06	0.96 ± 0.03
Hereford	0.69 ± 0.10	0.65 ± 0.06	0.68 ± 0.03
Santa Gertrudis	0.94 ± 0.10	0.92 ± 0.06	0.94 ± 0.04
Simmental	1.00 ± 0.12	0.87 ± 0.06	0.94 ± 0.04

Figure 6. Breed x Parity Interaction for Calf Crop Weaned

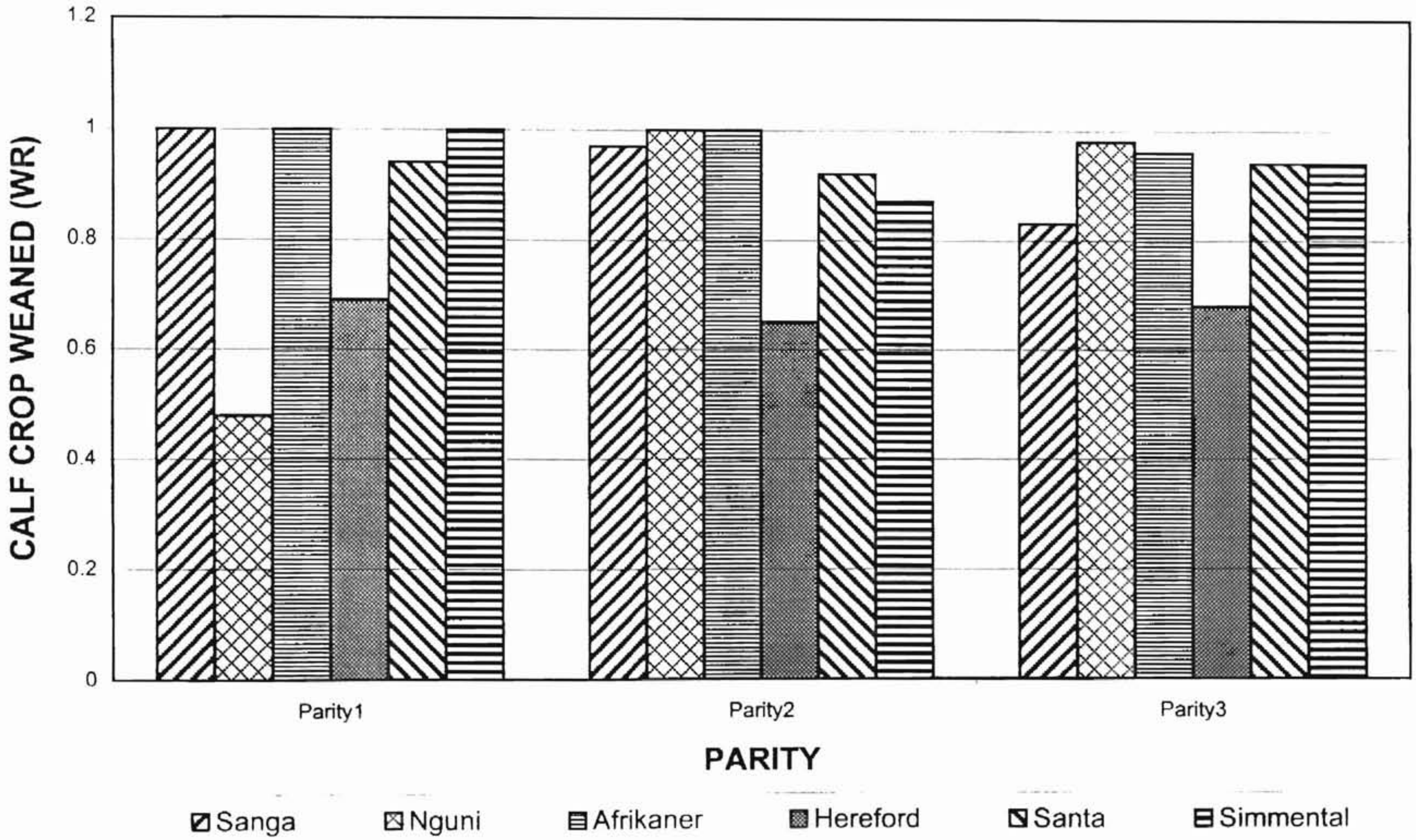

CALF CROP WEANED (WR)
1.2
1
0.8
0.6
0.4
0.2
0
Parity1
Parity2
Parity3
PARITY
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

