PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF TANZANIAN INDIGENOUS GOATS AND THEIR CROSSES WITH KAMORAI AND BOER

BY

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ABSTRACT

A study was conducted to compare genetic and non-genetic factors affecting growth and reproductive performance of Kamorai x Small East African (SEA), Boer x SEA and SEA using records kept at Department of Animal Science and Production from 1972 to 1989. In addition, changes in body measurements and mortality rates were studied.

Birth weight and weaning weight were significantly ($P<0.05$) affected by genetic group, with Kamorai x SEA and Boer x SEA having higher values, respectively. Males were heavier than females in birth weight. Birth type and period of birth had significant ($P<0.01$ and $P<0.001$, respectively) effect on both birth weight and weaning weight. Effects of genetic group, sex and birth type on weight at 52 and 72 weeks and preweaning and postweaning growth rates was small and non- significant. There were genetic group differences in body measurements at certain ages.

Body weight could be best predicted by the following Equation $Y = -17.91 + 0.50X_1 + 0.15X_2 + 0.21X_3 + 0.19X_4$ where, Y = Predicted body weight (kg), X_1 = width at the hind quarter X_2 = body length, X_3 = height at the wither and X_4 = heart girth in cm.

Age at first kidding ranged from 638 to 984 days and kidding interval ranged from 293 to 419 days. Age at first kidding was significantly ($P<0.001$) influenced by period of birth. Period of kidding as well as season of previous kidding affected kidding interval significantly ($P< 0.01$, $P< 0.05$, respectively).

Overall mortality rate was 40.6% and 25.7% for preweaning and postweaning period, respectively. Animals with birth weights of less than 1.5 kg and birth weights greater than 2.6 kg had the highest (57.9%) and lowest (29.8%) preweaning mortality rates, respectively. Twins exhibited highest (48.3% Vs 38.5%) preweaning mortality rate compared to singles. Lowest preweaning mortality (26.7%) occurred in period 1 (1972-1974).

It can be concluded that the non-genetic factors especially period and season of birth were the main source of variation in postweaning growth traits, reproductive performance and mortality rates. There was no much gain achieved by crossing SEA goats with Kamorai and Boer. This was due to irregularity of management in terms of nutrition and diseases control for the crosses which probably hindered them not to express their genetic potential.

DECLARATION

I, BERHANU BELAY ABUNIE, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation has not been submitted for a higher degree award in any other University.

Signature____________________

Date 22/6/92

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DEDICATION

This dissertation is dedicated to my Parents

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AFK	Age at first kidding
b_1	Regression coefficient for width at the hind quarter
b_2	Regression coefficient for body length
b_3	Regression coefficient for height at the withers
b4	Regression coefficient for heart girth
b_o	Constant (intercept)
cm	Centimetre
CV	Coefficient of variation
df	Degree of freedom
F	Females
FAO	Food and Agricultural Organization of the United Nation
g	gram
IDRC	International Development Research Center
ILCA	International Livestock Centre for Africa.
kg	Kilogramme
KI	Kidding interval
M + F	Males and Females
M	Males
n	Number of observations
OAU	Organization of African Unity
R^2	Coefficient of determination
s.e	Standard error

SEA	Small East African goats
SUA	Sokoine University of Agriculture
TR	Twinning rate
X_1	Width at the hind quarter
X_2	Body length
X^2_c	Chi-square calculated
X_3	Height at the withers
X_4	Heart girth
Y	Independent variable

CHAPTER 1

INTRODUCTION

Tanzania has 6.6 million goats and 4.7 million sheep which contributes 13.8% of total meat produced in the country (FAO 1988). It is also estimated by FAO (1988), of the total milk produced in Tanzania 0.12% comes from goats. However, the contribution of meat from the small ruminants is small compared to their total potential which is estimated to be 80,931 metric tonnes of meat produced per annum (MALD 1984). This low output of meat is also a characteristic of other livestock species. Although there are 13.5 million head of cattle in Tanzania, which is next to only Ethiopia and the Sudan in cattle numbers in Africa, the total meat production and consumption is still disappointedly low (Table 1).

