FACTORS AFFECTING WEIGH-SUCKLE-WEIGH MILK YIELD ESTIMATES AND CALF PERFORMANCE OF ZEBU CATTLE

BY

Alice Adhiambo Ngesa
B.Sc. Agriculture (UNIVERSITY OF NAIROBI) 1978.

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR A MASTER OF SCIENCE DEGREE IN ANIMAL PRODUCTION IN THE COLLEGE OF AGRICULTURE AND VETERINARY SCIENCES, UNIVERSITY OF NAIROBI.

1988.

D E C L A R A T I O N

This thesis is my original work and has not been presented for a degree in any other university

A. A. NGESA

This thesis has been submitted for examination with our approval as University supervisors.

Dr. S. Itulya

Dr. J.E.O. Rege

D E D I C A T I O N

Dedicated to Mwayi, Abiero and Ngesa.

Table of Contents Page

LIST OF TABLES

LIST OF FIGURES

PA

APPENDICES PAGE

ACKNOWLEDGEMENTS

The completion of this work was made possible by all those who helped me directly or indirectly in this work. I am awfully indebted to NORAD who sponsored this work especially Dr. Ola Syrstad and Ingerbjorg Stofring who were of great encouragement throughout the period. Special thanks go to the Board of Postgraduate Studies of the University of Nairobi for gracefully extending my study period until I finished the work. The quality of work and its successful completion is due to the effort and willingness of my supervisors, Dr. Susan Itulya and Dr. Ed. Rege, besides Dr. Lusweti who started me off. I am awfully grateful to them all. I am also grateful to the Ministry of Livestock Development for allowing me to use the data at Naivasha National Animal Husbandry Research Station and to the staff in the station who co-operated with me in the work.

Typing and the neat finish of this work was done by Patrick Mwaura and Charles Wendo Ouko with the permission of Dr. S. Chema, the Chief Veterinary Research Officer, Vet.Labs., Kabete. I am proud of my husband Mwayi and my little boys Abiero and Ngesa, together with my housegirl, Peninah, for being so patient with me and for the sacrifice they made over the long period. Finally I am grateful to God who made all things possible for me.

ABSTRACT

One hundred and twenty (120) Sahiwal cows suckling
Sahiwal calves or Friesian x Sahiwal calves and 180 Boran
suckling Boran calves or Friesian x Boran calves were used
suckling study. Milk yield and calf weight data were obtai
Weigh-Suckle-Weigh (WSW) method once per week for 36 weeks
1969 through 1972. Both milk yield/intake and calf perfo
(average daily gain and weaning weight) were analysed by a
Squares Computer Programme (Rege, 1986) for the effect of
breed, calf sex, season and year of birth on milk yield/
and growth traits of the calves. The effect of milk produ
of the dam and of rearing method on growth performance o
calves were also analysed by the same method. For compariso
handfed Sahiwal calves reared in the same year and 300 handm
Sahiwal cows were used in growth performance and milk
estimates, respectively.

Total milk yield estimates (1272.35 kg) and calf growt
per day and weaning weight (0.66 kg and 187 kg respectivel
determined by the WSW method showed that Sahiwal and Boran
were quite similar in their milk production therefore
grouped together. Their Friesian cross calves also per
similarly in growth rate but Friesian x Sahiwal (FS) calves
slightly superior to Friesian x Boran (FB) calves in we
weight. Both groups of crossbred calves were 18% heavier
their respective straightbred counterparts in average daily

Coefficient of variation obtained by WSW method for
yield determination was quite similar to that obtaine
handmilking (23.75% and 21.84% , respectively) indi

comparable accuracy in determining milk yield by the two methods. Correlation between monthly milk yield and monthly weight gains were highest in the second to fifth months (r=0.53) indicating that monthly tests in the first 5 months would be adequate to assess milk production of the cows and growth performance of suckling calves. Peak milk production by WSW coincided with peak rate of weight gain (in the second month) supporting the use of WSW method for determination of both traits.

The effect of calf breed, calf sex, season, year, initial weight of calf, weaning age and milk yield of the dam were highly significant for growth traits of the calf while age of dam was not significant. Milk yield of dam was also significantly influenced by calf breed, season, year and initial weight of the calf but not by age of dam and sex of calf.

1. INTRODUCTION

The production of beef from dairy cattle has been a practice in developed countries for many years. Mason (1963) estimated that about 70% of beef steers bred in Britain are out of dairy cows. Besides, Willham (1972) suggested that increased milk production in beef herds may be advantageous for efficiency of production since the cow can utilise low quality forage that the calf cannot utilise. A dual purpose animal whose performance in milk production and beef traits is satisfactory is, therefore, the ideal animal especially in arid and semi-arid areas of Kenya where pure exotic *(Bos taurus)* dairy or beef breeds cannot thrive. To obtain this type of animal from a population of predominantly low milk producing individuals, the farmer needs to identify high milk producing animals and decide what he can do further to improve them. The tools he has for improving his animals include selection and various breeding methods. The use of these tools require accumulated records of performance of many animals from which a choice of better animals can be made.

The use of the Weigh-Suckle-Weigh (WSW) method for determining milk yield of beef cows and assessing calf performance is very appropriate in acquiring information for both milk production and growth performance. The method involves weighing the calf immediately before and after suckling and taking the difference in the two weights to represent the amount of milk produced by the cow. The weight of the calf before suckling makes the record of calf performance in a given period. The application of this method has been recommended for selection of milking cows whose calves would equally well qualify for beef traits with few or no penalties (Neville, 1962). It has also been used in dairy cattle as an alternative method of calf rearing (Veitia and Simon, 1972; Ugarte, 1977). Other workers (Lampkin and Lampkin, 1960; Ronningen et al., 1972) have used the method as an alternative way of overcoming the milk let down problem associated with beef breeds of *Bos indicus* origin. In most studies where the method is used, the objective is usually to establish the relationship between milk production of the cow and growth performance of the calf (Drewry et al, 1959; Neville, 1962; Notter et al, 1978; Niedhardt et al, 1979; Williams et al, 1979; Randel, 1981).

Although there are limitations to WSW method such as difficulty in weighing heavy calves (Lampkin and Lampkin, 1960; Le Du et al, 1978) or inability of the calf to finish milk in early lactation (Schwulst et al., 1966; Le Du et al., 1978) or losses due to urination and defecation between the two weighings (Niedhardt et al., 1979), it has been proved to be reasonably accurate. Totusek et al. (1973) and Niedhardt et al. (1979) found estimates of milk yield by this method to be higher than in handmilking and highly correlated to estimates obtained by handmilking.

The objectives of this study, therefore, were:-

1. To determine the factors influencing the WSW estimates of milk yield and calf growth traits.
2. To determine the relationship between milk production of the dam and growth performance of the calf.

3. To determine the correlations between estimates taken at monthly intervals with each other and with the final estimates of milk yield and calf growth rate.

2. LITERATURE REVIEW

2.1 Methods of Determining Milk Yield in Beef Cattle

Milk production level for a particular breed of cattle may be reported differently by different researchers from different environments using different milk determination methods. Dawson et al. (1960) noted that if the differences in milk production figures obtained by several authors are partly due to the methods of estimation used, then further work is needed on estimating the milk production of beef cows. Chenette and Frahm (1981) warned that when comparing milk trait estimates from various studies to evaluate breeds, one should exercise caution because differences in technique can influence estimates of milk production. Variations in estimates caused by different milking techniques are due to the accuracy with which the method estimates the production and the extent to which milk is removed from the cow. The main reasons for a wide variation in milk yield estimates reported for Zebu cows, is milk let down problem, which in turn depends on the milking technique used. Various methods that have been used to determine milk production in beef cows are discussed below along with their relative advantages and disadvantages.

2.1.1 Handmilking - (Complete Milkout)

This is the most common method for *Bos indicus* cows in the tropics. Where these breeds have been treated as dairy cattle, handmilking method has been used quite successfully on Sahiwals in India (Acharya and Nagpal, 1971), Sahiwals in Kenya (Kimenye, 1978) and on Northern Sudan Zebu (Osman and El Amin 1971).

Where Zebu or their crosses are used as beef breeds, handmilking has been handicapped by the failure of the cows to eject milk without stimulation by the calf or to continue lactating when the calf dies or is removed.

This milk let down problem makes milk recording for Zebu beef breeds difficult because if a calf is used to stimulate milk let down then the amount of milk consumed by the calf cannot be accounted for (Ngere et al, 1973) or if the calf dies, lactation ceases thus shortening lactation length (Hayman, 1972; Ngere et al, 1973). Handmilking with calf at foot has been tried, to overcome milk letdown problem. This method, as described by Ngere et al (1973) involves the calf suckling one quarter at each milking until it is 4 or 5 months old, then later the calf is used only to stimulate milk letdown. Amble et al., (1965) found that complete milk out (without calf) underestimates total yield from milking and suckling by about 18% while Mahadevan, (1966) found that arbitrary calf consumption allowance resulted in overestimation of the actual yield under handmilking.

2.1.2 Weigh-Suckle-Weigh (WSW) Method

The WSW method involves separating the dam from the calf for a given time interval then weighing the calf immediately before and after suckling. The difference in the two weights is recorded as the milk consumed by the calf, hence the milk produced by the dam within the given time interval.

There are variations and modifications of this method depending on the objectives of the researcher. Workers interested in the effect of milking or suckling interval on milk yield of the dam or milk consumption by the calf have used intervals ranging from 4 - 16 hours (Drewry et al, 1959; Dawson et al, 1960; Le Du et al, 1978; Williams et al, 1979; Chennette and Frahm, 1981). Other workers investigating the effect of restricted suckling on the performance of the calf, milk production of the dam, and on fertility of the dam have varied the duration of suckling, for example, 15-20 minutes (Veitia and Simon, 1972; Ugarte, 1977), or free suckling limited to once per day instead of twice per day (Veitia and Simon, 1972; Randel, 1981),or alternated milking and suckling (Le Du et al, 1978; Niedhardt et al, 1979)

When the objective of the experiment is to determine the accuracy of the method, various factors that influence the accuracy have been corrected for in the experiment. These include losses due to urination and/or defecation (Niedhardt et al., 1979; Somerville and Lowman, 1980), incidence of rain falling during sucking period, year, sire of calf, age of calf, birth weight of calf, cow weight loss from calving to each test day, length of test period, mean maximum temperatures, total rainfall during 14 days preceeding test day, number of tests made in the lactation and their intervals (Lampkin and Lampkin, 1960; Neville, 1962; Totusek et al.,1973; Niedhardt et al.,1979; Bowden, 1980). The number of tests ranged from daily measurements for 150 days (Somerville and Lowman, 1980) to only 3 tests at various intervals (Bowden, 1980).

Another variation in WSW method is whether it is followed by stripping or not. Some workers (Drewry et al., 1959; Niedhardt et al., 1979; Chenette and Frahm, 1981) have used the method

followed by hand stripping while others (Schwulst et al., 19
Ugarte, 1977; Le Du et al., 1978) have used machine strippi
Another choice one has in the method, is whether the dams and
calves are given supplementary feed or not. Most experime
done on *Bos taurus* beef cows have been with supplementary feed
of the cows and calves (Neville, 1962; Totusek et al., 19
Niedhardt et al., 1978; Williams et al., 1979; Chenette
Frahm, 1981). On The other hand, Lampkin and Lampkin (196
working with Borans, did not supplement the calves and cows.

2.1.2.1 <u>Advantages</u> of the WSW Method

(a) <u>Dual</u> Purpose

Compared with other methods, WSW method suits beef cows b
because it is capable of measuring both milk yield and gro
traits of the calf in one operation. This is both convenient
inexpensive. From the two measurements, the efficiency
conversion can be calculated. Drewry et al. (1959) gave
following formula for Conversion Efficiency (C.E)

$$CE = \frac{\text{Days of suckling x daily milk yield}}{\text{Total gain by calf}}$$

(b) Overcomes Milk Let Down Problem

The Zebu cow requires stimulation by the calf to eject mi
(Hayman, 1972; Ngere et al., 1973). The use of WSW method avo
this problem, and has proved more efficient at removing resid
milk due to more effective and repeated stimulation by the c
as described by Mahadevan (1966). Other methods estimate o
the milk produced by the initial stimulation of milk let do

Anthony et al., (1959) measured milk secretion rate of beef cows using machine milking and oxytocin induction and found that most cows were milked out in 15 minutes. Unless oxytocin injection is repeated every 5 minutes, machine milking may not equal WSW method in total milk produced.

(c) WSW is More Precise

By using WSW method, the error caused by arbitrary calf allowance when calf suckling and handmilking are used can be eliminated. Where this method was used in comparison with handmilking, the estimates obtained were 29% higher than estimates obtained by handmilking (Totusek et al., 1973; Niedhardt et al., 1979). The higher estimate and high correlation between WSW estimates and handmilking estimates (r = 0.95) led Totusek et al. (1973) to conclude that the method provided a more precise estimate of actual milk yield. Niedhardt et al. (1979) reported a correlation coefficient of 0.47 with stripping between the two methods.

(d) Better Calf Rearing Method

Whether the calves are suckled fully or restricted, the resulting calf performance has been better than handfed calves. Marples (1962) studying the Ankole, Nganda and Zebu calves found that calves raised on whole milk up to 12 weeks, then on skim milk up to 20-22 weeks had a daily average gain of 0.43 kg (males) and 0.38 kg (females) while suckled Borans were reported to have gained 0.54 - 0.62 kg per day (Lampkin and Lampkin, 1960; Ronningen et al., 1972). The main problem with artificial calf rearing is that there is an initial slower gain (in the first two and a half months) which is due to adjustment to the new method (Mudgal and Ray, 1965). The advantage of faster growth and lower mortality rate in calves reared under restricted suckling was reported by Ugarte (1977) while using the WSW method to estimate milk consumed by the calf. He estimated that the amount of milk consumed by the calf corresponded to or was slightly lower than the amount used in artificial calf rearing. Randel (1981) reported higher rates of weight gain by suckled calves with no bad effect on fertility of the dam. Veitia and Simon (1972) reported faster growth under restricted suckling without reducing the amount of sellable milk.

2.1.2.2 Factors Affecting Accuracy of WSW Method

(a) Difficulty in Weighing the Calves:

Lampkin and Lampkin (1960) observed that some calves reached 227 kg before the suckling period of 36 weeks was over. They found the handling and weighing of these large calves cumbersome. Le Du et al. (1978), reported the same problem. Since one can wean early after tests have been taken at strategic points in the lactation, it is possible this problem may not remain valid. The use of a weigh bridge also can alleviate the problem.

(b) Variations in Milk Consumption by the Calf

Le Du et al. (1978) reported large within-animal variations in milk consumption by the calf. He overcame this problem by inclusion of additional measurements of calf weight change so that there were 3 consecutive controlled sucklings. Totusek et al. (1973), on the other hand, found that WSW estimates were less variable than handmilking estimates at every stage of lactation. The large within-animal variation in milk production had also been reported for handmilked Sahiwals in Kenya (Lindstrom, 1975). Hayman (1972) also reported a high within-herd variation in milk yield of *Bos indicus* in Australia indicating that the variation may not be due to WSW method as such.

(c) Residual Milk in Early Lactation

Error in estimation of total cow production due to the amount of residual milk present in early lactation, if only milk consumption by calf is used, has been reported by Schwulst et al. (1966). Further investigations on this problem have revealed that it only occurs in early lactation and only in high milk producing animals. Neville (1962) noted that some calves were able to consume 8.2-10.0 kg of milk in early lactation, which is the equivalent of daily production of moderate milk producers. Dawson et al. (1960) and Somerville and Lowman (1980), working independently, found that the limitation in the calf capacity was only in the first one month of lactation. Niedhardt et al. (1979) observed that some notable amounts of residual milk were extracted by hand stripping only when calves were 3-10 days old. Many workers have avoided this problem by taking test measurements after one month (Drewry et al., 1959; Dawson et al., 1960; Somerville and Lowman, 1980; Randel, 1981). This is quite reasonable because it includes the likely peak period for most cows. The same authors have indicated that peak production occurs 1-2 months after calving.