TABLE 14

ESTIMATE, STANDARD ERROR (SE), t-VALUE AND LEVEL OF SIGNIFICANCE (P) OF CONTRASTS FOR CALF CROP WEANED (WR) FOR THE CWC WITHIN BREED EFFECT

MAIN EFFECT	PARAMETER	ESTIMATE	SE	t-Value	Pr > |t|
CWC (BREED)	Indig vs Exotic	-0.0012	0.0004	-2.89	
	S & N vs SIM & SG	-0.0010	0.0005	-1.89	
	S & N vs A & H	-0.0012	0.0005	-2.23	
	S & N vs A	-0.0004	0.0006	-0.71	
	SIM vs SG & H	0.0003	0.0005	0.64	
	Bonferroni t *			2.58	< 0.05
				2.33	< 0.10

Indig =Indigenous, S = Sanga, N = Nguni, SIM = Simmental, SG = Santa Gertrudis, A = Afrikaner, H = Hereford
* = Bonferroni t is the critical value for the given probability.

TABLE 15

CHARACTERISTIC, ESTIMATE, STANDARD ERRORS (SE), t-VALUE AND LEVEL OF SIGNIFICANCE (P) FOR REGRESSIONS OF CALF CROP WEANED (WR) ON COW WEIGHT AT CALVING (CWC), BODY CONDITION AT CALVING (CSC) AND CWC WITHIN BREED

CHARACTERISTIC	ESTIMATE ± SE	t - VALUE	Pr > |t|
CWC	0.00025 ± 0.0002	1.18	0.2397
CSC	0.04417 ± 0.0326	1.36	0.1765
CWC (Sanga)	-0.00133 ± 0.0006	-2.18	0.0299
CWC (Nguni)	-0.00016 ± 0.0007	-0.23	0.8184
CWC (Afrikaner)	-0.00030 ± 0.0005	-0.65	0.5178
CWC (Hereford)	0.00122 ± 0.0004	3.24	0.0013
CWC (Santa Gertrudis)	-0.00024 ± 0.0004	-0.62	0.5373
CWC (Simmental)	0.00081 ± 0.0004	1.82	0.0688

There was a breed x year of birth interaction ($P < .05$) for CWC. Rankings of some breeds changed for CWC across years (figure 7). With respect to the preplanned contrasts, any breed x year of birth effect was due to the magnitude of difference, not changes in the sign of the contrast. In each of the years, (a) cows from exotic breeds (Simmental, Santa Gertrudis and Hereford) were heavier at calving ($P < .05$) than the cows from breeds indigenous to Africa (Sanga, Nguni and Afrikaner), (b) Sanga and Nguni cows were lighter ($P < .05$) at calving than large (Simmental and Santa Gertrudis) and medium (Afrikaner and Hereford) frame cows, (c) Afrikaner cows were heavier at calving ($P < .05$) than Sanga and Nguni cows. Simmental cows were heavier ($P < .05$) than the Santa Gertrudis and Hereford cows in years 85s and 86s.

There was a tendency for a breed x parity interaction ($P < .10$; table 16) for CWC. Rankings of some breeds changed for CWC across parity categories (figure 8). With respect to preplanned contrasts, any breed x parity effect on CWC was due to the magnitude of difference, not to changes in the sign of the contrast. Across parity categories, (a) cows from breeds indigenous to Africa (Sanga, Nguni and Afrikaner) were lighter at calving ($P < .05$) than cows from exotic breeds (Simmental, Santa Gertrudis and Hereford), (b) Sanga and Nguni cows were lighter at calving ($P < .05$) than large (Simmental and Santa Gertrudis) and medium (Afrikaner and Hereford) frame cows, (c) Afrikaner cows were heavier at calving ($P < .05$) than the Sanga and Nguni cows, while the Simmental cows were heavier at calving ($P < .05$) than the Santa Gertrudis and Hereford cows.

Cows from exotic breeds (Simmental, Santa Gertrudis and Hereford) were heavier at calving ($P < .05$; table 18) than cows from breeds indigenous to Africa (Sanga, Nguni and Afrikaner). Small frame Sanga and Nguni cows were lighter at calving ($P < .05$) than the large frame Simmental and Santa Gertrudis cows (table 18). Medium frame Afrikaner and Hereford cows were heavier at calving ($P < .05$) than the small frame Sanga and Nguni cows. Sanga and Nguni cows were lighter at calving ($P < .05$) than the Afrikaner cows (table 18). Simmental cows were heavier at calving ($P < .05$)

than Santa Gertrudis and Hereford cows (table 18). Second parity cows were heavier at calving ($P < .05$) than first parity cows. Third parity or more cows had greater CWC ($P < .05$) than first and second parity cows.