The annual per capita consumption of livestock products in Tanzania is estimated to be 9.7 kg of meat and 22.4 kg of milk. Animal protein consumption is about 11 g per day per person as compared to more than 50 g in developed countries (FAO 1988). The FAO minimum target is 21 g per day per person (Schmidt and Van Vleck 1974). There is also a great variation in protein consumption from one region to another and urban centres tend to consume more animal pro tein than rural areas. Since the population growth is

Table 1 : Meat production in Tanzania during 1988 [1,2]

Livestock species	No. of livestock ('000)	% offtake	Meat production ('000 meter-tonnes)	Meat production per species relative to total meat(%)	Meat protein consumption g/person/day
Cattle	13 500	11.6	162.0	71.6	7.9
Sheep	4 700	23.0	13.0	5.8	0.6
Goats	6 600	23.0	18.0	8.0	0.9
Pigs	184	71.7	5.0	2.2	0.2
Chicken	30 000	56.6	28.0	12.4	1.4

[1] Source : FAO 1988

[2] These are only estimates derived from abattoirs and skin sales. It does not include home slaughtering and consumption.

about 3.2% per annum (MALD 1984), there is urgent need for more effort towards increasing meat and milk output.

There is a need, therefore, to increase livestock productivity of the existing animals. Emphasis should be placed on animals which have higher production indices such as poultry, pigs and rabbits. However, efficient production from these animals depends on availability of surplus grains and agro-industrial by-products. In developing countries animals tend to compete for grains with man and preference for grain use is normally given for human consumption. More emphasis should, therefore, placed on livestock species, namely, ruminants which can make more use of available feed resources.

The importance of goats for meat, milk production and cash income need not be overemphasized. Goats have several production and social functions. They have better ability to convert forages into milk and meat than cattle and sheep (Devendra 1987). Their productivity index also outweighs that of cattle. In this aspect Wilson and Murayi(1988) showed productivity index of 442 g per kg of dam weight per year for goats in Rwanda, whereas Ankole cattle, which are native to that part of Africa, had an index of 199 g on comparable basis in a similar environment of South West Uganda (Trail et al. 1985).

In Tanzania goats are raised in a harsh environment in terms of nutrition,disease and management. The meat and milk production level from goats is therefore low in Tanzania.

There are many factors which contribute to the low production level. These can be classified into genetic factors such as within and between breeds variation and nongenetic factors, such as sex, season of birth, year of birth, birth type and dam kidding weight. For efficient meat production from goats one must improve the productive and reproductive efficiency of goats in terms of growth, age at first kidding, kidding interval and survival rate through improvement of the non genetic factors and use of proper breeding system. Growth of kids is an indicator of adaptation and viability and it is expressed as weight gain per unit of time. Litter size and kidding interval are important reproduction traits because of their effect on both efficiency of production and genetic improvement. Age at first kidding is also an important trait as it determines the life time productivity of the goats. Mortality rate should be given greater consideration as it is one of the major forms of reproductive wastage resulting in economic loss in goat farming.

The knowledge of weight of the animal is a pre-condition to find out the production indices at field level. Unfortunately, it is difficult to know the weight of the animal in rural areas, where information is not available. This is due to the scarcity of weighing scales under field conditions. Therefore, research should be extended which can help in the estimation body weight from external body measurements. The method should be applicable to different breeds sexes and age groups.

Production indices of goats can be improved through improving mature weight, increasing litter size, increasing survivability through selection within breeds coupled with good health care and nutrition. Genetic improvement through selection has not been tried seriously in Tanzania because it is a time consuming and money demanding procedure. Changing the genetic constitution of a population by selection requires skills and planning. In addition, good selection is impossible in flocks with inadequate or no records. This has led in the past to seek improvement by introducing crossbreeding programmes using exotic breeds.