The extent to which milk is removed from the udder has been studied by several workers using different milking methods. Ugarte and Preston (1973) reported a 30% increase in total milk production when suckling after milking was allowed. They attributed this increase to the removal of residual milk by the calf. Le Du et al. (1978) comparing secretion rate, using machine milking and milk consumption by the calf estimated by WSW method, found that residual milk effects may cause a 3.6% overestimation of milk yield by machine milking.

(d) Urination and Defecation

Underestimation by 0.224 kg of milk yield per-day caused by urination and defecation was reported by Niedhardt et al. (1979). The losses due to urination and defecation are not usually considered because the occurrence is not frequent. Lampkin and Lampkin (1960) noted that if calves are given adequate time before suckling they usually urinate and defecate before being weighed. Somerville and Lowman (1980) observed that defecation and urination occurred in 8% of suckling during the first week of lactation but very rarely thereafter. These observations suggest that the losses due to urination and defecation can be avoided by starting the tests at least after two weeks.

(e) Disturbance to Cows and Calves

Totusek et al. (1973) suggested that disturbance caused by WSW method to the cows and calves relative to their normal grazing and behaviour patterns may bias the milk yield estimates downwards. All milking methods cause some kind of disturbance to the animals, therefore, this may not be unique to WSW method. However, some of the disturbance can be removed by the choice of optimum frequency of suckling per day and the optimum number of tests required throughout the suckling period. Besides, the preliminary period is supposed to accustom the animals to the procedure of the experiment so that disturbance will not be unique to the test day.

2.1.2.3 Effect of WSW on Fertility of the Dam

That suckled dams take longer time to come to first estrus after calving has been reported by several workers (Wiltbank and Cook, 1958; Biswal and Rao, 1960; Lampkin and Lampkin, 1960). On the other hand, Thorpe et al. (1980) found breed differences in the effect of lactation on fertility. They found that lactating dams tended to be more fertile than dry dams in Angoni and Boran breeds when liveweights are adequate, while lactating Sanga dams were less fertile. The three breeds were all suckled without milking.

The fertility problem associated with suckling in particular and lactation in general is due to inadequate nutrition and long lactations or late weaning (after 180 days of age) as usually found in beef cows (Veitia and Simon, 1972). The same authors suggested that a relatively high nutritional level after calving together with a reduction of weaning age would reduce the days between calving and first estrus. The other alternative to early weaning is the restricted suckling. Randel (1981), studying the effect of once-daily suckling on post partum interval, found that all once-daily suckled heifers returned to estrus before weaning while only 50% of heifers suckled twice per day returned to estrus before weaning.

2.1.3 Hormonally Induced Lactations

This is the most common approach to determining milk yield of beef cows in developed countries because milk let down without calf is a problem even among *Bos taurus* breeds which are not used to milking. In most experiments where milk yield of beef cows has been determined by machine milking or handmilking without calf, different hormones have been used. The most commonly used ones are discussed below.

2.1.3.1 Oxytocin

Oxytocin is the most commonly used hormone for induction of lactation. Schwulst et al. (1966) used oxytocin in suckled dams to find out if calves suckle more milk when the oxytocin is administered to the dams before suckling. The results showed that oxytocin did not have significant effect on milk consumption and total milk produced. This may emphasise the fact that suckling is quite exhaustive in removing milk from the dam, although suckling was followed by machine stripping in this study. It also shows that suckling is adequate as a stimulus for milk letdown.

Swanson and Claycomb (1969) used oxytocin in dry cows to initiate lactation with the result that it caused significant lowering of yield in the next lactation. Hayman (1972), also using oxytocin, failed, however, to restore lactation in cows that dried off following calf removal. Other workers who used oxytocin prior to handmilking or machine milking include Le Du et al. (1978) Niedhardt et al. (1979) and Bowden (1980). In all these studies 20-40 I.U of oxytocin was injected intravenously immediately before the test. A synthetic oxytocin (Syntocin) was used by Chenette and Frahm (1981) in a similar study.

2.1.3.2 <u>Prolactin</u>

Prolactin is not widely used because it causes a lot of pain to the cows. This was reported by Hayman (1972) who used prolactin after he failed to restore lactation using oxytocin in suckled dams whose calves were removed. He succeeded with prolactin and concluded that lactation pattern such as that exhibited by Red Sindhi x Jersey and Sahiwal x Jersey crosses was influenced by hormones affecting secretion of milk rather than milk ejection.

2.1.3.3 <u>Progesterone and Estrogen</u>

This combination was used on foster dams, with and without calf contact to find out if calf contact increased the degree of stimulation (Bel Isle and Swanson, 1978). The results showed that hormone treatment with calf contact gave faster response than hormone treatment alone. (Milk secretion occurred after 8.9±1.1 and 10.1±2.0 days, respectively for the two treatments). Lactation continued and reached a peak at 56 days from first secretion.

2.1.4 <u>Machine Milking</u>

This is the most commonly used method in dairy cattle in developed countries. In beef cattle it is used together with hormonal induction as described above. Beef cows whose calves are weaned immediately after birth have been milked successfully without hormonal induction but the production is limited by shortened lactations (Somerville and Lowman, 1980).

Machine milking on its own cannot be successful with *Bos indicus* cows which have a milk let down problem without the calf. Used together with hormonal induction, machine milking would be limited by the unequal size of the teats of some *Bos indicus* breeds like the Red Sindhi and the Sahiwal. Mason (1965) reported disastrous effects of machine milking on Sahiwals in Kenya.

Compared with other methods, machine milking has proved to be more effective in removing milk than handmilking and has been used to determine secretion rates (Le Du et al., 1978) as a method of predicting milk production potential of cattle. Other methods used in determining milk yield of beef cows include the use of taped calf call on dairy cows to increase stimulation (Pollock and Hurnick, 1978) and teat cannulation following injection of oxytocin (Bowden, 1980). Among all the methods mentioned above, only WSW method comes close to the natural way of removing milk from beef cows that are normally not milked.

2.2 Factors Affecting Milk Yield Estimates of Zebu Cattle

2.2.1 Milk Let Down

Bos indicus breeds of cattle have a maternal instinct that hinders milk let down or ejection in absence of the calf. This poor temperament is expressed even in a highly improved Israeli Friesian which was built up by continuous backcrossing of local cows, mainly Damascus cows to Friesian bulls (Rendel, 1972). Hayman (1972) confirmed this tendency in Red Sindhi x Jersey and Sahiwal x Jersey crosses in Australia. This maternal instinct also leads to cessation of lactation on removal or loss of calf (Hayman, 1972; Ngere et al, 1973). Hayman (1972) describes it as a wild essential character in an environment in which large predators were common. It is essential in that should a cow lose her calf to a predator, she is not encumbered by a heavy udder which can hinder fast escape from predators. *Bos taurus* cattle have lost this trait through selection.

Mahadevan (1966) has described the suckling process in two phases. The first phase involves vigorous massaging of the udder by the calf resulting in the release of oxytocin from the maternal neurohypophysis. The second phase involves a rapid rise in pressure inside the udder releasing milk which is quickly consumed by the calf. Consequently the pressure drops and the calf repeats the vigorous massaging and the cycle is repeated. Where methods other than suckling are used, the repeated stimulation of the udder is not done, therefore there is the possibility of leaving some milk in the udder. Where milk yield determination is not the interest, the residual milk can always be removed by the calf as usually done in traditional milking method (handmilking with calf at foot).

2.2.2 Season

Season has a significant effect on milk production where it affects pastures and consequently the nutrition of the cow. Osman (1970) noted that season was important where suckling was involved and pasture was used. This may suggest that suckling demands more milk production and therefore leads to higher nutritional requirement, making season effect magnified. Kiwuwa (1974) found a negligible seasonal effect on milk yield of Friesians but quite a large effect in Jersey cows in Kenya suggesting a difference in breed tolerance or sensivity to seasonal variation. This lack of seasonal variation among Friesians may be due to supplementation and other feeding regimes. He also found that the season in which Friesians gave the poorest milk yield was the best for Jerseys in terms of yields implying that there may be a breed by season interaction.

Season also seems to affect different lactations differently. Nagpal and Acharya (1971) found that season was not significant for all lactations except second lactation and average production. Johanson (1961) from his studies suggests that it is preferable to restrict comparisons to individuals calving in the same season since the magnitude of influence of season on lactation vary from herd to herd and from year to year.

2.2.3 Year

Year has variable effect on milk yield. Nagpal and Acharya (1971) found that year had the largest variance component due to annual rainfall variations. Kiwuwa (1974) found that year was not significant for milk production of Friesians and Jerseys in Kenya except one particular year that was known to be a drought year. Kimenye (1978) found significant effect of year on milk yield of Sahiwals in Kenya. In suckled dams, year was not significant for milk yield but was significant for growth rate of calves (Reynolds et al., 1978; Williams et al., 1979). Dawson et al. (1960) found significant year variation only when calves were weaned at 252 days and not at 245 days.

2.2.4 Age of Dam

Generally, the capacity of milk yield increases at a decreasing rate until body maturity is reached, and thereafter it decreases at an increasing rate with advancing age (Johanson, 1961). This author also states that investigations tend to show that the relationship between condition of the cow at calving and the milk yield in the following lactation is curvilinear. This implies that there is an optimum calving weight at which the cow's milk production reaches peak, then above that weight, milk yield remains steady or goes down. Since body capacity increases with age until maturity is reached, the effect of age of dam may actually reflect the effect of weight at calving.

Zebu cattle reach their peak yield in the third lactation (Galukande et al, 1962). Osman and El Amin (1971) observed that 305 days yield increased at different rates to a maximum in the 5th lactation when the cow is about 8.3 years old. The effect of age of dam on milk production varies with other environmental conditions. In suckling dams, Williams et al. (1979) found significant effect of age of dam on all production traits of calves. On the other hand, Nagpal and Acharya (1971) found small but significant effect in Sahiwals but non-significant effect in Hariana cattle.

2.2.5 Sex of Calf

This is not important for milk production since in most cases calves are not involved in the milking method. It may be important in suckled dams whose milk production can only be estimated by the WSW method. In experiments where WSW method is used, calves are usually grouped according to sex to avoid differences in growth rate (Lampkin and Lampkin, 1960; Randel, 1981). Williams et al. (1979) found that sex of calf had no significant effect on milk yield.

2.2.6 Length of Recording Period

This depends on lactation length and the type of records required as discussed below.

2.2.6.1 Lactation Length

Bos indicus breeds are characterised by short lactations. Galukande et al. (1962) found a correlation coefficient of 0.68-0.81 between lactation length and milk yield of East African Zebu. They found that lactation length accounted for 53-66% of the total variation in milk yield. Lactation length varies among different *Bos indicus* breeds as reported below: 239 days for East African Zebu and 283 days for for Sahiwals, (Galukande et al; 1962) 274 days for Kenyan Sahiwals, (Kimenye, 1978) and 294 days for Kenana and Butana in Northern Sudan (Osman and El Amin,1971)

While Mason (1965) suggested that short lactations were major in controlling herd average yield in grade Sahiwals in Kenya, Mahadevan, (1966) pointed out that short lactations resulting in drastically reduced calving interval might have advantages since the most profitable milk production is obtained in early lactation. Naidu and Desai (1965) studying lactation length in relation to milk production concluded that it should not be used as a parameter for selection since long lactations increase calving interval with little advantage in milk yield.

Generally, Sahiwals have mean lactation lengths of 10 months while other Zebu types like White Fulani in Nigeria, Small East African Zebu in Kenya and Sinhala in Ceylon average about 8 months or less with a few extremes of over 10 months, e.g., Red Sindhi (Mahadevan, 1966). He reported that even among improved Zebu, 60% still end their lactation before 300 days. Generally, suckled dams have longer lactation than milked ones. Amble et al, (1965) observed that suckled Tharparkar cows had an average of 311 days while milked ones had a mean of 279 days in lactation.

2.2.6.2 <u>Types of Records</u>

There are different types of milk records depending on the duration of the recording period. These include actual yield record, estimated yield record, yearly records, total lactation records and amputated lactation records.

Actual yield records are obtained when daily milk yields are recorded for 301 days starting from 5 days after calving (Lindstrom, 1975) or until lactation ceases (Ngere et al., 1973; Somerville and Lowman, 1980). The disadvantage cited by Lindstrom (1975) was that it had a large standard deviation which gave a coefficient of variation as high as 40%, about twice as large as generally obtained in Europe. Johanson (1961), on the other hand, recommended that actual yield of a cow is the manifestation of her genotype under a given set of enivironmental conditions. Ngere et al. (1973) observed that deleting short lactation records leads to a serious bias especially where environmental disturbances could be a factor influencing the estimated value of cows.

Estimated yield records are obtained by calculation from the totals of sample days. The sample days or test days are distributed over a given period of the lactation. Lindstrom (1975), used 7th, 14th, 28th and 56th day after calving as the test days. Other workers have used different test periods like 85, 135 and 180 days (McGinty and Frerichs, 1971), and 70, 112, 140 and 210 days, (Totusek et al., 1973).

Yearly records are obtained by adjusting other types of records to 365 days while Total lactation records use the international standard of 305 days yield (Johanson, 1961). In his discussion of the accuracy of various records, Johanson (1961) showed that the variance for Yearly records and Total lactation records was only 3.5% and 4.5% of the total respectively while it was 9.5% and 25% for 300 days and 200 days records, respectively. He attributed the difference in variance to the differences in persistency of yield during the lactations.

Amputated lactation records refer to records of the first given number of days in lactation, for example the first 150, 180 or 200 days after calving. This type of record has the advantage of not being influenced by the length of current lactation. Johanson (1961) discussing the accuracy of amputated lactation records recommended that when part-records are used, age corrections become increasingly important with decreasing length of the part-time lactation (due to difference in persistency). He also concluded that selection for higher milk yield would have about the same efficiency when based on records for the first 200 days of lactation as when based on 305 days when sampling is done daily. When sampling is done every third week the error of measurement increases and the value of short-time records decreases. The acceptability of part-lactation yields was indicated also in the findings of Van Vleck and Henderson, (1961) and Reynolds et al. (1978) that there is relatively large correlations between part-lactation yields for 3 or more months and complete lactation yields. Mahadevan (1966) states that when cows with less than say 870 kg per lactation or cows with less than a certain number of days in lactation are excluded in the records, the value of such records is genetically questionable unless accompanied by the contemporary herd average. Most types of individual records are at least able to identify low producers from high producers and are adequate for that purpose but for more efficient selection of genetically superior animals, more records of relatives of individuals are needed, (Syrstad, 1966). This author also observed that the low heritability estimates of milk production indicate that selection based on the records of an individual animal is not efficient. Progeny testing is, therefore, recommendable and the records of collateral relatives would add to the efficiency. This suggests that whatever type of record used in selection of individual cows should be supplemented with records of relatives.

2.2.7 Sampling Procedure

In any experiment, sampling procedure is the most important part because many types of errors arise from it. In a study of accuracy of lactation records, Dickinson and McDaniel (1969) stated that the goal of any sampling procedure is to minimise both bias and random variation and yet still be practical and economical to operate. In milk production records, sampling procedure includes milking technique, frequency of milking or suckling per day, days in lactation at first sampling, sampling intervals and number of sample days throughout the lactation period.

2.2.7.1 Frequency of Milking or Suckling

Frequency of suckling has been of greater concern than frequency of milking as indicated by the extent to which it has been studied. Dickinson and McDaniel (1969), investigating random variation in milk records, showed that once per day (only morning or only afternoon) milking procedure had much greater errors than twice per day milking (morning and afternoon milking).