Parity did not affect CSC ($P > .50$). Breed ($P < .0002$) and year of birth ($P < .0001$) influenced CSC. The Hereford cows had the greatest body condition at calving, followed by the Nguni, Santa Gertrudis, Sanga, Simmental and Afrikaner (table 17). During the summer of 1987, cows had the greatest CSC, while during the summer of 1985 cows had the least CSC (table 17). The cows in the summer of 1986 and summer of 1988 did not differ in CSC (table 17). The year 1987/88 had the lowest rainfall (351 mm) and 1985/86 had the greatest (670 mm). The years 1986/87 and 1988/89 had rainfall of 431 mm and 468 mm, respectively. Cows from breeds indigenous to Africa (Sanga, Nguni and Afrikaner) did not differ in CSC ($P > .10$; table 18) when compared to cows from exotic breeds (Simmental, Santa Gertrudis and Hereford). Cows from small frame breeds (Sanga and Nguni) were not different in CSC ($P > .10$) when compared to either large frame (Simmental and Santa Gertrudis) or medium frame (Afrikaner and Hereford) breeds (table 18). Small frame Sanga and Nguni cows tended ($P < .10$) to have greater CSC when compared to medium frame Afrikaner cows (table 18). The Santa Gertrudis and Hereford cows had a greater CSC ($P < .05$) than the Simmental cows (table 18).

Bellows & Short (1978) indicated that with a reduction in food supply, body weight and condition would decrease and affect the re-breeding ability of cows. The present study agrees with Bellows & Short (1978). There was a tendency for an increase in re-breeding ability with greater CSC, however, the regressions of CWC or CSC on WR were not significant. The results of this study are in agreement with those from Richards et al. (1986) and Richards et al. (1989) who concluded that reduced nutrient supply would affect the body condition and consequently reproduction of cows.

TABLE 16

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF COW WEIGHT AT CALVING (CWC) FOR THE BREED X PARITY, BREED X YEAR OF BIRTH (YS) INTERACTIONS AND BREED MAIN EFFECT

		Sanga	Nguni	Afrikaner	Hereford	Santa Gertrudis	Simmental
PARITY	1	376.23 ± 11.79	383.63 ± 13.28	439.01 ± 13.10	495.17 ± 13.65	480.23 ± 13.26	545.20 ± 13.67
	2	391.14 ± 10.09	397.68 ± 10.04	467.04 ± 10.54	502.55 ± 12.55	527.42 ± 13.14	576.14 ± 12.71
	≥3	417.97 ± 6.07	412.94 ± 7.05	514.72 ± 7.08	527.87 ± 6.96	576.93 ± 7.60	607.18 ± 8.47
YS	85s	399.73 ± 8.43	394.96 ± 8.34	456.53 ± 10.65	482.00 ± 10.25	506.65 ± 10.07	592.32 ± 10.45
	86s	392.17 ± 8.17	401.12 ± 9.82	484.60 ± 8.93	510.22 ± 9.02	536.51 ± 9.87	569.87 ± 10.51
	87s	393.45 ± 9.66	398.18 ± 11.00	479.65 ± 9.73	533.36 ± 11.82	541.40 ± 12.38	566.33 ± 13.10
BREED MAIN EFFECT		395.12 ± 5.48	398.08 ± 5.76	473.59 ± 6.05	508.53 ± 6.60	528.19 ± 6.67	576.17 ± 6.57