In Tanzania improvement of performance of goats through crossbreeding and nutrition was initiated during the early colonial period (French 1944). However, no major systematic study was undertaken and in most cases, objectives were poorly defined. In the early 1970s a detailed crossbreeding programme was initiated at Sokoine University of Agriculture (SUA) (then Faculty of Agriculture, Forestry and Veterinary Science of University of Dar es Salaam) using SEA goats as a dam line and Boer and Kamorai as a sire line. The programme was well run up to 1975 and thereafter the breeding plan was not seriously followed. From the 1980s to date temperate breeds, like Saanen, Norwegian, Anglonubian and Toggenburg breeds have been introduced to improve milk production. This clearly indicates a change in approach to improve the available genotype. Instead of improving goats for meat production emphasis has changed to introduce milk genes into the meat type goat population.

It should not be assumed that imported goats will automatically adapt to the harsh environment and produce and reproduce at the same level as in their country of origin. It should also not be assumed that they will automatically improve production of indigenous breeds. Valuable genetic asset of indigenous goats such as adaptive characteristics in a harsh and hot climate can easily be lost in aiming for higher productivity from crossbreeding with exotic breeds, if the breeding programme is not well established.

There is evidence in Tanzania in the case of cattle where exotic indigenous crossbred outperformed pure bred indigenous animals. This has been realized under improved management, nutrition and health. It has also been recommended that under traditional system with slight improvement in management, 50% exotic indigenous inheritance in cattle can improve milk yield (Mgheni and Petersen

1989). There is no such evidence in goats. The accumulated data at SUA and West Kilimanjaro have not been systematically analyzed. Before widespread distribution of the crosses to the villages it is important to assess their on station performance.

There was therefore an urgent need to assess the existing crossbreeding programmes and develop appropriate recommendations. The purpose of this study was to compile, analyze and draw conclusions on production and reproduction traits from the data collected on Tanzanian indigenous goats and their crosses with Kamorai and Boer from 1972 to 1989 at Sokoine University of Agriculture. The knowledge to be gained from this study would partly facilitate improving the productivity of goats by devising economically efficient and sound management and breeding strategies. Specific objectives of the study were:

1. To compare local Tanzania goats and their crosses for growth, reproductive traits and viability.
2. To study the non-genetic factors affecting the above traits.
3. To investigate the association between body measurements and body weights.
4. From 1, 2 and 3 to suggest some recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Growth

2.1.1 Introduction

Fowler (1968) described growth to include two aspects: increase in mass per unit of time and changes in form and composition resulting from differential growth of the component part of the body. The process of growth and physiological factors governing it in young animals involves centripetal body growth and successive growth and development of the tissues: bone, muscle and fat in that order.

Growth can be expressed by measuring the actual weight change of the animal at particular period intervals or using growth curve and weight gain per unit of time. The rate of growth is one of the most important traits which should receive consideration in meat production as it has implications in the amount of meat output obtained and age at puberty.

The rate at which an animal grows is determined by genetic, non-genetic factors and the interaction between them. These factors contribute to the existence of variation in growth rates within breed, between breed and between species. The knowledge of breed differences on growth traits enables selection for fast growing breeds for meat production. Similarly, knowledge of non-genetic factors enables one to control or modify such effects to improve animal productivity. It also allows adjustment of records for reliable genetic parameter estimates.

In this review, genetic variability among and within breeds especially in tropical goats and their crosses with respect to growth performance is considered. Furthermore, the review includes non-genetic factors that affect growth performance of goats such as sex, birth type, season of birth, year of birth, parity and dam kidding weight.

2.1.2 Growth at different ages

The growth cycle was classified by Hafez (1963) into prenatal and postnatal stages, the latter being further classified into preweaning and postweaning periods. The preweaning growth of a kid is mainly influenced by maternal environment (the milk production and mothering ability of the doe) and management of the does and the kids. Postweaning growth pattern, on the other hand, is influenced by quality and quantity of the feed available and the ability of the animal to withstand harsh environments, including disease conditions. All animals grow faster when they are young. As they approach physiological maturity growth rate decreases until a stage is reached where there is no further increase of bone or muscle. Gain in live weight beyond this point is almost exclusively due to fat deposition (Preston and Willis 1970).

2.1.2.1 Birth weight

To make use of selection procedure as a breeding tool, birth weight is the first observation which can be used to select superior animals. Birth weight is an economic trait which has a positive relation with kid survival and postnatal development. In addition, there is positive relation between birth weight and adult size (Guha *et al.* 1968; Devendra and Burns 1970). Birth weight is highly variable as shown in Table 2. This variation is attributed to genetic and environmental factors.