In suckling experiments the ideal frequency would be one that is closest to the natural suckling frequency. Drewry et al. (1959) studied the suckling habit of calves and observed that duration of suckling increased up to about 6 weeks then declined and the frequency of suckling per day was 4.5 times in the first month, 4.8 times in the third and 3 times daily in the 6th month. This suggests that suckling experiments should start with the higher frequency in early lactation. They, therefore, suggested a normal separation time of about 4.5 hours during the day and 10 hours at night. Several workers, (Dawson et al., 1960; Hayman, 1972; Williams et al, 1979; Channette and Frahm, 1981), have tried out some separation intervals and found that 4 hours separation interval (about 3 times suckling per day) gives the highest milk yield. The above authors also noted that 16 hours separation was not suitable during the first 2 months, and recommended 8 hours interval for its moderate yields and convenience. Williams et al. (1979) found a measurement error of 1.4 kg for 24 hour yields for 4 hours interval compared with 0.7 kg and 0.3 kg for 8 hours and 16 hours, respectively.

2.2.7.2 Date of First Test

Dickinson and McDaniel (1969), in their study of accuracy of milk records, noted that the number of days in lactation at first test had effect on accuracy of lactation records and suggested six weeks after calving to be the first test. This is in agreement with the observation made by Drewry et al. (1959) that duration of suckling increases up to about six weeks then declines. Six weeks also coincides with the peak period for most breeds as mentioned earlier, and is convenient for suckling calves because there is no problem of residual milk.

2.2.7.3 Interval and Frequency of Testing

Studying the day-to-day variation in milk yield of dairy cows, Syrstad (1977) concluded that the magnitude of the daily variation determines to a large extent the frequency of recording required to achieve a satisfactory accuracy of lactation records. Dickinson and McDaniel (1969) had observed that the longer the test interval the greater the random error in estimating lactation milk yield. Totusek et al. (1973), studying the effect of sampling interval in a WSW experiment, observed that estimates made at weekly or monthly intervals throughout the 210 days lactation were highly correlated with 210 days yield (r = .99 and .94 respectively) and that the correlations were lower when the weekly or monthly estimates terminated at 112 days or 70 days. From the results, they suggested that a limited number (2 - 4) of correctly timed, carefully obtained daily estimates of milk yield provide a good indicator of total lactation milk yield of beef cows. Reynolds et al., (1978) obtained high correlation coefficients between average daily gain at 83 days and 105 days with average daily gain at 140 days (r = .74 and .99 respectively) and suggested that calves could be evaluated for growth rate with as much accuracy at 105 days of age as at later ages. The same observation was made for milk yield by the same authors.

Lindstrom (1975) found error variance of monthly and bimonthly records to be 4% and 10% of the error variance respectively for daily recording. He, therefore,recommended 14 days interval. Johanson (1961) had concluded that milk yields must be recorded at intervals of 3 weeks if an upper limit of 10% absolute error was set. McDaniel (1969),however, observed that from monthly test intervals, only half of lactations had errors of 2% and concluded that errors as large as 10% are rare.

2.3 Milk Production and Calf Performance

In beef cattle, milk production accounts for about 66% of variance in weaning weights (Neville, 1962). This means that calf performance is a reflection of the cow's mothering ability. Lengeman and Allen (1955) and McCarthy and Kesler (1956), stated that the average daily gain during early lactation is an indicator of actual milk production of the dam because forage utilization by young calves is negligible.

2.3.1 Relationship Between Milk Yield and Growth Traits

Genetic relationship between milk yield and growth traits in the same idividual and between milk yield of the dam and growth traits of her calf are not covered in this study. However a mention of the relationship is important for further discussions.

2.3.1.1 Genetic Correlation

Genetic correlation between growth rate and milk yield of the same individual animal is usually low. Mason (1963) obtained a very low genetic correlation not significantly different from zero. Ndu (1977), working with Swedish Red and White sires and their performance tested sons, found very low genetic correlation (0.01 - 0.06) between performance test values for growth rate and breeding values for milk yield and concluded that selection can be achieved simultaneously for milk and beef since the two traits seem to be very weakly correlated (zero). He also suggested that selection based on index (weighting of the milk and beef traits according to the prevailing market conditions) can be used. This in turn would result in maximum genetic progress in the two traits.

On the other hand, Sing and Desai (1967) found high genetic correlation between body weight and milk yield of crossbred Sahiwals, indicating that selection of animals on the basis of body weight at first calving could bring about improvement in milk yield at least in first lactation. While high yielding cows may raise fast growing calves, larger or heavier cows are not necessarily high milk producers. Williams et al. (1979) found that height at the withers, hip height, weight and condition score of Hereford cows were not significantly correlated with milk production, suggesting that high producing cows cannot be selected by the use of physical traits. Lampkin and Lampkin, (1960) observed that high yielding cows also raised fast growing calves, but that such cows lost weight to the extent of affecting their fertility and health during dry seasons.

2.3.1.2 <u>Phenotypic Correlations</u>

Phenotypic correlations between average daily gain of calf and milk yield of dam that have been reported by various workers (Table 1) range from 0.29 - 0.93 . The correlation between rate of gain and milk production decreases as the general nutrition of the calf increases (Neville, 1962). The same relationship was observed by Franke et al. (1975) and Boggs et al. (1980). In their study Franke et al. (1975) found that milk yield did not influence average daily gain in the 5-7 months period.

The correlations between rate of gain of calf and milk production of the dam seem to be influenced also by the stage in lactation at which sampling is done and the number of samples taken. Neville, (1962) found the greatest correlation coefficient during the first 60 days and suggested that only two or three milk samplings are necessary to determine the relationship although the correlation between estimated milk yield and calf weaning weight increased as sampling increased from 1-4.

There are conflicting results on the relationship between calf growth and milk production as far as weaning weight is concerned. Totusek et al. (1973) found that high weaning weight of calves did not reflect high yield of the dams. This might be due to the fact that in this study the calves suckled only half the udder and not all the milk. Wistrand and Riggs (1966) obtained a significant correlation (r = 0.68) between calf weight and milk yield at 120 days after calving. Lampkin and Lampkin (1960) stated that a straight-forward correlation analysis between calf growth and milk yield would be biased because milk yield and calf growth are independently influenced by other factors like seasonal variations as it affects quantity and quality of grass. Table 1 summarises correlations between milk production and calf performance from various sources.

Table 1 Correlation Estimates between Milk Yield of Dam and Growth Performance of Calf From Various Sources

Growth trait	Correlation	Source
ADG	0.29	Schwulst et al. (1966)
ADG	0.54-0.60	Reynolds et al. (1978)
ADG	0.46	Williams et al. (1979)
ADG	0.54-0.61	Ronningen et al. (1972)
ADG	0.17-0.45	Franke et al. (1975)
Weaning weight	0.61-0.73	Franke et al. (1975)
Weaning weight	0.15	Dinkel and Brown (1978)
Weaning weight	0.68	Wistrand and Riggs (1966)
Weaning weight	0.69-0.83	Neville (1962)
Weaning weight	0.91-0.93	Totusek et al. (1973)
Weaning weight	0.20	Chennette and Frahm (1981)

2.3.1.3 Maternal Effect

Notter et al. (1978), studying milk production and growth performance of calves of young crossbred cows, found that all breeds had a positive maternal effect for average daily gain and 200 days weight, and that crosses of some breeds also had positive maternal effects on birth weight. The same author observed that in 3 year old dams, rankings for maternal ability corresponded closely to those for milk production.

Trail and Gregory (1981), in their study on Pedigree Boran and Pedigree Sahiwal in Kenya, observed that the Sahiwal breed probably has higher transmitted effects for maternal ability than the Boran while the Boran probably has higher transmitted effects for growth rate than Sahiwal. They suggested that the transmitted effects for maternal ability could be exerting greater influence on average daily gain in early stages than later stages. Trail et al. (1982) made a similar observation between the Red Poll and Boran breeds concerning their additive maternal effects. The Red Poll had significant reciprocal cross difference for birth weight and Boran dams had reciprocal cross difference for weaning weight (a reversal of additive maternal effects between prenatal and postnatal gains).

The regression of calf weight on milk yield also has been shown to be significant. Wistrand and Riggs (1966) showed that a 1 kg increase in daily milk yield resulted in 90 gm and 50 gm increases in daily calf gain in two separate years. Boggs et al. (1980) working with Herefords found that each kg of milk per day added 0.34 kg per day of weight gain and 7.2 kg to 205 days adjusted weaning weight. Drewry et al. (1959) found that to produce 1 kg of weight gain, calves consumed 12.5 kg of milk in the first month, 10.8 kg in the third month and 6.4 kg in the sixth month.

2.3.2 Factors Affecting Growth Performance of Calves

Environmental factors which influence calf performance include age of dam, year and season of birth, sex of calf, stage of lactation and others.

2.3.2.1 Age of dam

Koch and Clark (1955) reported that birth weight and weaning weight of calves increased with age of dam until 6 years then declined. The same trend was observed for birth weights (increased with age until 6-8 years), the greatest change being between first and second calf. Franke et al. (1975) found that age of dam influenced average daily gain in the first three months only. Williams et al. (1979) also found that age of dam was significant for both milk yield and growth rates. Mwandotto (1978) found significant effect of age of dam on weaning weights.

2.3.2.2 Year and Season of Birth

Neville (1962), working with suckled calves, found that season had significant effect on growth at 4 months but negligible and non-significant effect at 8 months of age. Lampkin and Lampkin (1960) also found significant effect of season on growth rate and weaning weights. Franke et al. (1975) found that year influenced average daily gain throughout the 7 months suckling period. Mwandotto (1978) and Williams et al. (1979), however, found year and season non-significant for weaning weights. Trail et al. (1982) found period of birth significant for weaning weights and post weaning growth performance.

2.3.2.3 Sex of Calf

Franke et al. (1975) found that sex influenced average daily gain throughout the suckling period in that males were superior to females. Most studies usually correct for sex of calf to avoid differences (Lampkin and Lampkin, 1960; Totusek et al., 1973; Williams et al., 1979). Mwandotto (1978) found that sex contributed only 0.12% to total variation in weaning weights.

2.3.2.4 Calf Genotype

Calf genotype influences both birth weight and growth rate. The influence also includes maternal effects and heterosis. Birth weight as such does not affect average daily gain although heavier calves at birth also finish up heavier at weaning (Boggs et al., 1980). Gregory et al. (1965) found that there is significantly greater heterosis effect on average daily gain and weaning weights in females than males. Other workers (Carpenter, 1961; Pahnish et al., 1969) reported that there is a 5% increase in weaning weight of crosses due to heterosis. Trail et al. (1982) found significant heterosis effects for weaning weights and weights at later ages (post weaning weights). Heterosis effect has also been reported for milk yield and viability of calves as indicated by lower mortality rate (Rendel, 1972).

3. MATERIALS AND METHODS

The data used in this study were collected from National Animal Husbandry Research Station, Naivasha and its extension at Ol' Magogo Farm. The study covered a period of 4 years from 1969-1972 and included data on WSW records at Ol' Magogo and handmilking records and calf rearing records from Naivasha Farm. This work is composed of analysis of field data. The WSW data was composed of records from Borans and Sahiwals while records of handmilked cows and handfed calves were from Sahiwals only. The handmilking and handfeeding data were collected to enable comparison of the effect of calf sex, year, season, initial weight and weaning age on growth traits of suckled and handfed calves.

3.1 Description of the Area

Naivasha lies between 0 degrees 40'S. and 36 degrees 26'E. in Nakuru District of Rift Valley Province. It is 1900 meters above sea level. It is a relatively dry and windy area with monthly rainfall varying from very low to high as indicated on Table 2. Its natural vegetation is a modified savanna with some *Acacia spp.* trees. The dominant grass is stargrass (*Cynodon spp.*) and Kikuyu grass (*P. clandestinum*).

3.2 Classification of Seasons

Due to the great variation in monthly rainfall figures, it is difficult to classify seasons with rigidity but generally there are rainy seasons which refer to 2-3 months when the rains come persistently and the dry season when very low or no rain comes. From the rainfall figures for Naivasha (Table 2), the seasons have been termed wet if the 3 months have rainfall which is consistently higher than 150 mm in total or 50 mm on average. This happens to be in March - May (season 1) and September - November (season 3). Dry seasons are June - August (season 2) and December to February (season 4). In the analysis, the two wet seasons (1 and 3) are grouped into one wet season and the two dry seasons (2 and 4) are referred to as dry. The 50mm rainfall is taken as minimum for the wet season because it is the mean monthly precipitation needed to stimulate pasture growth (Morgan, 1972).

Table 2 Monthly Rainfall for Naivasha (mm)

During the Study Period

Season	Month	1969	1970	1971	1972
	March	110.6	114.5	0	23.7
1	April	28.4	82.5	92.3	11.9
	May	94.6	65.8	146.1	61.9
	June	16.8	42.8	7.9	105.3
2	July	8.6	28.7	55.6	21.0
	August	44.5	12.0	175.4	48.6
	September	43.1	82.2	16.4	19.6
3	October	31.3	37.7	45.5	100.5
	November	77.8	51.5	37.3	61.5
	December	15.2	6.9	74.3	17.8
4	January	78.6	92.5	45.2	8.5
	February	31.8	28.4	1.0	112.8

3.3 <u>The Experimental Animals</u>

There were 120 Sahiwal dams suckling either Sahiwal calves or Friesian x Sahiwal calves and 180 Boran dams suckling either Boran calves or Friesian x Boran calves in the WSW data.

The Sahiwal breed of cattle was first introduced to Kenya in 1939 (Mason, 1965). Some of the dams used in this study were bought into the station from other livestock improvement centres or from individual farms. Others were, however, born on the farm, sired by a few proven bulls from Central Artificial Insemination Centre, Kabete.

The Boran dams refer to the improved Boran or Kenya Boran which is described by Mason and Maule (1960) as the Boran cattle which as a result of selection, careful breeding and greatly improved management on European Ranches in Central and Rift Valley Provinces of Kenya (especially Laikipia District) have been developed into large, robust animals of very good conformation. The improved Boran has been bred and selected mainly as a beef animal. A champion Kenya Boran bull at Kenya Royal Show in 1956, (Now Nairobi International Show) was reported to have attained 586 kg at 18 months of age (Mason and Maule, 1960). The dairy characteristics of the Boran indicate that it is also a good milker compared to other Zebus in East Africa. Maximum lactation yield recorded was 2647 kg with butter fat content of 5 - 6.8% (Mason and Maule, 1960).

The Sahiwal and Boran dams in the WSW data were both treated as beef cows, either because they were too wild for normal handmilking without calf or they had a defect (damaged teat or other defects that hindered milking) or they had no pedigree record. Their age ranged from three years to 12 years and parity from first to 8th.

3.4 Management of the Herd

3.4.1 Feeding

The WSW herd at Ol' Magogo Farm was totally maintained on pasture and was supplemented only with hay during extremely dry periods. Calves normally ran with their dams from birth and were weaned at 8 months without supplementation. The day before the test day, they were separated from their dams from 7 p.m to 7 a.m. and housed at night without any feed to ensure effective suckling the next morning.

The handmilked Sahiwals were also on pastures alone except at milking time when they were given some "factory waste" to keep them calm. Their calves were removed from them at birth and fed on colostrum for 4 days. The handfed calves received whole milk until they reached 42 kg, as follows:

The first 2 weeks ------ 4 kg per day
3-4 weeks ---- 6 kg per day
5-6 weeks ---- 8 kg per day
7th week ----- 6 kg per day
8th week till 42 kg. --- 4 kg per day

They were then weaned onto pastures and calf pellets at 8 weeks onwards.

3.4.2 Breeding Cycles

Heifers were inseminated at 27 months of age. The breeding cycles aimed at avoiding calvings during the dry months of December to February. For all the 4 years of the study, only 2 calves were (accidentally) born in this season. This seasonal breeding was clearly observed in the WSW data.