Figure 7. Breed x Year of Birth (YS) Interaction for Cow Weight at Calving

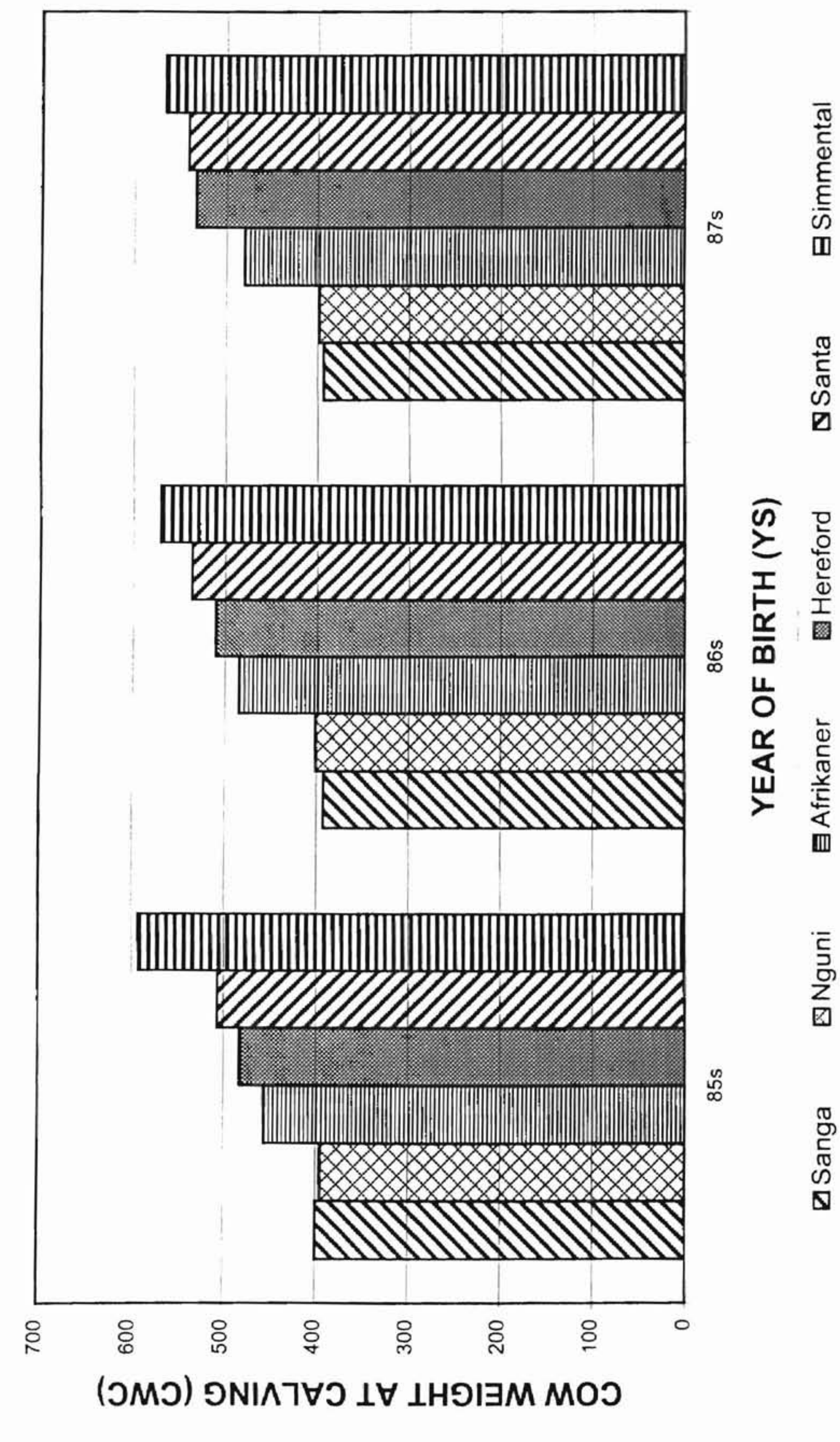

COW WEIGHT AT CALVING (CWC)
0
100
200
300
400
500
600
700
85s
86s
87s
YEAR OF BIRTH (YS)
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