The birth weight of kids depends primarily on adult size of the breed (Devendra and Burns 1970; Morand-Fehr 1981). This was clearly shown by Mchau (1979), Mukundan, Bhat and Khan (1982), Malik, Kanaujia and Pander (1986) and Wilson and Murayi (1988). Mchau (1979) showed significant differences in birth weight between Small East African (SEA), Boer x SEA and 3/4 Boer - ¼ SEA goats. He observed that birth weight increased with increasing proportion of Boer blood. Malik, Kanaujia and Pander (1986) reported significant differences in birth weight between Beetal, Black Bengal and Black Bengal x Beetal. In their study

Beetal kids had the heaviest (2.24 kg) and Black Bengal kids had the lightest (1.31 kg) weight at birth. The performances of the crosses were intermediate. Wilson and Murayi (1988) also reported birth weight of 2.4, 2.7 and 2.9 kg for SEA, Anglonubian x SEA and Alpine x SEA, respectively. Differences in birth weight between Assam local and Saanen x Assam local was reported by Bhadula (1979) and between Malabari and Malabari x Saanen by Mukundan, Bhat and Khan (1982). In both studies the crosses were superior. This variation is expected as birth weight is correlated with mature size and different breeds have different mature sizes. On the contrary, Kyomo (1978) working on Small East African (SEA), Kamorai x SEA and Boer x SEA goats failed to show significant differences in birth weight among genetic groups. This was attributed to poor environmental conditions which made the improver breeds failing to express their genetic potential under poor management conditions.

Birth weight is also markedly influenced by sex (Singh et al. 1977; Siddiqui et al. 1981; Khan and Sahni 1983; Naik, Patro and Mishra 1985; Malik, Kanaujia and Pander 1986; Sivaiah, Sadasiva Rao and Raghava Rao 1988 ; Wilson and Murayi 1988). Birth weight of male generally exceeds that of the females 5 to 15% (Morand - Fehr 1981; Sivaiah, Sadasiva Rao and Raghava Rao 1988). This is due to greater muscle cell number of males over females (Joubert 1956; Dass

Table 2 : Summary of birth weight (kg) of kids in the tropics

Breed	Location	Sex	Birth weight	Source
East African dwarf	Uganda	M	2.3	Wilson (1958)
		F	2.0	"
Black Bengal	India	M	1.3	Moulick and
		F	1.0	Syrstad (1970)
Jamunapari x Saanen	India	M	3.1	Singh et al.
		F	3.0	(1977)
3/4 Saanen - ¼ Jamunapari	"	M	2.6	"
		F	2.4	"
Jamunapari x Local	"	M	2.4	"
		F	1.9	"
Barbari x Saanen	"	M	2.2	"
		F	1.8	"
Barbari	"	M	1.8	"
		F	1.6	"
Local	"	M	1.4	"
		F	1.3	"
Boer x SEA	Tanzania	M+F	2.3	Kyomo (1978)
Kamorai x SEA	Tanzania	M+F	2.1	"
Small East African	"	M+F	2.0	"
Boer	"	M	3.1	Mchau (1979)
		F	2.3	"
7/8 Boer - 1/8 SEA	"	M	3.2	"
		F	2.7	"
3/4 Boer - ¼ SEA	"	M	2.8	"
		F	3.0	"
Boer x SEA	"	M	2.9	"
		F	2.4	"
SEA	"	M	2.0	"
		F	1.8	"
Osmanabadi	India	M	2.5	Siddiqui et al
		F	2.3	(1981)
Assam	India	M+F	1.1	Sarma et al (1981)
Beetal	India	M	3.5	Misra (1981)
	"	F	3.1	"
Tswana	Botswana	M+F	2.8	Senyatso (1986)
Boer x Tswana	"	M+F	3.0	"
Boer	"	M+F	3.2	"
Alpine x Saanen	India	M+F	3.1	Nagpal & Chawla (1985)

Table 2 cont.