3.4.3 Routine Management

Male calves were castrated from 2 months onwards after selection had been done for bull calves to be retained for breeding. All the calves were identified by eartagging and their date of birth, sex, birth weight and sire and dam information were recorded on cards.

Routine vaccinations and innoculations were done against Anthrax, Black Quarter, Foot and Mouth Disease, Rinderpest and Brucellosis. Also deworming and general treatment for various diseases were done by the veterinarian in the station.

3.5 Data Collection and Classification

WSW data for milk yield and calf weights were taken weekly in the morning only. The morning suckling started from 6 a.m. to 7 a.m. The calves were suckled in groups of 5 - 6 to allow immediate weighing after end of suckling. The period of suckling was not limited since the aim was to ensure complete depletion of the udder.

Milk consumed by the calf at each suckling was obtained by weighing the calf immediately before and after suckling and recording the two weights. The difference in the two weights was recorded in separate sheets as the milk intake by the calf and milk yield by the cow. Twenty-four hour milk production was computed as being 1.5 of the yield in the morning suckling. The 1.5 factor was obtained from a pilot study carried out by the investigator for 3 months, which showed that evening suckling was, on average, half the yield of morning suckling. The monthly milk yield estimates were obtained from the average of 4 consecutive weekly estimates multiplied by 1.5 to give 24 hours estimate then multiplied by 30 days. Average daily milk yield was obtained by dividing total milk yield throughout the suckling period by the number of days in suckling. Maximum daily yield was however picked from the weekly estimates (morning suckling yields multiplied by 1.5 as daily yields).

Calf weights were also recorded weekly at the same time as milk intake estimates. Monthly weights were taken as the weights at every 4 weeks. Final weight was taken at 8 months or when cows dried up, or refused to be suckled. The dam information, that is, the breed, age of dam and dam identity number were obtained from separate record books that had been kept since the dams were brought in or born. Some cows had more than one lactation or suckling period because the cows were included for analysis as often as they had suckling calves during the 4 years (1969 - 1972). Dam information was not included for handfed calves. The information concerning the calves included breed of calf, sex of calf, season and year of birth, weight at the onset of experiment and age at first weighing which was all recorded in the individual data cards for the calves.

Handfed calves had only weights recorded every week for varying length of time before weaning. The only years of recording for handfed calves were 1969 and 1970. The average weaning age for suckled calves was 243 days and ranged from 211 to 257 days. Handfed calves had weaning age ranging from 90 to 240 days with a mean of 190 days. Milk recording was done for an average of 235 days but ranging from 150 - 240 days. The handmilked cows had an average lactation length of 303 days and ranged from 213 to 356 days.

3.6 Data Analysis

The data were divided into three separate datasets according to the parameters being estimated and according to the milking method or calf rearing method used.

The WSW dataset contained both milk yield and calf growth information and was analysed for the influence of calf breed, calf sex, season of birth and year of birth on milk yield of the dam and growth performance of the calf. The same dataset was analysed for the effect of milk production of the dam or milk intake by the calf on calf performance (average daily gain and weaning weight) when all the fixed effects were included.

According to the rearing method used, the suckled calves were analysed separately for growth traits when milk intake was not considered and the handfed calves were also analysed separately for the same effects. A combined data set was used to analyse for the effect of rearing method on growth performance of calves.

Handmilking data was analysed separately for the influence of season, year, age of dam and age at peak lactation yield on total milk yield, average daily yield and peak lactation yield. In all of the datasets, initial weight of the calf, age of the dam, weaning age and milk consumed by calf were entered as covariates. The data were analysed by a Least Squares Computer Programme (Rege, 1986) on IBM microcomputer

The general model used in the analysis of the above datasets is given below as:

$$\underline{y} = X\underline{a} + Z\underline{b} + \underline{e}$$

where $\underline{y}$ = a vector of n observations on the dependent variable. The dependent variables were milk yield, average daily gain, growth rate per month and weaning weight.

X = a known incidence matrix corresponding to the discrete effects

$\underline{a}$ = an unknown vector of discrete effects which included calf breed, calf sex, season and year.

Z = a known incidence matrix corresponding to the covariates

$\underline{b}$ = an unknown vector of partial regression coefficients for the covariates which included initial weight of the calf, age of dam, weaning age, and milk yield.

$\underline{e}$ = a vector of random residuals.

Correlations between monthly weight gains and total weight gain and among the monthly weight gains were obtained from a correlation matrix output by the programme. Other correlations between growth traits and milk yield were obtained in the same way.

The specific models that were fitted are shown in Table 3.

Table 3 Specific Models Fitted

Model	Independent Factors	Dependent Factors
1.	Calf breed Calf sex Season Year Initial weight Age of dam Milk yield	Weaning weight Growth rate per month Average daily gain
2.	Calf sex Season Year Initial weight Weaning age	Weaning weight Growth rate per month Average daily gain Total weight gain
3.	Calf sex Season Year Initial weight Rearing method	Weaning weight Growth rate per month Average daily gain
4.	Calf breed Calf sex Season Year Initial weight Age of dam	Total milk yield Average daily yield Maximum daily yield 305 days yield
5.	Age of dam Season Year Age at peak lactation	Total yield Average daily yield Peak lactation yield

4. RESULTS AND DISCUSSION

4.1 Milk Yield Estimates

The average total yield of Sahiwals and Borans together was estimated as 1272.35 kg in an average of 240 days by WSW method and ranged from 703 - 1941 kg in a range of 211 - 257 days in suckling. These estimates agree with the results obtained by Lampkin and Lampkin (1960) for Borans in Kenya, and by Neville (1962) for Herefords, using the same method. The range in milk yield is, however, lower than 1141.5 - 2809 kg obtained by Dawson et al. (1960) for beef Shorthorn. The average daily milk yield of the dam or milk consumption by the calf obtained in this study (5.31 kg) is quite similar to those obtained by various workers (Neville, 1962; Schwulst et al. 1966; Totusek et al. 1973; Boggs et al, 1980) for *Bos taurus* beef cows using the same method.

The similarity in milk yield estimates between *Bos taurus* and *Bos indicus* beef breeds is rather unexpected because their production level is not the same. Possible reasons for this similarity could be that the other authors reported least square means while the results in this study are raw means. The other reason could be that the estimates are limited by the stomach capacity of the calf in that at a given age and weight calves are bound to have the same stomach capacity. This may limit milk production estimates by WSW especially of high yielding cows. The third reason could be that when adjustment for various factors like calf sex, age of dam and period of birth are made as may be the case for some of the estimates reported for *Bos taurus* beef cows, the estimates are bound to be lower, thereby reducing them to the level of *Bos indicus* estimates. Maximum daily yield was 10.22 kg per day on average but ranged from 6 - 15 kg per day (Table 4). This estimate is higher than peak yield that was reported by Lampkin and Lampkin (1960) for Boran cows in Kenya but quite similar to 10.28 kg that was reported by Dawson et al. (1960) for beef Shorthorn cows.

Milk yield estimates by handmilking were 20% higher than those of WSW. This is contrary to the results of Totusek et al. (1973) and Niedhardt et al. (1979) both of whom reported 29% higher yields by WSW method compared with handmilking estimates. The conflicting results could be due to the difference in milking technique. In the studies by Totusek et al. (1973) and Niedhardt et al. (1979) the two methods of milking were done on the same animal, simultaneously in the first case and at different times in the second. In this study, handmilking estimates were obtained from different animals in a different herd. It should be noted that the comparison of the two methods in the same animal is likely to be more reliable because other sources of variation like age of the cow, nutrition and genotype of the cow are eliminated. Another reason for obtaining higher milk yield estimates by handmilking than by WSW method in this study could be that milk production level of the cows used in the WSW data was actually lower than that in the handmilked herd. This is expected because the animals used in the WSW milk yield determination were culled from the milking herd for various reasons mentioned earlier.

4.2 Coefficient of Variation for Milk Yield Estimates

Coefficient of variation for WSW total milk yield estimates and for handmilking estimates were quite similar (23.75% and 21.84%, respectively). This indicates that the two methods were quite similar in accuracy. The same observation was made by Totusek et al. (1973). On the other hand, Le Du et al. (1978) reported a large within-animal variation in milk consumption by the calf and hence large within-animal variation in milk yield estimates. This variation could be due to the disturbance as the change is made from calf nursing method to machine milking as was done in the above study. The coefficient of variation obtained in this study agrees with that obtained by Osman and El Amin (1971) for Sahiwals using handmilking but was smaller than the 40% reported by Lindstrom (1975) for handmilked Sahiwals in Kenya.

Coefficient of variation for average daily yields (18.70% and 20.72% for WSW and handmilking, respectively) was slightly lower than for total milk yield but was similar to coefficient of variation for maximum milk yield and 305 days adjusted milk yield (17.68% and 18.70% respectively). This would suggest that average daily yield, maximum daily yield and 305 days adjusted yields are more accurate statistics for milk yield estimate than total milk yield (actual yield). Totusek et al. (1973) obtained similar coefficient of variation for daily WSW estimates. The slightly higher coefficient of variation for total milk yield estimate is expected because total yields in this study covered varying number of days in lactation thus causing more variation in milk yield.

4.3 Growth Performance of Suckled Calves

The growth traits that were measured included weaning weight, average daily gain, monthly weight gains and total weight gains at 240 days of suckling.

4.3.1 Weaning Weight

The average weaning weight at 240 days in this study was 187 kg with the males being 193.85 $\pm$ 23.55 kg and females being 180.39 $\pm$ 22.94 kg. These results are quite similar to those of Lampkin and Lampkin (1960) who obtained an average weaning weight of 185 kg for males and 167.83 kg for females of Boran calves at 8 months and of Thorpe et al. (1980) who obtained a mean of 169.5 kg for Borans at 7.5 months. Mwandotto (1978) obtained means varying by years from 128.53 - 169.79 kg for East African Zebu calves.

Various workers have reported weaning weights for *Bos taurus* calves that are quite close to those estimated in this study. For example, Totusek et al. (1973) reported 164.7 kg at 210 days, Notter et al. (1978) reported 194 kg at 200 days, Niedhardt et al. (1979) reported 172 kg at 216 days and Bowden (1980) reported 222 kg at 200 days. However, direct comparison of weaning weights obtained in this study with those reported for *Bos taurus* suckled calves can be confusing because the latter are usually supplemented and have superior genotype for growth traits. The adjustments usually made for various factors in different studies could also lead to bias in the reported values. In this study, raw means are reported with no adjustment made. This could be responsible for the relatively high weaning weights obtained.

4.3.2 Average Daily Gain and Growth Rate per Month

The overall average daily gain for suckled calves in this study was 0.66 kg with males being 0.69 kg and females 0.64 kg. These values are slightly higher than 0.62 kg for males and 0.54 kg for females obtained by Lampkin and Lampkin (1960) and 0.61 kg for males and 0.54 kg for females, obtained by Ronningen et al. (1972) both for Boran calves in Kenya. They are quite comparable with the values reported for suckled *Bos taurus* calves (Neville, 1962; Totusek et al., 1973; Notter et al., 1978; Niedhardt et al., 1979). Relatively lower average daily gains were reported by Williams et al. (1979) for *Bos taurus* calves but higher values have been reported by Reynolds et al. (1978) and Bowden (1980). The comparison between the rate of gain for *Bos taurus* beef calves and *Bos indicus* calves has not come out clearly. The values seem to be quite close between the two groups, although genetically they are expected to be quite different.

The average daily gain estimates for handfed calves in this study (0.48 kg) is quite comparable with the values reported for bucketfed Zebu calves. Marples (1962) obtained 0.38 kg for females and 0.43 kg for males while Mudgal and Ray (1965) obtained 0.34 kg and 0.46 kg for females and males, respectively. Compared with average daily gains of handfed calves, the suckled calves had 72% higher rate of weight gain per day with lower coefficients of variation (Table 4). The same superiority is reflected also in monthly weight gains. Bucketfed calves are known to have some growth check at the beginning when they are learning how to feed from the bucket. This may be responsible for their low overall growth rate.

4.3.3 Coefficient of Variation for Growth Traits

Coefficient of variation for growth traits, however, was lower for suckled calves than for handfed calves (12.90 - 13.94% compared with 16.61 - 16.79% as shown in Table 4). The growth traits determined here were average daily gain, growth rate per month, weaning weight and total weight gain at 240 days, all of which had quite similar coefficients of variation. This suggests that they are equally good statistics for growth traits. The difference in coefficients of variation between suckled and handfed calves growth traits suggests that suckled calves perform more consistently in growth traits since they had a smaller error of estimation. It means that calf growth is influenced by less environmental factors when they suckle than when they are bucketfed. Suckling method, therefore, allows expression of the calf's potential for growth more than handfeeding does.

Table 4 Means and Coefficients of Variation for Growth Traits of Suckled and Handfed Calves and for Milk Yield of Suckled and Handmilked Cows

Trait	Mean		Range		Std. Dev		Coeff. of Variation	
	Suckle	Hand	Suckle	Hand	Suckle	Hand	Suckle	Han
ADG	.66	.48	0.41-.93	.28-.70	.09	.08	13.63	16.
GRM	19.93	14.27	12.3-27.9	8.5-21	2.74	2.37	13.80	16.
WW	187.00	112.90	130-256	50-138	24.12	18.96	12.90	16.
TWG	159.43	114.00	110-220	67-168	22.23	19.03	13.94	16.
TYD	1272.35	1933.20	703-1941	---	302.14	422.20	23.75	21.
MDY	10.21	----	6-15	---	1.81	----	17.68	--
ADY	5.31	6.40	2.93-8.09	3-11.3	0.99	1.33	18.70	20.
305DY	1620.64	1952.0	893.65-2467	618-3441	303.14	----	18.70	--

KEY

ADG = Average daily gain (kg)

GRM = Growth rate per month (kg)

WW = Weaning weight (kg)

TWG = Total weight gain at 240 days (kg)

TYD = Total milk yield (kg)

MDY = Maximum daily milk yield (kg)

ADY = Average daily milk yield (kg)

305DY = 305 days adjusted yield (kg)

Suckle = Suckled calves/dams

Hand = Handfed calves or handmilked dams.

----- = Parameters not estimated

4.3.4 Correlations of Monthly Yields

The correlation matrix among monthly yields is given in Table 5. The first month had a low but significant ($p < .05$) correlation with all other months (highest $r = 0.34$) but was quite highly correlated with total milk yield ($r = .53$) and average daily yield, ($r = .54$). The months that are highly correlated with each other are 3rd and 4th month ($r = .51$) and 4th month with 5th month ($r = .51$). All months were highly correlated with total yield and average daily yield. Milk yield for the eighth month had a low but significant correlation with all other months except the third month, where the correlation was low and non-significant ($p < .05$). The second up to fifth months had the highest correlation with total yield ($r = .68$ to .75) and were significantly correlated ($p < .05$) with each other ($r = .48$).

The low correlation between the first month's yield with all other months could be due to the limited stomach capacity of the calf which limits the amount of milk consumed, and therefore, does not reflect milk production of the cow. The limitation by the stomach capacity in the first 2 - 4 weeks of lactation has been observed by Dawson et al. (1960); Schwulst et al. (1966) and Somerville and Lowman (1980). The high correlations between second to fifth monthly yields with total yield agree with those obtained by Totusek et al. (1973) between milk yield estimates at 70, 112 and 210 days of lactation and total yield ($r = .74$, .80 and .88 respectively). However, no comparison can be made between the two observations because the estimates determined by Totusek et al. (1973) at 70, 112 and 210 days were total yields up to the sampling day and not monthly yields as in this study.

This relationship suggests that the best time to take the first test samples is from the 2nd to the 5th month because of their high correlation with total yield and with each other. The same observation was made by Dickinson and McDaniel (1969) and Totusek et al. (1973) who suggested that the first test sample be taken at 6 weeks and 70 days, respectively.