Figure 8. Breed x Parity Interaction for Cow Weight at Calving

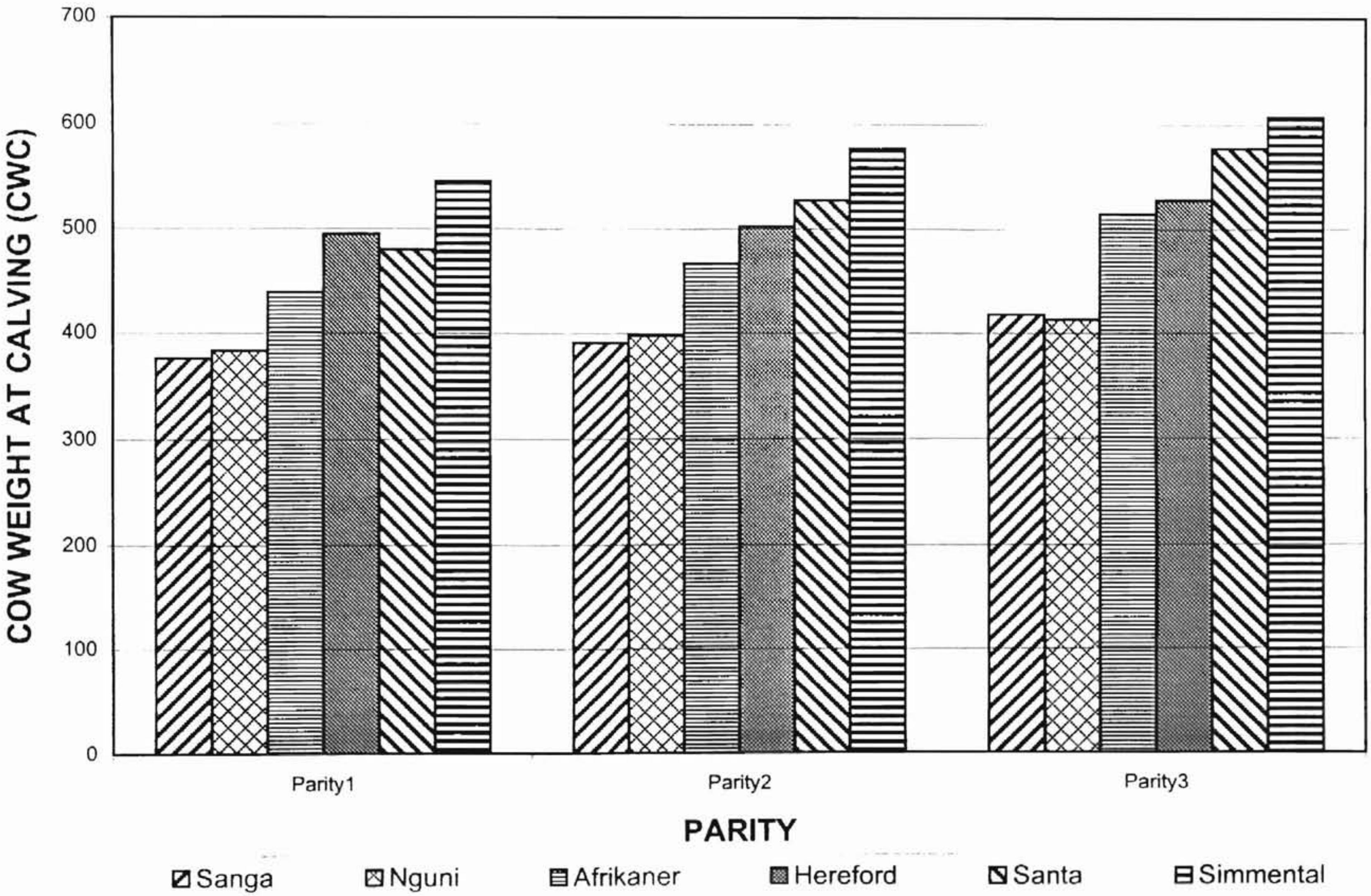

COW WEIGHT AT CALVING (CWC)
700
600
500
400
300
200
100
0
Parity1
Parity2
Parity3
PARITY
Sanga
Nguni
Afrikaner
Hereford
Santa
Simmental

TABLE 17

LEAST SQUARES MEANS (LSMEANS) AND STANDARD ERRORS (SE) OF BODY CONDITION AT CALVING (CSC) FOR BREED, PARITY AND YEAR OF BIRTH (YS) MAIN EFFECTS

		CSC
BREED	Sanga	3.18 ± 0.04
	Nguni	3.29 ± 0.04
	Afrikaner	3.11 ± 0.04
	Hereford	3.39 ± 0.05
	Santa Gertrudis	3.25 ± 0.05
	Simmental	3.13 ± 0.05
PARITY	1	3.19 ± 0.04
	2	3.23 ± 0.03
	≥3	3.25 ± 0.02
YS	85s	2.99 ± 0.03
	86s	3.27 ± 0.03
	87s	3.36 ± 0.04
	88s	3.27 ± 0.04

TABLE 18

ESTIMATE, STANDARD ERROR (SE), t-VALUE AND LEVEL OF SIGNIFICANCE (P) OF CONTRASTS FOR COW WEIGHT AT CALVING (CWC) AND AND BODY CONDITION AT CLAVING (CSC) FOR THE BREED AND PARITY MAIN EFFECTS