Breed	Location	Sex	Birth weight	Source
Saanen x Beetal	India	M+F	3.1	Nagpal & chawla
Saanen x (Alpine x Beetal)	"	M+F	3.3	(1985)
Alpine x (Saanen x Beetal)	"	M+F	3.0	"
Beetal	India	M+F	2.2	Malik, Kanaujia
Black Bengal	"	M+F	1.3	Pander (1986)
Beetal x B. Bengal	"	M+F	1.6	"
B. Bengal x Beetal	"	M+F	1.9	"
Nellore	"	M	2.2	Sivaiah, Sadasiva
		F	2.1	Rao & Raghava Rao (1988)
Saanen x Katjang	Malaysia	M+F	2.1	Mohd, Sulaiman &
Anglonubian x Katjang	"	M+F	2.2	Othman (1988)
British Alpine x Katjang	"	M+F	2.0	"
Katjang	"	M+F	1.4	"
SEA	Rwanda	M+F	2.4	Wilson & Murayi
Anglonubian x SEA	"	M+F	2.7	(1988)
Alpine x SEA	"	M+F	2.9	"
Jamunapari	India	M	3.1	Roy,Prakash & Khan (1989)
		F	2.9	"
Black Bengal	"	M+F	1.6	Patnaik & S.Nayak
Ganjam	"	M+F	1.8	(1988)
Jamunapari	"	M+F	2.3	"
Blended x Galla	Tanzan	M+F	2.9	Das and Sendalo
Kamorai x SEA	"	M+F	2.7	(1990)
Blended	"	M+F	2.9	"
SEA	Kenya	M+F	2.0	Kiwuwa (1986)
Mubende	Uganda	M+F	2.1	"
Sudan nubian	Kenya	M+F	2.2	"
Galla	"	M+F	2.4	"
Boer	"	M+F	4.2	"
Galla x Boer	"	M+F	4.3	"

and Acharya 1970). However, Diliwali (1943) Mittal and Pandey (1978) found no difference between males and females, though males tended to be heavier than females.

Birth type is a source of variation in birth weight (Moulick and Syrstad 1970; Devendra and Burns 1970; Kyomo 1978; Siddiqui et al. 1981; Malik, Kanaujia and Pander 1986; Patnaik and Sukadev Nayak 1988; Roy, Prakash and Khan 1989; Das, Joshi and Bisht 1989). In these studies singles were heavier than twins by 13 to 20%.

Siddiqui et al. (1981) working with Osmanabadi goats and Nagpal and Chawla (1985) working with Alpine and Beetal goats, showed that season of birth has influence on birth weight. The study carried out by Naik, Patro and Mishra (1985) indicated that kids born in November and December had higher body weight at birth than those born in other seasons. This was due to the availability of browse during these months of the year. Similarly Sivaiah, Sadasiva Rao and Raghava Rao (1988) showed significant effect of season of birth on birth weight in Indian local kids. Kids born in rainy monsoon season were heavier than those born in other seasons. This was attributed to the availability of more tree leaves and shrubs in the monsoon season. Moulick and Syrstad (1970), Singh (1973) and Sarma et al. (1981), however, reported that there was no significant effect of season of birth on birth weight. This was due to uniform feed provision for the does throughout the year. It can be concluded that if feed provision is not limiting factor, effect of season of birth on birth weight is small and non significant.

Birth weight is further influenced by year of birth of the kid (Kyomo 1978; Mukundan, Bhat and Khan 1981; Nagpal and Chawla 1985). This is attributed to the availability of good quality and quantity of feed to the doe before parturition. Contrary to these findings, Sivaiah, Sadasiva Rao and Raghava Rao (1988), Khan and Sahni (1983) failed to show any significant difference in birth weight between years and attributed this effect to uniformity of management through out the years.

It has been reported by Nagpal and Chawla (1985) and Wilson and Murayi (1988) that kids born at later parities had heavier weight at birth and maximum birth weight was recorded from does at the third and fourth parity. However, better performance in birth weight has also associated with dam kidding weight (Mukudan, Bhat and Khan 1982).