Table 5 Correlation Matrix for Monthly Milk Production of Suckled Cows

	TY	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	MDY	ADY
TY	1.00	.53	.70	.68	.75	.74	.68	.59	.45	.70	1.00
Y1		1.00	.27	.27	.33	.34	.27	.24	.13	.46	.54
Y2			1.00	.48	.48	.48	.41	.30	.17	.55	.71
Y3				1.00	.51	.43	.38	.28	.10	.56	.68
Y4					1.00	.51	.47	.31	.16	.54	.75
Y5						1.00	.44	.36	.22	.51	.74
Y6							1.00	.34	.27	.46	.69
Y7								1.00	.32	.33	.60
Y8									1.00	.19	.45
MDY										1.00	.70
ADY											1.00

Y1 to Y8 are monthly milk yield for month 1 to 8

TY = Total milk yield for the 8 months

MDY = Maximum daily yield

ADY = Average daily yield

4.3.5 Correlations of Monthly Weight Gains

Table six shows the correlation matrix for monthly weight gains. Weight gain in the first month is highly and significantly correlated with the weight gains in the first five months. (r = .66 - .82) but has low and non-significant correlation with the weight gain in the eighth month (r = .09). Because the correlation coefficient is decreasing from the second to fifth month, there could be a relationship between growth rate and milk consumption during these periods. The high correlation between the first and the second month's growth rate corresponds to the period when the calf is completely dependent on milk. As the calf starts to eat other feeds, the correlation between growth rate in the first month and later months becomes less and less. The highest correlation coefficient occurred between the third and fourth months' growth rate (r = .97), suggesting that by the third month the calves have established a steady growth rate that they would maintain if other factors remained unchanged. The lowest and non-significant correlation coefficient was observed between the first month's weight with weight gain in the eighth month. Weight gain in the eighth month generally had low correlation with all other months. This suggest that the growth rate at this stage is affected by different factors not affecting growth in the other months. This may include reduced milk yield by the cow or consumption by the calf. It also implies that extending tests up to the eighth month is not necessary. This is supported by the non-significant correlation between growth rate in the eighth month and total weight gained throughout the suckling period.

The first to the seventh months growth rate are highly correlated with weaning weight (r = .58 - .89), the highest correlation being in the fifth month and the lowest in the first month. This suggests that more reliable tests can be taken in the first five months of growth. This would be very useful for selecting beef calves in that adequate information will have been collected for selection purposes and early weaning can be practised which, in turn, will reduce the interval between calving and first estrus (Wiltbank and Cook, 1958). The high correlation between weight gains in the first five months with weaning weight also suggest that monthly tests in the first five months would be adequate for assessing growth performance of suckling calves. This agrees with the observation made by Totusek et al. (1973) that growth estimates based on four or five samplings were the most highly correlated with total milk yield of the dam. Reynolds et al. (1978) obtained very high correlations between part-of-period average daily gains and whole period daily gain (r = .89 - .96) and suggested that calves could be evaluated for growth rate with as much accuracy at 105 days of age as at later ages.

Initial weight of the calf (or birth weight where it applies) was highly and significantly correlated with the weight gains in the first five months but non-significantly correlated with weight gains in the 8th month. Its high correlation with the first month's weight gain, especially, emphasises the fact that the more vigorous the calf, the more milk is suckled and hence the greater the weight gain. This suggests that high birth weights are advantageous to suckling calves because they start off at higher growth rate.

Table 6 Correlation Matrix for Monthly Weight Gains of Suckled Calves

	TWG	G1	G2	G3	G4	G5	G6	G7	G8	WWT	IWT
TWG	1.00	.55	.70	.80	.82	.89	.75	.70	.16	.90	.32
G1		1.00	.82	.76	.74	.66	.47	.40	.09NS	.58	.75
G2			1.00	.93	.90	.85	.63	.54	.14NS	.70	.63
G3				1.00	.97	.93	.72	.65	.19	.80	.57
G4					1.00	.95	.73	.64	.21	.82	.56
G5						1.00	.79	.71	.18	.89	.50
G6							1.00	.86	.24	.75	.34
G7								1.00	.28	.70	.19
G8									1.00	.16NS	-.17NS
WWT										1.00	.33
IWT											1.00

KEY

G1 - G8 = Monthly gains from 1st to 8th month

TWG = Total weight gain in 240 days

WWT = Weaning weight

IWT = Initial weight

NS = Not significant

4.4 Factors Influencing Growth Traits of Suckled Calves

Table 7 shows the effect of various factors on growth performance of suckled and handfed calves. The factors are discussed below.

4.4.1 Calf Breed

Calf breed affected all the growth traits significantly ($p < .05$). In a separate analysis, where milk production of the dam was not fitted in the model, Friesian x Sahiwal (FS) calves were 29 kg (20%) heavier than pure Sahiwals in weaning weight and Friesian x Boran (FB) calves were 20 kg (13%) heavier at weaning than pure Borans. When milk production of the dam was considered (model 1) the FS calves were 18% better than pure Sahiwals in weaning weight and average daily gain and FB calves were 13% better than pure Boran calves in weaning weight but 18% better in average daily gain. The smaller difference in weaning weight between FS and Sahiwal calves means that although the crossbred calves are genotypically better in growth (weaning weight) their superiority over pure Sahiwals is slightly smaller when milk yield of the dam is similar (common maternal effect). The same relationship is observed between the FS and FB calves. The FS and FB crossbreds are almost similar in growth performance when milk production is considered (a difference of only 3.8 kg compared with 14.2 kg when milk production is not considered). The FB and Boran calves, however, have not shown the same relationship maybe because the difference in weaning weight between the FB and Boran calves is mainly genetic and milk yield had very little influence on it, or it may suggest that Sahiwals dams have greater maternal influence on their calves in the form of milk yield while FB calves have the advantage over FS calves in higher birth weight due to pre-natal maternal effect. The same differences were observed by Trail and Gregory, (1981) on pedigree Boran and pedigree Sahiwals in Kenya and by Trail et al. (1982) on Red Poll and Boran breeds. Sahiwal and Boran calves showed quite similar performance and the crosses were also quite similar (a difference of only 3.8 ± 2.8 Kg at weaning and 10.8 g in average daily gain) when milk consumption by the calf is considered.

These results agree with what was obtained for the same breeds by Mwandotto (1978). However, the superiority of the crossbreds over the straight breds differ in that the above author obtained greater improvement in weaning weight by FB crosses while in this study it is the FS crosses that showed greater improvement in weaning weights and were similar in average daily gain. The difference in superiority could be due to the milk consumption aspect that was not considered in the study by Mwandotto (1978). Since pure Boran calves had slightly higher weaning weights than Sahiwal calves (178.61 versus 169.71 kg) in pre-analysis, the superiority of the Sahiwal crosses must be due to greater milk yield and improved rate of weight gain.

4.4.2 <u>Calf Sex</u>

Table 7 shows that calf sex had highly significant effect on all the growth traits investigated ($p < .01$) in model 1. The males were significantly ($p < .01$) heavier than females at weaning (10.59 ± 1.86 kg) and had higher average daily gain (0.69 kg vs

.64 kg). The highly significant effect of calf sex on growth raits of both suckled and handfed calves has also been reported y several workers (Lampkin and Lampkin, 1960; Marples, 1962; adgal and Ray, 1965; Totusek et al., 1973; Franke et al., 1975; vandotto, 1978 and Notter et al., 1978). Among those who have orked with suckled Sahiwal or Boran breeds (Lampkin and Lampkin, 960; Ronningen et al., 1972; Mwandotto, 1978; Thorpe et al., 980), the difference in weaning weight between males and females as ranged from 8 kg to 17 kg. The results obtained in this tudy, therefore, fall in this range but are slightly higher than hose obtained by Lampkin and Lampkin (1960) and Ronningen et al. 1972). Boggs et al. (1980) obtained similar results for ereford calves. Because sex of calf did not influence milk onsumption significantly, the difference in growth performance ust be, due to difference in rate of gain itself and birth eight.

In the analysis of handfed calves (model 2), the effect of alf sex is the opposite of that in suckled calves in that emales performed better than males. Average daily gains and rowth rate per month were almost similar for both sexes when nitial weight and age at weaning were considered. However, emales had higher weaning weights than males.

Table 7 Analysis of Variance for Growth Traits of Suckled and Handfed Calves

Source	df	WW	TWG	GRM	ADG
Model 1					
Calf breed	3	11060.93 **	- -	187.07 **	0.2096 **
Calf sex	1	7037.62 **	- -	122.68 **	0.1413 **
Season	1	1927.88 **	- -	29.59 **	0.0280 **
Year	3	1021.65 **	- -	21.77 **	0.0228 **
1st weight	1	6845.84 **	- -	0.26 N.S	0.0000 N.S
Age of Dam	1	73.25 N.S	- -	1.02 N.S	0.0009 N.S
Weaning Age	1	13012.28 **	- -	4.17 N.S	0.0051 N.S
Milk Yield	1	13912.47 **	- -	250.81 **	0.28 **
Error	288	189.5	- -	2.94	0.0034
Model 2					
Calf Sex	1	1364.04 **	2238.38 **	34.93 **	0.0382 **
Season	1	1764.33 **	2811.77 **	43.96 **	0.0502 **
Year	1	923.09 *	1232.12 *	19.22 *	0.0217 *
1st Weight	1	337.40 N.S	3566.45 **	55.72 **	0.0615 **
Weaning Age	1	5275.78 **	5703.21 **	88.94 **	0.1006 **
Error	129	166.89	288.19	4.50	0.0050
Model 3					
Calf Sex	1	699.68 N.S	- -	10.27 N.S	0.0118 N.S
Season	1	48.20 N.S	- -	1.21 N.S	0.0007 N.S
Year	1	8747.62 **	- -	124.69 **	0.1533 **
Rearing Method	1	55861.99 **	- -	897.51 **	0.9626 **
1st Weight	1	64.88 N.S	- -	0.13 N.S	0.0014 N.S
Error	259	382.07	- -	5.79	0.0066

KEY

Model 1 = Analysis for suckled calves
Model 2 = Analysis for handfed calves
Model 3 = Analysis for suckled and handfed calves
WW = Weaning weight
TWG = Total weight gain
GRM = Growth rate per month
ADG = Average daily gain
* p < .05
** p < .01

4.4.3 Season

Season had a significant effect on growth traits of both suckled and handfed calves separately (models 1 and 2) but not for both groups together (model 3). Least squares solutions (Appendix 1) showed that calves born in the wet season were 14 kg heavier at weaning and gained 50 g more per day than calves born in dry season. The effect of season on growth traits of the suckled calves is as expected since season significantly influenced milk production of the dam (or milk consumption by the calf). The higher weaning weights and growth rates in the wet season reflect greater quantity of milk consumed and availability of good pasture for the young calves. Comparable results were obtained by Lampkin and Lampkin (1960), Neville (1962), Franke et al. (1975), Mwandotto (1978) and Thorpe et al. (1980). However, Boggs et al. 1980) found a non-significant effect of season on daily gain.

The effect of season on growth traits of handfed calves was opposite to that of suckling calves in that the calves born in the dry season performed better than those born in the wet season. The difference in weight at weaning was 8 kg and in average daily gain was 30 g (Appendix 3).

Since these calves obtained regular milk from season to season the significant effect of season on their growth performance was not expected. Season might have affected their health more than their milk intake as reflected in the results that the dry season was better for them than the wet season. The wet season, perhaps, exposed the handfed calves to more infections and other diseases.

4.4.4 Year

Year had a highly significant ($p < .01$) effect on growth traits of suckled calves but was only significant at the 5% level for handfed calves. Weaning weights and average daily gain increased progressively from 1969 to 1972 (Appendix 2) with a greater increase occurring between 1969 and 1970 (about 9% increase in weaning weight). Performance in 1971 was a little better than 1972 in all growth traits of suckled calves.

However, when maximum daily milk yield was considered (model 1), year effect was not significant. This indicates that year influenced milk production which in turn influenced growth performance. Williams et al. (1979) did not find significant effect of year on weaning weight when feeding regime of the cows and calves remained the same throughout. It also suggests that year has no effect on growth of calves if milk yield of the dam is adequate. This means calves of high milking dams would not be affected by year. Other workers (Lampkin and Lampkin, 1960; Neville, 1962, Franke et al., 1975; Mwandotto, 1978 and Trail et al., 1982) found significant effect of year on growth traits of suckled calves. The progressive improvement in growth performance of the calves could be due to change in rainfall availability and actual improvement in genotype of the calves since more and more superior sires were being used in the farm.

For handfed calves, year effect was significant only at the 5% level and not at the 1% level. Calves born in 1969 were 7.79 kg heavier at weaning than those born in 1970 (Appendix 3). Since these calves were being fed on regular amount of milk up to a certain age (8 weeks), the effect of year was less pronounced. Secondly, the years 1969 and 1970 which were the only years considered in the handfed calves' growth might have been rather similar compared with the four years (1969 - 1972) considered for the suckled calves.

4.4.5 Weaning Age

Weaning age was highly significant for weaning weight of both suckled and handfed calves but was not significant for monthly and daily weight gains of suckled calves. The weaning weight of suckled calves increased by 568.9g for every extra day, and that of handfed calves increased by 244.8g per extra day (Appendix 1). The greater increase in weaning weight of suckled calves reflects the additional influence of milk on growth. As lactation advances the calf gets less and less milk but eats more and more other feeds, therefore, there is no serious growth check at weaning.

The effect of weaning age on weaning weight is as expected for both suckled and handfed calves because calves at different ages have different weights according to their position in the growth curve. Since weaning age did not significantly affect growth rate of the suckled calves, the observation made by Reynolds et al. (1978) that calf age and milk yield of dam were not significantly correlated support these results. The significant effect of weaning age on weaning weight is, therefore, due to the initial differences in weight and the length of growing period but is not due to growth rate.

4.4.6 First Weight of Calf

The effect of first weight of suckled calves was highly significant for weaning weights but was not significant for growth rates per month or per day. Partial regression coefficients (Appendix 1) show that for each kilogramme of initial weight of calf, there was an increase of 1.52 kg in weaning weight. This agrees with the results obtained by Neville (1962) that heavier calves at birth maintained the advantage up to weaning and that their rate of weight gain was not affected by their birth weight. Lampkin and Lampkin (1960) also noted that superiority of male calves over females at weaning still remained highly significant even at constant birth weights suggesting that difference in birth weight was not responsible for difference in weaning weights in the case of male and female calves.

First weight did not have any significant effect on weaning weights of handfed calves but had a highly significant effect on monthly and daily weight gains. First weight affected growth rate negatively, in that calves with higher initial weight lost more weight at the beginning of rearing period and grew at a slower rate. It seems as though high initial weights are advantageous to suckled calves in that they maintain the superiority throughout the growth period and they are able to suckle more vigorously and obtain more milk. Partial regression coefficients for first weight on weaning weight, total weight gain and growth rate per month and per day were negative but small (Appendix 1). The non-significant effect of first weight on weaning weights obtained in handfed calves can be explained by the fact that calves lost weight in the first stage of handfeeding then only picked up slowly, thus affecting their overall growth rate. Mudgal and Ray (1965) attributed the slow rate of gain in the first 2.5 months to initial loss in weight.

4.4.7 Age of Dam

Age of dam did not significantly influence growth traits of suckled calves. Since age of dam did not significantly influence milk yield of suckled cows the non-significant effect on growth traits is expected. Partial regression coefficients (Appendix 1) indicate that age of dam had negative effect on all growth traits of the calves. This means that older cows weaned smaller calves compared to those of younger cows. The influence however was not significant. The effect of age of dam on growth traits has been reported significant by Mwandotto (1978) and Williams et al. (1979).