MAIN EFFECT	CONTRAST	ESTIMATE	SE	t-Value	Pr > |t|
	CWC:				
BREED	Indig vs Exotic	-115.25	5.0621	-22.77	
	S & N vs SIM & SG	-155.58	6.1411	-25.33	
	S & N vs A & H	-94.46	5.9885	-15.77	
	S & N vs A	-76.99	7.2418	-10.63	
	SIM vs SG & H	57.82	8.0731	7.16	
	Bonferroni t *			2.58	< 0.05
				2.33	< 0.10
PARITY	1 vs 2	-23.75	7.1586	-3.32	0.0010
	1 & 2 vs 3	-44.48	4.7436	-9.38	< 0 0001
	CSC:				
BREED	Indig vs Exotic	-0.06	0.0373	-1.70	
	S & N vs SIM & SG	0.05	0.0443	1.02	
	S & N vs A & H	-0.02	0.0441	-0.36	
	S & N vs A	0.12	0.0520	2.39	
	SIM vs SG & H	-0.19	0.0584	-3.21	
	Bonferroni t *			2.58	< 0.05
				2.33	< 0.10
PARITY	1 vs 2	-0.04	0.0534	-0.78	0.4341
	1 & 2 vs 3	-0.03	0.0344	-0.92	0.3577

Indig =Indigenous, S = Sanga, N = Nguni, SIM = Simmental, SG = Santa Gertrudis, A = Afrikaner, H = Hereford
* = Bonferroni t is the critical value for the given probability.

Under the dry and sparse rainfall conditions in Namibia, fodder production can be problematic. Maintenance costs of animals increase as the animals increase in size (Klosterman, 1972). The largest expense in a production system is feed costs

(Klosterman, 1972). Therefore, using the most suitable type of cattle would be beneficial to Namibia.

In the present study, smaller frame type of animals tended to be more efficient at weaning. Smaller type of cows produced more total weaning weight than the larger type of cows. This agrees with López de Torre et al. (1992) and Dinkel & Brown (1978). Selk et al. (1988) and Spitzer et al. (1995) stipulated that cows that are in better body condition at calving would be able to conceive and have shorter postpartum anestrous periods. Calving rate would be improved with greater body condition (Rae et al., 1993). In the present study, except for the Hereford, the small frame animals tended to have higher body condition scores at calving than the large frame types. Average calving percentages (table 12) agree with the study conducted by Buttram & Willham (1989). Small frame breeds (Sanga & Nguni) had higher calving rates than medium and large frame breeds. During years when pasture conditions were poor, cow body condition decreased. This agrees with Bellows & Short (1978) and Richards et al. (1986).

In the present study, the cattle were stocked on biomass (kg/ha). Equal numbers of hectares were distributed to each of the breeds. For that given amount of hectares, the small frame Sanga & Nguni animal numbers increased. The large frame Simmental and Santa Gertrudis had the lowest animal numbers. The maintenance cost is less with smaller animals; therefore a larger number of the small frame animals could be kept on a hectare. Due to higher fertility of the small frame breeds, more calves can be produced on an annual basis. Since smaller animals tended to be more efficient at weaning, and with more animals, more meat could be produced. Mezzadra et al. (1992) confirmed that under high stocking rates the large frame animals produce less meat per hectare and on an individual basis. The opposite was true when low stocking densities prevailed. The author indicated that under conditions when less forage is available, the small frame animals are more flexible due to their lower maintenance costs. Joandet (1969) and Molinueva (1969) observed similar results.

Most of the Sanga cattle are found in the northern regions of Namibia (Caprivi, Owamboland, Kavango and Damaraland). This region is also referred to as communal area. Production in these areas are low and can be attributed to several reasons such as lack of proper nutrition to animals due to overstocking and cultural traditions. Over the years, through natural selection, the most productive Sanga cattle survived. By realizing the unique favorable characteristics of the Sanga type of cattle, to improve the quality of their cattle herds instead of the quantity and to reduce overgrazing, communal farmers would be able to increase their animal production as well as their living standard. Commercial farmers that have the infrastructure to provide the best to their animals, could utilize the Sanga and Nguni breeds beneficially in their production systems, for example as maternal lines.

CHAPTER IV

SUMMARY AND CONCLUSION

Birth weight

When pasture conditions deteriorated (as indicated by the annual precipitation) a reduction in birth weight was apparent. In general, bull calves were heavier at birth than heifer calves. Across years, (a) the calves from exotic breeds had greater birth weights than the calves from breeds indigenous to Africa, (b) the Sanga and Nguni calves were lighter at birth than the calves from medium (Afrikaner and Hereford) and large (Simmental and Santa Gertrudis) frame breeds, (c) the Afrikaner calves were heavier at birth than the Sanga and Nguni calves, while the Simmental calves were heavier at birth than the Santa Gertrudis and Hereford calves.

Implication: The results from this study indicated that small frame animals would be less likely to experience dystocia because they produce calves with low birth weights. The Simmental and Hereford breeds produce heavy calves that could lead to dystocia and consequently to a lower calf crop weaned. Small frame animals tended to produce smaller calves, while the large and medium frame breeds produced heavier calves at birth. This lowered birth weight of calves from small frame animals could probably be a mechanism of the indigenous breeds to adapt to the harsh conditions and still produce a calf annually.