4.4.8 Milk Yield/Intake

Milk yield by the dam or milk intake by the calf significantly affected all growth traits of the suckled calves (Table 7). The influence of milk intake by calf reduced the influence of calf genotype on weaning weights as indicated earlier. When milk consumption by the calf is considered the difference in weaning weight between different calf breeds is reduced. The fact that when milk yield of the cow or milk intake by the calf is considered (its effect removed) the Sahiwal and Boran calves performed quite alike, indicates that the difference in their growth traits is influenced by the difference in milk yield or milk intake. Partial regression coefficients for average daily milk yield/intake and weaning weight showed that for every kilogramme of daily milk yield/intake there was additional 9.37 kg of weaning weight and 40g of average daily gain. The effect of one kilogramme of milk consumed per day on growth traits is quite similar to what has been reported by other workers. Wistrand and Riggs (1966) found an increase of 50 - 90g in average daily gain per kilogram of milk consumed while Boggs et al. (1980) found an increase of 7.2 kg in 205 day weaning weight per kilogram of milk consumed.

4.4.9 Rearing Method

The effect of rearing method on growth performance of the calves was highly significant. Suckled calves were 37.75 ± 3.12 kg heavier at weaning and gained 156.7 ± 13.1 g more per day than the handfed calves. When the two rearing methods were considered (model 3), the effects of season, year and sex of calf were reduced to non-significant levels while all the three effects were significant for the separate rearing methods (models 1 and 2).

The effect of season and year is smaller under handfeeding because the calves are on milk for a shorter time than the suckling calves and the amount of milk fed does not depend on the amount of milk produced by the dam. The influence of calf sex is also smaller in handfed calves since differences in vigour of suckling is not applicable as in suckling calves. Another reason for the non-significant effect of season, year and calf sex on growth traits in model 3 is that under separate analysis of the handfed and suckled calves, the effect of season was contrasting in that handfed calves performed better in the dry season and vice versa for suckled calves. This might have changed the effect to non-significant level. Also for model 3 only the years 1969 and 1970 were considered, and these might have been similar in their influence on growth performance

Since the difference in average daily gain of suckled and handfed calves was large and highly significant ($p < .01$), the two rearing methods had significantly different effects on weaning weight. This agrees with reports in the literature (Lampkin and Lampkin, 1960; Ronningen et al., 1972; Veitia and Simon, 1972; Ugarte, 1977; Randel, 1981).

4.5 Factors Influencing Milk Yield of Suckled Cows

Table 8 shows the influence of various factors on milk yield of suckled cows.

4.5.1 Calf Breed

The influence of calf breed on milk production by the dam was highly significant. The results showed that crossbred calves (Friesian x Sahiwal and Friesian x Boran) obtained more milk from their dams than straightbred calves (15% and 7% more, respectively). Between the crossbred calves Friesian x Sahiwal calves obtained 11% more milk than Friesian x Boran calves. These results agree with those of Reynolds et al. (1978) who reported a 16% increase in milk yield when dams were suckled by crossbred calves and also found that different dam breeds were influenced by calf breed to varying extents.

The difference in the amount of milk obtained from the dams by different calf breeds may be due to difference in birth weight of the calves. It has been observed that heavier calves at birth suckle more vigorously and more frequently, thereby removing more milk from their dams than lighter ones (Drewry et al., 1959; Reynolds et al., 1978). It is likely that both higher milk production capacity of Sahiwal dams and greater suckling vigour of the FS calves contributed to the differences in milk obtained by the FS crosses (suckling Sahiwal dams) and FB crosses (suckling Boran dams).

4.5.2 <u>Calf Sex</u>

Sex of calf was not significant for milk yield although males obtained slightly more milk in total than females. When first weights were considered (model 4), females showed higher milk consumption than males but the difference was not significant.

The non-significant effect of sex of calf on milk production of dam agrees with the results obtained by Reynolds et al. (1979), Williams et al. (1979), and Niedhardt et al. (1979). This suggests that calf sex is not as important as calf genotype or initial weight in determining the vigour with which calves suckle and the rate of milk secretion by the dam.

4.5.3 Season

Season had significant influence on all milk yield traits determined by WSW method (model 4) but was significant only for peak lactation yield determined by handmilking (model 5). Least squares solutions (Appendix 2) show that 129.4 kg more milk was produced in the wet season than in the dry season (a difference of 13%). Maximum daily yield, however, increased by 6.5% only. Table 8 shows that maximum daily yield was less influenced by season than the other yield estimates. This could be because maximum daily yield was realised at an early stage in lactation when other factors, including season were favourable. Several workers have reported significant influence of season on milk yield of dam when suckling and pasture without supplementation is used (Lampkin and Lampkin, 1960; Osman, 1970). This suggests that when suckling is involved, more milk is extracted from the cow than by normal milking (Totusek et al., 1973; Niedhardt et al 1979; Somerville and Lowman, 1980) such that seasonal limitations on pastures becomes more pronounced. This is reflected in the fact that the handmilked herd was not significantly affected by season of calving. The handmilked cows were not supplemented either, except for some factory waste that was given at milking. The non-significant effect of season on milk yield of handmilked cows was also reported by Nagpal and Acharya (1971), Kiwuwa (1974), and Lindstrom (1975) but Kimenye (1978) reported significant effect of season on milk yield of handmilked Sahiwals in Kenya. The effect of season on peak lactation yield is conflicting with effect of WSW estimates in that both the highest and the lowest yields were obtained in dry seasons (December - February and June - August). This could be due to the fluctuating nature of the seasons in this region. When seasons shift, the wet and the dry seasons overlap and the effect of season becomes difficult to determine. Besides, peak lactation yield covers more than one season (a full lactation period), therefore, season effect is not reflected.

Table 8 Analysis of Variance for Suckling and Handmilking Yield Estimates

Source and Models	df	Mean Squares				
		Total yield	Av. D.Y.	Max.D.Y.	305 D.Y.	Peak
Model 4						
Calf breed	3	224764.6 **	3.71 **	8.10*	345704.5 **	
Calf sex	1	13320.5 NS	0.21 NS	0.95 NS	20192.8 NS	
Season	1	11152860.0**	18.94 **	29.21 **	1760576. **	
Year	3	1405206.6**	23.75 **	63.21 **	2211036.2**	
1st calf wt.	1	305262.3**	5.09 **	2.99 NS	473606.7**	
Age of dam	1	69637.6 NS	1.22 NS	9.52 *	112333.8 NS	
Error	289	31747.8	0.55	2.16	50980.7	
Model 5						
Age of dam	9	480721.0**	4.77**			46412
Season	3	125500.4 NS	1.17 NS			54281
Year	3	81324.1 NS	0.39 NS			6198
Age at peak lactation	5	382476.0 *	2.82 NS			11979
Error	115	166066.6	1.66			128

KEY

Model 4 = Analysis for suckling cows
Model 5 = Analysis for handmilked cows
Av. D.Y = Average daily yield
Max.D.Y = Maximum daily yield
Peak L.Y= Peak lactation yield
* = p < .05
** = p < .01

4.5.4 Year:

Year effect on WSW milk estimates show a progressive increase in milk yield from 1969 to 1972. There was an increase of 39% in total milk yield from 1969 to 1972. The effect of year on WSW milk yield estimates indicate that there were some factors that improved over the study period, therefore, led to increased milk production by cows. Some of the factors could be improvement in the WSW procedure as the cows got used to the method, or improvement in genotype of the cows and the calves as more crossbreeding and more improved cows joined the herd. The other factor could be increase in age of the dams as the year progressed, assuming that milk yield increased with age of dam up to about eight years (Osman and El Amin 1971). The significant year effect was also obtained by Lampkin and Lampkin (1960) and Dawson et al. (1960). Reynolds et al. (1978) and Williams et al. (1979), however, did not get significant effects of year on WSW milk estimates. This could be because the management (feeding regime) in their study was uniform over the years. On the other hand, year was not significant for handmilking estimates. This could be due to the little supplementation they were given at milking time throughout the years. Besides, their milk yield was not influenced by the calf factor as in suckled cows.

4.5.5 Age at Peak Lactation

Age at peak lactation affected peak lactation yield of handmilked cows at the 1% level and total milk yield at the 5% level. The highest peak lactation yield was recorded for 8 year old cows although most cows reached their peak lactation by 6 years. These results confirm that Sahiwals reach their peak lactation between the third and fifth lactation when they are 6 - 8 years old. The same observation was made by Osman and El Amin (1971) for Sahiwals in India. The results also suggest that low milk producing cows reach their peak earlier, in the first 3 lactations. This is confirmed by the observation that those which reached their peak yield at 3 years old (first lactation) had the lowest peak lactation yield (1935 kg compared with 2718 kg of 8 year old cows).

4.5.6 First Weight of Calf

First weight of calf in this study refers to the weight of calf at the beginning of suckling period and not necessarily birth weight. First weight was highly significant for total milk yield and average daily yield but not for maximum daily yield (Table 8). Partial regression coefficients for first weight on 305 day milk yield showed that for every kilogramme of first weight of calf there was 8.6 kg increase in 305 day yield (Appendix 2).

The fact that the first weight of calf did not significantly influence maximum daily yield of suckled cows indicates that it exerts its effect mainly in early lactation. In this study maximum daily yield was reached around two months or later in lactation when stomach capacity of the calf was not a limiting factor. This suggests that the vigour of suckling by the calf in early lactation depends on its initial weight, hence on its stomach capacity. Neville (1962) found significant effect of birth weight on milk yield throughout the suckling period.

4.5.7 Age of Dam

Age of dam was not significant for WSW estimates of total milk yield and average milk yield but was significant for maximum daily yield ($p < .05$). Partial regression coefficients indicate that every lactation increased 305 days yield (Appendix 1) by 10.5 kg. This indicates that milk production is still on the upward trend in this herd. The effect of age of dam on maximum daily milk yield is of interest because it is the only milk parameter that is significantly affected by age of dam. Since in this study, age of dam had no significant effect on growth of calves either, it seems that effect of age of dam is important only at the stage when there is highest milk production or highest demand for milk by the calf. The non-significant effect of age of dam on milk yield of suckled cows could be that the cows used in this study were, on average, six years old, therefore, their milk production was still increasing and age was not a limiting factor yet (Osman and El Amin, 1971). On the other hand, age of dam was highly significant for total milk yield and average daily yield of handmilked cows but not for their peak lactation yield. The highest total milk yield among the handmilked cows was recorded for 5 and 7 year old cows (23% higher than the yield of 3 year old cows).

This is opposite to the effect of age of dam on suckled cows where maximum yield was the only factor affected by age of dam. Suckling could be responsible for the non-significant effect of age of dam on total milk yield if the 240 days of suckling was too short to drain the cows of all the milk they are capable of producing. In the case of handmilked cows, the long lactation length of 305 days on average could have ensured complete milk removal and therefore a greater challenge to the cow's milk production capacity.

Nagpal and Acharya (1971) found non-significant effect of age of dam on milk yield of Hariana cattle but a significant effect for Sahiwals. This indicates that there are breed differences in influence of age of dam on milk yield. Reynolds et al. (1978) and Williams et al. (1979) working with suckled beef cows found age of dam significant for milk yield while Niedhardt et al. (1979) and Boggs et al. (1980) found no significant difference in milk yield between young Polled Hereford cows (3 - 4 years old) and older cows (9 years and over).

4.6 Milk Production and Calf Performance

4.6.1 Correlations Between Growth Traits of Calf and Milk Yield of Dam

Table 9 shows the correlations between growth traits of calf and milk yield of dam. There were high correlations between total milk yield and weaning weight (r = .51) and between total milk yield and growth rate per month (r = .53). Average daily gain of the calves had close correlation coefficients (r = .43 to .48) with average daily milk yield throughout the suckling period. This figure agrees with the 0.46 obtained by Williams et al. (1979) but is lower than 0.54 reported by Ronningen et al. (1972) and 0.61 reported by Reynolds et al. (1978). It is however higher than 0.29 reported by Schwulst et al. (1966), who obtained non-significant correlation between average daily gain and milk yield in the first two weeks and significant correlation in the third week (r = .63).

The close correlation coefficients between average daily gain in various months of lactation indicates the need for milk by the calf throughout the suckling period. Partial regression coefficients for average daily milk yield and weaning weights (Appendix 1) showed that for every kilogramme of milk consumed there was an increase of 9.37 kg and 40g in weaning weight and average daily gain, respectively. These results are close to 50 - 90g per day for every kg of milk consumed, obtained by Wistrand and Riggs (1966) and 7.2 kg increase in weaning weight (205 days) for every kg of milk consumed per day obtained by Boggs et al. (1980).

However, the correlation between average daily gain and total milk yield decreases in the 2 month periods as shown in Table 9 (r = .46 - .12). The decreasing correlation was also observed by Franke et al. (1975), Neville (1962) and Schwulst et al. (1966). The correlations indicate that the calf is fully dependent on milk production of the dam in the first 2 months and thereafter the correlation decreases as the calf starts to eat other feeds. This result agrees with the observation made by Neville (1962) that the relationship between milk production of the cow and growth rate of the calf is greater in the first 60 days then it decreases as the calf depends more on other feeds and less on milk. While the correlation between average daily gain and total milk yield varied from period to period, growth rate per month had an overall correlation of 0.53 with total milk yield. This agrees with results obtained by Ronningen et al. (1972) and Reynolds et al. (1978) for average daily gain. Dinkel and Brown (1978) and Chenette and Frahm (1981) obtained lower correlations while Neville (1962), Wistrand and Riggs (1966), Totusek et al. (1973) and Franke et al. (1975) obtained higher correlations between milk yields of dams and weaning weights of their calves.

Table 9 Correlations between growth traits of calf and milk yield of dam

Growth Trait	Total Milk yield	Average daily yield
1-2 months ADG	0.46	0.46
3rd-4th month ADG	0.29	0.43
5th-6th month ADG	0.18	0.48
7th-8th month ADG	0.12	0.46
Weaning weight	0.51	---
Growth rate per month	0.53	---

KEY

ADG = Average daily gain

-- = Parameters not estimated

4.6.2 Conversion Efficiency

The conversion efficiency seems to be quite consistent throughout the suckling period (Table 10). The first two months had higher efficiency (13%) compared with 11% in the third month. This efficiency is quite comparable with 9% reported by Drewry et al. (1959) at three months, 13% reported by Lampkin and Lampkin (1960) and 11% reported by Niedhardt et al. (1979) for the whole suckling period, but higher than 8% reported by Drewry et al. (1959) at one month of suckling. Drewry et al (1959) observed that the efficiency was increasing while in this study, it decreased slightly with the advancing stage of lactation although the seventh month had the highest efficiency (14%). Neville (1962) also obtained different efficiencies (9% and 17%) at different nutritional levels of the calf. The reason for decreasing efficiency of conversion for milk could be due to the amount of other feeds being consumed by the calf.

The suckled calves had higher conversion efficiency than handfed calves (i.e. less milk consumed per kg of weight gained). The results show that suckling calves consumed an average of 1272.35 kg of milk and gained an average of 159.43 kg which gives a conversion efficiency of 12.5% compared with a conversion efficiency of 8.6% obtained for handfed calves. The amount of milk consumed per day by suckled and handfed calves are quite comparable (5.53 kg and 5.57 kg per day respectively), therefore, the faster growth rate and higher final weight at 240 days achieved by suckled calves indicate the superiority of suckling as a calf rearing method over handfeeding of calves.

Table 10 Daily and Monthly Milk Consumption, Weight Gains and Efficiency of Conversion

Month	Weight Gains (kg)		Milk Consumption (kg)		Efficiency %
	Monthly	Daily	Monthly	Daily	
1	21.71	0.72	165	5.50	13.16
2	23.99	0.80	185	6.18	13.00
3	20.25	0.67	182	6.07	11.13
4	21.25	0.71	173	5.79	12.30
5	20.50	0.68	157	5.25	13.10
6	17.26	0.58	149	4.90	11.60
7	19.26	0.64	136	4.55	14.16
8	14.95	0.50	129	4.30	11.58
1 - 8	159.43	0.66	1272	5.31	12.50

4.6.3 Lactation and Growth Curve

Table 10 shows the monthly yields and average daily yields in each month as lactation proceeds and monthly gains and average daily gains in each month. Peak milk production was reached at the end of the second month. There was a 12% increase in production from first month to the second month. This increase indicates the increased capacity of the calf to consume more milk (Figure 1). This compares well with Lampkin and Lampkin (1960) who obtained peak yield in the seventh week for Borans in Kenya while Dawson et al. (1960) obtained peak yield at the end of second month for beef Shorthorn cows. Other workers have also reported peak production to occur between one and two months (Drewry et al., 1959; Neville 1962; Totusek et al., 1973; Williams et al.,1979; Somerville and Lowman, 1980; Randel, 1981). In this study the average daily milk yield was still 4.3 kg at 8 months. Lampkin and Lampkin, (1960) also obtained 3 kg of milk per day in the last week of suckling and Dawson et al. (1960) obtained 6 kg of milk per day in the last month of suckling.

Weight gains followed the same trend as milk yield of dams (Figure 2). The highest gain occurred in the second month although quite a similar range of gain was maintained from first to 5th month before it decreased in the 6th month. This trend in the growth curve is also reflected in the high correlation between the first 5 months growth with total weight gain (r = .61 - .74). The same observation was made by various workers (Veitia and Simon, 1972; Totusek et al., 1973; Franke et al., 1975) who found the highest average daily gain occurring from second month to 5th month. They also obtained high correlation between average daily gains and weaning weight or total weight gain. Handfed calves, on the other hand, had very poor gains in the first month in this study (Figure 3). Rate of weight gain reached the peak at two months but was still very low compared with that of suckled calves. This agrees with the results obtained by Mudgal and Ray (1965) who observed highest average daily gain in the 5th month and lowest in the first 2.5 months.

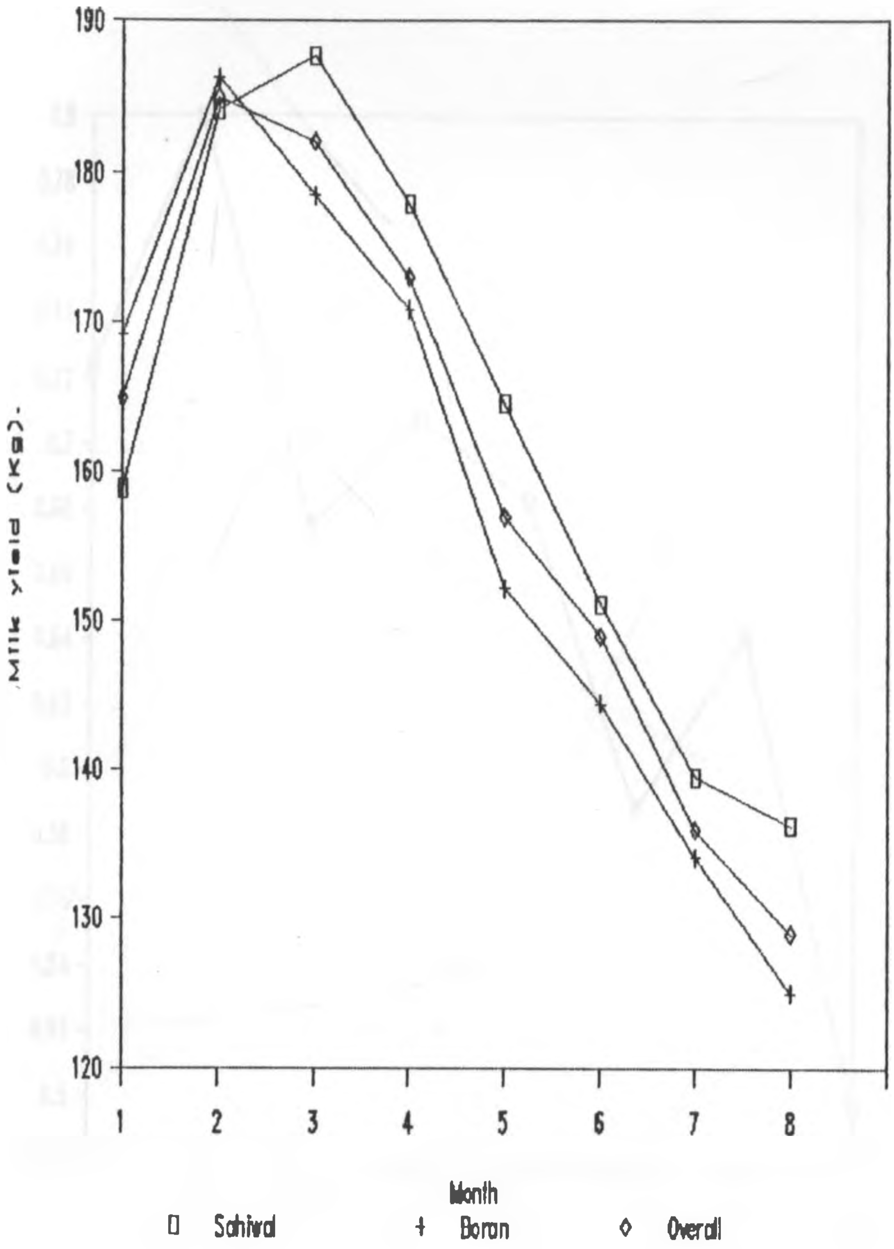

Figure 1 Lactation Curve for Sahiwal, Boran and Both Breeds Combined (Overall)

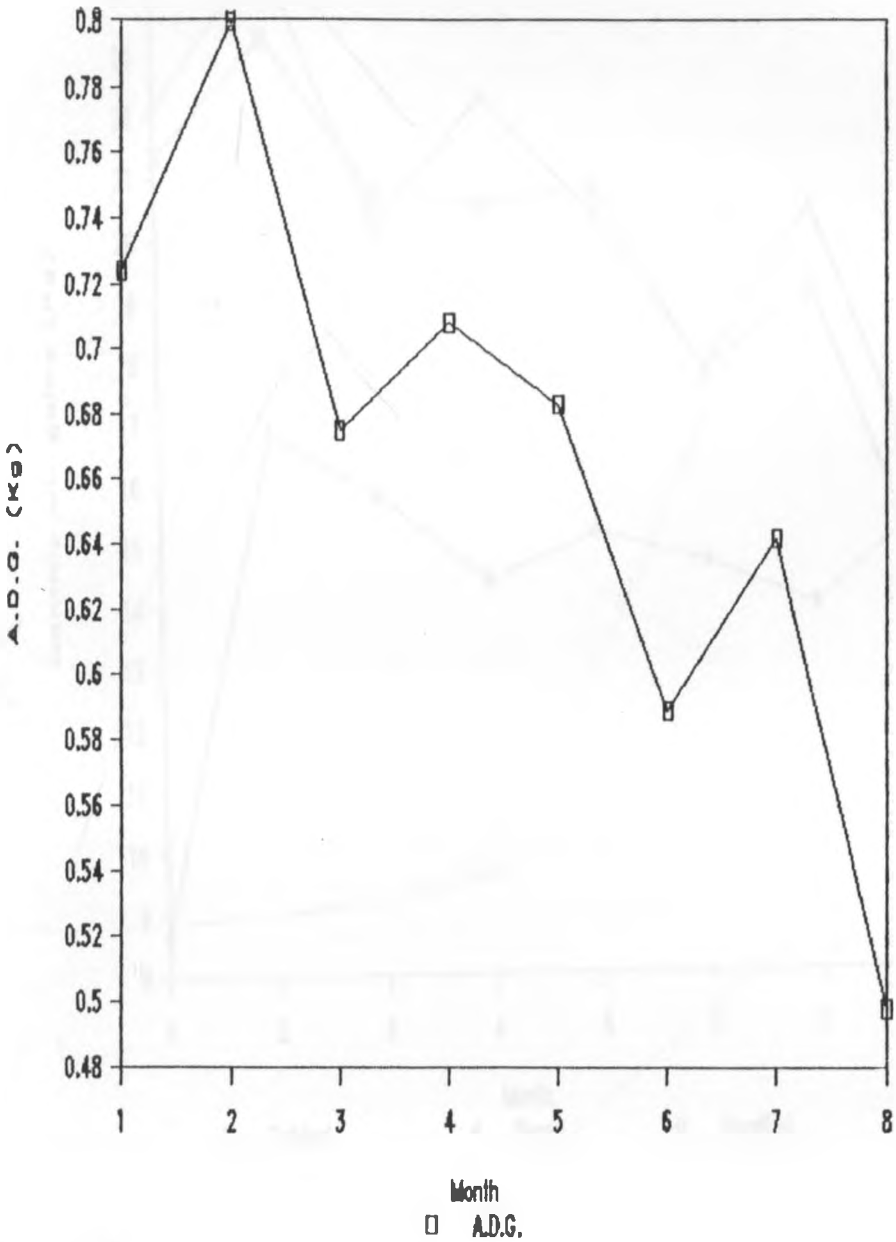

Figure 2 Growth Curve for Both Breeds (ADG)

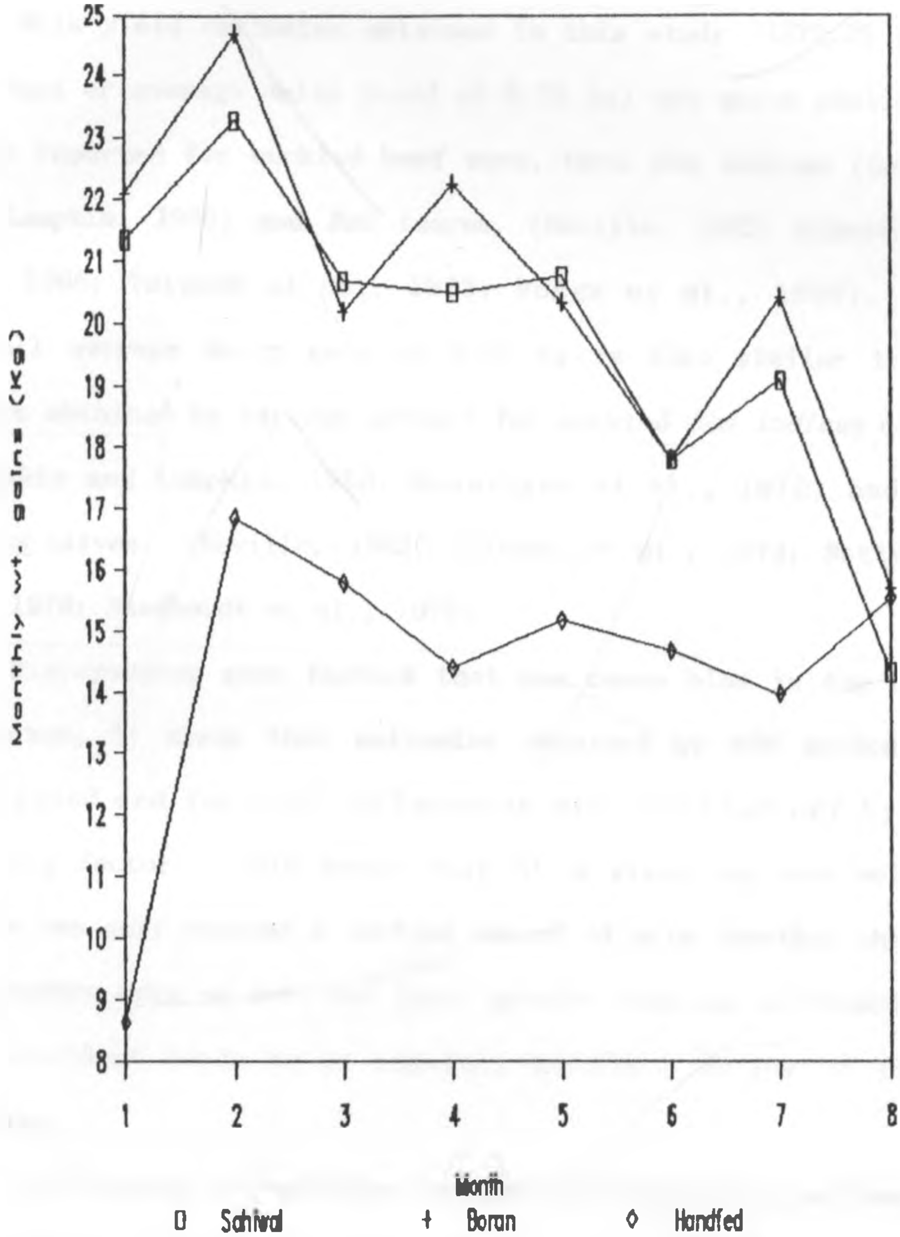

Figure 3 Growth Curve for Sahiwal, Boran and Handfed Calves

5. SUMMARY AND CONCLUSIONS

Milk yield estimates obtained in this study (1272.35 kg in 240 days or average daily yield of 5.31 kg) are quite similar to those reported for suckled beef cows, both *Bos indicus* (Lampkin and Lampkin, 1960) and *Bos taurus*, (Neville, 1962; Schwulst et al., 1966; Totusek et al., 1973; Boggs et al., 1980). The overall average daily gain of 0.66 kg is also similar to the figure obtained by various workers for suckled *Bos indicus* calves (Lampkin and Lampkin, 1960; Ronningen et al., 1972) and *Bos taurus* calves (Neville, 1962; Totusek et al., 1973; Notter et al., 1978; Niedhardt et al., 1979).

Disregarding some factors that may cause bias in the above estimates, it seems that estimates obtained by WSW method for milk yield and for calf performance are levelled off by the suckling factor. This means that at a given age and weight, calves can only consume a certain amount of milk (whether the dam can produce more or not) and their growth rate, as influenced by milk consumed tends to be regular, mainly a factor of their genotype.

Coefficients of variation for WSW and handmilking methods of determining of milk yield were quite similar (23.75 and 21.84%, respectively) suggesting that the two methods are quite comparable in their accuracy. Coefficient of variation for growth traits estimates for suckled and handfed calves were, however, different (13% vs 16%) suggesting that suckling as a rearing method allows the calf to realise its growth potential more than bucket feeding, therefore is ideal for growth performance studies.

Part-to-whole period correlations have also shown that the strategic points at which sample tests should be taken lie between the 2nd and 5th month when the correlations are highest and that the ideal number of tests for both milk yield and growth performance could be 5, all in the first 5 months of lactation/suckling since correlations between milk production and calf growth and correlations of part-to-whole period estimates decrease after the fifth month. Because the correlations between consecutive month estimates are highest in the first five months for both milk yield and growth rate estimates and the relationship between milk production of the dam and growth rate of the calf is greatest during the same period, calves can be conveniently weaned at 5 months after all the necessary information has been obtained both on milk production and growth rate. This was supported by the fact that both lactation and growth curves reached their peak at 2 months and then decreased in a similar manner. Conversion efficiency for milk consumed was also highest at 2 months. It is recommended that high yielding cows should be stripped after suckling or suckled more frequently to stimulate more milk production or to ensure complete emptying of the udder especially in the first month of lactation when the calf may not finish the milk.

It is shown that factors like season and year, calf breed and initial weight of the calf significantly influenced both milk production of the cows and weaning weights of the calves. Milk yield of the cows in turn significantly influenced weaning weight and growth rate of the calves. Since the same factors influenced both traits, they should be corrected for in suckling experiments. Age of dam did not have significant effect on both milk yield and calf growth traits. However, age of dam significantly influenced milk yield of handmilked cows. Milk yield of cows older than 8 years on average should be corrected for age in milk yield estimates since milk yield decreases around eight years of age.

Calf breed effect showed that FS calves were 18% better than pure Sahiwal calves both in weaning weight and average daily gain while FB calves were 13% higher in weaning weight and 18% higher in average daily gain than Boran calves. This means that FS calves had greater improvement in weaning weight and growth rate over pure Sahiwals than FB calves had over pure Borans. The crossbred calves (FS and FB) also obtained more milk from their dams (15% and 7% respectively) than their straightbred counterparts.