Weaning Weight

There was a breed x parity and breed x year of birth (YS) interaction for weaning weight. Across all parities and years: (a) the calves from indigenous breeds (Sanga, Nguni and Afrikaner) were lighter at weaning than calves from exotic breeds (Simmental, Santa Gertrudis and Hereford), (b) calves from small frame breeds (Sanga & Nguni) were lighter at weaning than calves from large frame breeds (Simmental and Santa Gertrudis), (c) Simmental calves were heavier at weaning than Santa Gertrudis and Hereford calves. At parities 2 and ≥3, Afrikaner calves were heavier at weaning than the Sanga and Nguni calves. Sanga and Nguni calves were lighter at weaning than the Afrikaner and Hereford calves in the second and third or more parity categories. In 85s, 86s and 87s, the calves from small frame breeds were lighter than the calves from medium frame breeds. Likewise, Afrikaner calves were heavier at weaning in 85s, 86s and 87s. Across years and for all breeds, the bull calves were heavier at weaning than to the heifer calves. Bull calves from large frame breeds were heavier at weaning than the bull calves from small frame breeds and bull calves from medium frame breeds were intermediate in weight. The same pattern applied to the heifers.

Implication: Male calves and calves from larger framed breeds were the heaviest at weaning, which in turn is indicative of greater productivity. Poor grazing conditions can influence the potential to produce heavier weaners.

Cow Efficiency

There was a breed x parity, breed x year of birth (YS) and breed x sex interaction for cow efficiency at weaning. Across years, cows producing bull calves were more efficient at weaning than cows producing heifer calves, i.e. cows producing bull calves produced more kg calf weaning weight per cow weight at weaning than cows that produce heifer calves. Across parities, (a) cows from indigenous breeds were not different from cows of exotic origin in efficiency at weaning, (b) Simmental cows were not different from the Santa Gertrudis and Hereford cows in efficiency at weaning, (c) Sanga and Nguni cows did not differ from the Simmental and Santa Gertrudis cows in efficiency at weaning. Third or more parity Afrikaner cows was less efficient at weaning than contemporary Sanga and Nguni cows. First and third or more parity, small frame cows were more efficient at weaning than contemporary medium frame cows. Cows from indigenous breeds were not different from cows of exotic origin in efficiency at weaning in any of the three years. Across years, Sanga and Nguni cows did not differ from the Simmental and Santa Gertrudis cows in efficiency at weaning. Sanga and Nguni cows were more efficient at weaning than the Afrikaner and Hereford cows in 86s, but not in 85s and 87s. Sanga and Nguni cows were more efficient than Afrikaner cows in 86s, while Simmental cows were more efficient than the Santa Gertrudis and Hereford cows in 87s.

Implication: These results indicate the small frame breeds produce more weaning weight per kg cow weight, even during years when annual precipitation decreased. When calving rate is considered, the small frame breeds produce greater total weaning weight than the larger and medium frame breeds. Cows with bull calves and younger cows produced more weaning weight per kg cow weight. Under harsh conditions, the small frame breeds would be able to produce more weaning weight per kg cow weight, while medium and larger frame breeds would have to maintain themselves first.

Reproduction

Calf crop weaned was defined as whether a cow weaned a calf when exposed to a bull the previous year. There was a breed x parity interaction for calf crop weaned. Across parities (a) cows from indigenous breeds did not differ in WR from the cows of exotic breeds, (b) Simmental and Santa Gertrudis cows did not differ from Sanga and Nguni cows in calf crop weaned, (c) Simmental cows did not differ from Santa Gertrudis and Hereford cows in calf crop weaned, (d) Afrikaner and Hereford cows did not differ from Sanga and Nguni cows in calf crop weaned, and (e) Afrikaner cows did not differ from Sanga and Nguni cows in calf crop weaned.

CSC did not significantly influenced WR. Regressions of WR on CWC within breed were significant for the Hereford and Sanga breeds, and approached significance for the Simmental breed. For every unit increase in CWC, the Hereford breed increased in calf crop weaned by 0.12 %, the Sanga breed decreased in calf crop weaned by 0.13%, while the Simmental breed tended to increase in calf crop weaned by 0.08 %. The regression of WR was greater for exotic breeds than for cows from indigenous breeds.