Weigh-Suckle-Weigh estimates for milk yield determination in suckler herds is, therefore, just as good as other methods, with the advantage of being a better calf rearing method that enables the calf to realise its potential for growth traits. The growth traits estimates by WSW method are higher and less variable than estimates obtained by handfeeding. Since WSW method estimates both milk yield of dam and calf performance in one experiment it achieves two goals at once, thus making it cheaper than two operations separately. This is supported by the high correlation between growth rate of the calf and milk yield of the dam and the fact that both traits reach their peak at the same time suggesting the possibility of weaning as early as 3-5 months of age. The two estimates are also affected equally by common factors like calf breed, season, year and birth weight of the calf.

REFERENCES:

Acharya, R.M. and Nagpal, M.P. 1971. Studies on Sahiwal dairy herd records: genetic and phenotypic parameters for milk production. Indian J. Anim. Sci., 41 (7): 511.

Amble, V.N., Jaine, J.P., Dave, A.D., and Amin V.C. 1965. Estimation of the amount of milk suckled by calves. Indian J. Vet. Sci. 35: 56.

Anthony, B. W., Mayton E.L., Brown V.L., and Patterson T.B. 1959. A new technique for securing milk production data for beef cows nursing calves in nutrition studies. J. Anim. Sci. 18: 1541.

Bel Isle, D.M., and Swanson L. 1978. Effect of calf contact on hormonally induced lactation. J. Dairy Sci. 61: 509.

Biswal, G. and Rao, A. M. 1960. Effect of weaning on Red Sindhi cows. Indian Vet J. 37: 383.

Boggs, D.L., Smith, E.F., Schalles, R.R., Brent, B.E., Corah L.R., and Pruit R.J. 1980. Effects of milk and forage intake on calve performance. J. Anim. Sci., 51: 550.

Bowden, D.M. 1980. Feed utilization for calf production in the first lactation by 2 year old F1 crossbred beef cows. J. Anim. Sci. 51: 304.

Chenette, C.G. and Frahm, R.R. 1981. Yield and composition of milk from various two breed cross cows, J. Anim. Sci. 52: 482.

Dawson, W.M., Cook, A.C., Bradford and Knap Jr. 1960. Milk production of beef Shorthorn cows. J. Anim. Sci. 19: 502.

Dickinson, F.N., and McDaniel, B.T. 1969. Single milking yields versus 24-hour yields for estimating lactation milk production by the test interval method. J. Dairy Sci. 53 (2): 200.

Dinkel, C.A., and Brown, M.A. 1978. Evaluation of the ratio of calf weight to cow weight as indicator of cow efficiency. J. Anim. Sci. 46 Vol. 3: 614.

Drewry, K.J., Brown, C.J., Honea, R.S. 1959. Relationships among factors associated with mothering ability in beef cattle. J. Anim. Sci. 18: 938.

Franke, D.W., Burns, W.G., and Koger, M. 1975. Milk yield and pre-weaning growth in beef cattle J. Anim. Sci. 41: 267 (abstract).

Galukande, E.B., Mahadevan, P., and Black, J.G. 1962. Milk production in East African Zebu cattle (a paper on investigations done in Kenya) Anim. Prod. 4:329.

Gregory, K.E., Swiger, L.A., Koch, R.M., Sumption, L.J., Rowden, W.W., and Ingall, J.E. 1965. Heterosis in preweaning traits of beef cattle. J. Anim. Sci. 24:21.

Hayman, R.H., 1972. *Bos indicus* and *Bos taurus* crossbred dairy cattle in Australia II: Effect of calf removal and prolactin treatment. Australian J. Agric. Res. 24: 449.

Johanson, I. 1961. Genetic Aspects of Dairy Cattle Breeding. Urbana. University of Illinois Press pp. 230-232.

Kimenye,D.M. 1978. A genetic study of the Kenya Sahiwal breed (Ph.D Thesis, University of Nairobi). pp. 92-95.

Kiwuwa, G.H. 1974. Age, year and season effects on dairy cattl performance of Friesian and Jersey cattle on privatel owned farm in Kenya. East African Agric. For. J. p. 298.

Koch, R.M., and Clark, R.T. 1955. Influence of sex, season o birth and age of dam on economic traits in range bee cattle J. Anim. Sci. 14: 386.

Lampkin,K., and Lampkin, G.H. 1960. Studies on the production o beef from Zebu cattle in E. Africa. II Milk production i suckled cows and its effect on calf growth. J. Agric Sci. 55: 233.

Le Du, Y.L.P., Baker R.D., and Barker, J.M. 1978. Secretion rat in suckler cows. J.Dairy Res. 45: 1.

Lengeman, F.W., and Allen N.N., 1955. The development of rume function in the dairy calf. I. Some characteristics o the rumen contents of cattle of various ages. J. Dairy Sci. 38: 651.

Lindstrom, U.B., 1975. Studies on milk records from Kenya. I Accuracy of milk recording with various intervals. Z Tierzuchtg. Zuchtgbiol. 93: 146.

Mahadevan, P. 1966. Breeding for milk production in tropica cattle. Technical Communication No. 17 of th Commonwealth Bureaux of Animal Breeding and Genetic Edinburgh pp. 154.

Marples, H.J.S., 1962. Birthweights and gains in weights to si months of age of Uganda cattle. E.A. Agric. For. J. 29:39.

Mason, I.L., 1963. Genetic relations between milk and bee characters in dual-purpose cattle breeds. A.R.C. Unit c Animal Genetics. Institute of Animal Genetics, Edinburg pp. 31.

Mason, I.L., 1965. Report to the Government of Kenya on th National Sahiwal Stud. F.A.O. Rep., Rome, 1965. pp. 24.

Mason, I.L., and Maule, J.P. 1960. The indigenous livestock c Eastern and Southern Africa. Technical Comm. No. 14 c the commonwealth Bureau of Animal Breeding and Genetics Edinburgh. pp. 151.

McCarthy, R.D., and Kessler, E.M. 1956. Relation between age c calf, blood glucose, blood and rumen levels of volatil fatty acids and in vitro cellulose digestion. J. Dair Sci. 39: 1280.

McDaniel, B.T., 1969. Accuracy of sampling procedures fc estimating lactation yields (a review) J. Dairy Sci. 52 1742.

McGinty, D.D., and Frerichs, W.G. 1971. Milk yields and cal performance from crossbred and Hereford cows. J. Anim Sci. 33: 210.

Morgan, W.T.W., 1972. East Africa: Its People and Resources Oxford University Press, pp. 312.

udgal, V.D., and Ray, S.N. 1965. Growth studies on Indian breeds of cattle. II. Studies on the growth of Sahiwal cattle. Indian J. Dairy Sci. 18: 14.

wandotto, B.J., 1978. Factors affecting weaning weight of the small E.A. Shorthorn Zebu, Boran, Sahiwal, Boran x E.A.S.Z., Sahiwal x E.A.S.Z, Fresian x Boran and Fresian x Sahiwal cattle at Kiboko and Buchuma (Kenya). Msc. thesis, University of Nairobi pp. 72.

agpal, M.P., and Acharya R.M. 1971. Studies on Sahiwal dairy herd records: effect of non-genetic factors. Indian J. Anim. Sci. 41(7): 515.

aidu, K.N., and Desai, R.N. 1965. Genetic studies on Holstein Friesian x Sahiwal cattle for their suitability in Indian tropical conditions as dairy animals. Indian J. Vet. Sci. and Anim. Husb. 35(3): 197.

du, Ihe Dim. 1977. Genetic correlation between growth rate and milk yield. Swedish J. Agric. Res. (7): 25.

eville,W.E., 1962. Influence of dam's milk production and other factors on the 120 and 240 days weight of Hereford calves. J. Anim. Sci., 21: 315.

gere, L.O., Mc Dowell, R.E., Bhattacharya, S. and Guha, H., 1973. Factors influencing milk yield of Hariana cattle. J. Anim. Sci. 36(3): 457.

iedhardt, R., Plasse, D., Weniger, J.H., Verde, O., Beltran, J., and Benavides, A., 1979. Milk yield of Brahman cows in tropical beef production system. J. Anim. Sci. 48(1): 1.

Notter, D.R., Cundiff, L.V., Smith G.M., Laster D.B., and Gregor
K.E. 1978. Milk production in young cows ar
transmitted and maternal effects on preweaning growth c
progeny. J. Anim. Sci., 46: 908.

Osman, A.H. 1970. Genetic analysis of daily milk yield in
dairy herd of Northern Sudan Zebu cattle. Trop. Agric
Vol. 47: 205.

Osman, A.H., and El Amin, F.M. 1971. Inheritance of som
reproductive and milk production traits. Trop. Agric
Vol. 48(3): 201.

Pahnish, O.F., Brinks, J.S., Urick, J.J., Knapp, B.W. and Riley
T.M. 1969. Results from crossing beef x beef and beef
dairy breeds: Calf performance to weaning. J. Anim
Sci., 28:291.

Pollock, W.E., and Hurnick, J.F. 1978. Effect of calf calls c
rate of milk release of dairy cows J. Dairy Sci. 61
1624.

Randel, R.D. 1981. Effect of once-daily suckling on post partu
interval and cow-calf performance of first calf Brahman
Hereford heifers. J. Anim. Sci., 53(3): 755.

Rege, J.E.O. 1986. 'REGE 1' A Least Squares Programm
Fortran 77) that does Analysis of Variance and Regr
Analyisis for Non-orthogonal data. Dept.
Production Univ. Nairobi, Kenya.

Rendel, J. 1972. Dairy cattle in hot climates. World Rev
Anim. Prod. 8: 16.

Reynolds, W.L., De Ronen, T.M., and Bellows, R.A.,
Relationships of milk yield of dam to early growth
of straightbred and crossbred calves. J. Anim.
47(3): 584.

Ronningen, K., Lampkin, K., and Gravir, K. 1972. The inf
of environmental factors on some traits in Boran c
Sweedish J. Agric. Res. Vol. 2: 209.

Schwulst, F.J., Sumption, L.J., Swiger, L.A., and Arthand
1966. Use of oxytocin for estimating milk product
beef cows. J. Anim. Sci. 25: 1045.

Sing, R.A., and Desai, R.N. 1967. Effect of body weight o
production. Indian J. Vet. Sci. and Anim. Husb. 37(

Somerville, S.H., and Lowman, B.G. 1980. A comparison of m
milking and the calf suckling technique as metho
measuring the milk yield of beef cows. Anim. Pro
365.

Swanson,E.W., and Claycomb, J.E. 1969. Oxytocin in dry
inhibits lactation. J. Dairy Sci. 52: 1116.

Syrstad,O. 1966. Studies on dairy herd records. Ac
Agriculturae Scandinavica. pp. 16.

Syrstad,O. 1977. Day-to-day variation in milk yield, fat conte
and protein content. Livestock Production Sci. 4: 14

Thorpe, W., Cruickshant, D.K.R., and Thomson R., 1980. Be
Production in Zambia. Anim. Prod. 30: 217.

Totusek,R., Arnett, D.W., Holland, G.L., and Whiteman, J.V. 19
Relation of estimation method sampling interval and m
composition to milk yield of beef cows and calf gai
J. Anim. Sci. 37: 153.

Trail, J.C.M., and Gregory, K.E. 1981. Characterization of
Boran and Sahiwal Breeds of cattle for econo
characters. J. Anim. Sci., 52:1286.

Trail, J.C.M., Gregory, K.E., Marples, H.J.S., and Kakonge,
1982. Heterosis addative maternal and addative dir
effects of the Red Poll and Boran breeds of cattle.
Anim. Sci. 54(3): 517.

Ugarte, J. 1977. Residual milk in cows suckling or not suckl
their calves after milking. Cuban J. of Agric. Sc
11(3) 1977.

Ugarte, J. and Preston, T.R. 1973. Rearing dairy calves
restricted suckling; III. The effect of reducing suckl
frequency to once daily, after the fourth week on m
yield and growth of the calf. Cuban J. of Agric. Sc
7(2):147.

Van Vleck, L.D., and Henderson, C.R. 1961. Extending part lactation milk records by regression, ignoring her effect. J. Dairy Sci., 44: 1519.

Veitia, J.L., and Simon L. 1972. Effect of two restricte suckling systems of calf rearing on milk production ar calf growth. Cuban J. of Agric. Sci., 6(2): 189.

Willham, R.L., 1972. Beef milk production for maximu efficiency. J. Anim. Sci. 34: 864.

Williams, J.H., Anderson, D.D., and Kress, D.D., 1979. Effect o separation interval on weigh-suckle-weigh milk estimates J. Anim. Sci., 49: 1438.

Wiltbank, J.N., and Cook, A.C. 1958. The comparativ reproductive performance of nursed cows and milked cows J. Anim. Sci. 17: 640.

Wistrand, F.C., and Riggs, J.K. 1966. Milk Production of Sant Gertrudis cows as measured by calf nursing and machir milking method. J. Anim. Sci., 25:263 (abstract).

Appendix 1 Partial Regression Coefficients for Various Variables

(Growth Traits and Milk Yield)

Variables	Traits			
	WW	GRM	ADG	305 DYD
Initial wt	1.05	0.00	0.00	8.63
Weaning Age	0.24	-.03	0.00	----
Age of dam	0.27	0.00	0.00	10.57
ADY	9.37	1.26	0.04	-----

KEY:

WW = Weaning Weight

GRM = Growth Rate per Month

ADG = Average Daily Gain

ADY = Average Daily Yield

305 DYD = 305 Days Adjusted Yield

Appendix 2 Least Squares Solutions for Suckled Calves

Factor		Traits			
		WW	GRM	ADG	ADY
Calf Sex	M	185 ± 22	20 ± 3	.69 ± .09	5.40 ± .90
	F	182 ± 22	19 ± 3	.64 ± .09	5.24 ± 1.06
Calf breed	S	173 ± 17	18 ± 2	.61 ± .06	5.16 ± 1.02
	B	178 ± 21	18 ± 2	.61 ± .08	5.07 ± 1.08
	FS	206 ± 17	22 ± 2	.74 ± .07	5.93 ± .62
	FB	202 ± 19	21 ± 2	.72 ± .08	5.43 ± .89
Season:	Wet	194 ± 22	20 ± 3	.68 ± .09	5.62 ± .99
	Dry	180 ± 22	19 ± 2	.63 ± .09	4.96 ± .89
Year:	1969	174 ± 19	18 ± 2	.60 ± .08	4.26 ± .79
	1970	189 ± 22	20 ± 2	.67 ± .09	5.36 ± .81
	1971	191 ± 23	20 ± 3	.68 ± .09	5.53 ± .89
	1972	193 ± 22	21 ± 2	.68 ± .08	5.90 ± .71

WW = Weaning Weight

GRM = Growth Rate per Month

ADG = Average Daily Gain

ADY = Average Daily Yield

Appendix 3 Least Squares Solutions for Handfed Calves

Factor		Trait		
		TWG	GRM	ADG
Calf Sex	M	113 ± 21	14 ± 3	.47 ± .09
	F	115 ± 17	14 ± 2	.48 ± .07
Season	Wet	110 ± 18	14 ± 2	.46 ± .08
	Dry	118 ± 19	15 ± 2	.49 ± .08
Year	1969	111 ± 17	14 ± 2	.46 ± .07
	1970	118 ± 20	15 ± 3	.49 ± .09

GRM = Growth Rate per Month

ADG = Average Daily Gain

TWG = Total Weight Gain

M = Male

F = Female

Appendix 4 Calf Breed and Rearing Method on Calf performance

Trait	Suckled				Handfed
	S	B	FB	FS	
WW	169.71	178.61	202.17	204.13	114.14
GRM	18.61	18.46	21.43	22.62	14.27
ADG	0.62	0.61	0.72	0.75	0.48

Key:

WW = Weaning weight

GRM = Growth rate per month

ADG = Average daily gain

FS = Friesian x Sahiwal

S = Sahiwal

B = Boran

FB = Friesian x Boran