Across all the years, (a) the cows from exotic breeds (Simmental, Santa Gertrudis and Hereford) were heavier at calving than the cows from breeds indigenous to Africa (Sanga, Nguni and Afrikaner), (b) the Sanga and Nguni cows were lighter at calving than both medium (Afrikaner and Hereford) and large (Simmental and Santa Gertrudis) frame cows, while Afrikaner cows were heavier at calving than the Sanga and Nguni cows. In 85s and 86s, the Simmental cows were heavier at calving than the Santa Gertrudis and Hereford cows. Across parities, (a) indigenous cows were lighter than exotic cows at calving, (b) small frame cows (Sanga and Nguni) were lighter at calving than medium (Afrikaner and Hereford) and large (Simmental and Santa

Gertrudis) frame cows, (c) Afrikaner cows were heavier at calving than the Sanga and Nguni cows, while Simmental cows were heavier at calving than the Santa Gertrudis and Hereford cows.

First parity cows did not differ from second parity cows in CSC, while third or more parity cows did not differ from first and second parity cows in CSC. Cows from indigenous breeds did not differ from exotic breeds in CSC. Cows from small frame breeds (Sanga and Nguni) did not differ from either large (Simmental and Santa Gertrudis) or medium (Afrikaner and Hereford) frame breeds in CSC. Afrikaner cows tended to have lesser CSC than Sanga and Nguni cows. Santa Gertrudis and Hereford cows were greater in CSC than the Simmental cows. Cows had the least CSC in the summer of 1987, while the cows in the summer of 1985 had the greatest CSC. CSC in the summers 1986 and 1988 did not differ.

Implication: Exotic breeds, particularly the Hereford and Simmental, need to be at greater CWC to have greater WR, while Sanga and Nguni breeds will conceive even when having lesser CWC. If Sanga and Nguni cows become too fat (greater CWC), reproduction will be adversely affected. Greater CSC at calving tended to improve fertility.

Conclusion

Hereford cows were sensitive to changes in environmental conditions. Small frame type of cattle breeds are suitable for the Namibian environment, because of (a) fertility, (b) lower birth weights, because less dystocia would be experienced, (c) greater efficiency at weaning, i.e. more kg calf weaning weight per cow weight, even during low rainfall years, (d) more total weaning weight, because of higher fertility more calves could be weaned, (e) lower maintenance requirements and lowered feed-costs and, (f) less need for a high CWC to wean a calf the next year. Rainfall influenced the pasture availability and when rainfall decreased, pastured deteriorated. During poorer grazing conditions medium and large frame breeds tend to decrease in production and reproductive ability.

The ideal size of animals used depends on the production system used by the producer, the surroundings to which the animal is exposed, the place of production as well as the trends of the industry for that particular species (Dickerson, 1978; Andersen, 1978). Using animals that are well adapted to their environment would be beneficial, because maximum production can be obtained.

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APPENDIX

APPENDIX A: Precipitation (mm) at Omatjenne Research Station (Von Wielligh, 1999).

Year	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Total
83/84	9	23	73	45	102	54	50	356
84/85	31	37	11	149	234	56	4	522
85/86	74	39	18	49	173	315	2	670
86/87	44	6	61	8	215	52	45	431
87/88	51	14	27	176	35	0	48	351
88/89	26	36	100	87	96	24	99	468
89/90	0	0	4	128	84	100	31	347
Mean	33.6	22.1	42	91.7	134.1	85.9	39.9	449.3

APPENDIX B: Composition of Omatjenne Winterlick (Von Wielligh, 1999).

NUTRIENTS:	**MIN**	**MAX**	**%**
Metabolic Energy KJ/kg	1.5	2.5	2.49
Protein	33.0	42.0	37.98
Calcium	4.0	6.0	5.60
Phosphate	2.0	3.3	3.28
Urea		14.0	11.94
RAW MATERIALS:	**MIN**	**MAX**	**Kg**
Molasses Meal	50.25		50
Germ-Meal			120
Di-Calcium Phosphate			200
Salt	321.25	450.25	450
Sunflower Oil Cake Meal	50.25	70.35	65
Urea			120

APPENDIX C: Description of Body Condition Scores of cows.

SCORE	CONDITION	DESCRIPTION
5	Very fat	Fat pods at tail head, brisket and ribs. Walks uncomfortable.
4	Fat	Well muscled with good fat distribution over body.
3	Average	Well muscled with fat accumulation on some areas on the body.
2	Thin	Muscled, but ribs and hipbones starts to show.
1	Very thin	Emaciated. Little muscling. Ribs and hipbones are very prominent

VITA 2

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