The heritability value of birth weight ranges from 0.10 to 0.46 (Kyomo 1978; Mukundan, Bhat and Khan 1982; Malik, Kanaujia and Pander 1986 ; Roy, Prakash and Khan 1989).

These are low to medium values and it appears, therefore, that genetic progress can be achieved in improving meat production through selection procedure for birth weight.

2.1.2.2 Preweaning weights (birth to 4 months)

The period during which the kid suckles may last from 1 to 5 months depending on management (Devendra and Burns 1970 ; Morand-Fehr 1981). Growth performance of kids during the milk feeding period is linearly related with the intake of milk dry matter and more closely with energy intake level (Morand-Fehr 1981). Preweaning performance of the kids is also influenced by the breed, sex, birth type, season of birth, year of birth, dam kidding weight and parity.

A number of workers have examined the effect of breed on preweaning growth traits. Most have examined preweaning growth traits on station (Kyomo 1978; Mchau 1979; Mukundan et al. 1983; Malik, Kanaujia and Pander 1986; Patnaik and Sukadev Nayak 1988) and some on farm (Wilson 1976;Mukasa Mugerwa, Ephraim and Tadesse 1986; Lebbie and Manzini 1989). Mukundan et al.(1983) reported that Saanen x Malabari were heavier than Malabari kids 1 to 3 months of age. This difference was attributed to difference due to breed of sire (Saanen Vs Malabari), since the dam breed (Malabari) was the same in both cases, heterosis in halfbreds and the superiority of Saanen genes for preweaning growth traits exerted an effect. Malik, Kanaujia and Pander (1986) reported the influence of genetic group at 1 and 2 months weight. In this study Beetal goats were superior to Black Bengal and Black Bengal x Beetal. Similarly Patnaik and Sukadev Nayak (1988) found difference between Black Bengal, Ganjam and Jamunapari, the Jamunapari kids being heavier.

In the tropics, the superiority of Boer over other tropical breeds of goats need not be overemphasised. Reiser et al. (1985), cited by Shelton (1986) in Tunisia compared Boer goats with local and three European breeds (Alpine, Saanen and Poitevin) and found that Boer excelled in weight at preweaning period over locals and other European breeds. Furthermore, studies carried out by Kyomo(1978) and Mchau (1979) in Tanzania, Naude and Hofmeyr (1981) in South Africa, Senyatso (1986) in Botswana, all reported the superiority of Boer for meat production over other indigenous tropical goats. Singh and Sangar (1981), cited by Shelton (1986) reviewed small and large breeds of goats in India and noted that:

a) Growth rates and body weight at given ages favour larger breeds
b) All reproductive parameters tended to favour small breeds.

c) In terms of efficiency of growth and carcass yield, the larger breeds were not superior to smaller breeds, when slaughtered at comparable stage of growth (i.e 50% of mature weight).

d) The overall efficiency of meat production favoured small breeds.

These conclusions are drawn from limited trials in India. More detail and comprehensive studies on small and larger breeds in both growth, reproduction and survival or in general terms on production indices is required.

Sex has significant effect on weight during the preweaning period (Misra 1981; Siddiqui et al. 1981; Mukundan, Bhat and Khan 1982; Malik, Kanaujia and Pander 1986; Wilson 1988). In these studies males were heavier than females. This effect was due to differences in muscle cell numbers which contributed to faster growth rate in males than females (Joubert 1956). On the contrary, Mittal and Pandey (1978), Naik, Patro and Mishra (1985), Patnaik and Sukadev Nayak (1988) failed to find significant effect of sex on preweaning growth traits. This was probably caused by the substandard of the feed which was given for the kids and does. It is important to note that, where there is nutritional deficiency, sex difference appears to be non-significant.

The effect of birth type on weights at different preweaning periods was reported by Siddiqui et al. (1981), Malik, Kanaujia and Pander (1986), Patnaik and Sukadev Nayak (1988), Wilson (1988) and Roy, Prakash and Khan (1989). Single kids have heavier birth weights and get more milk than twins and hence have higher growth rate. Mukundan, Bhat and khan (1982) however did not find any significant difference in preweaning weights between singles and twins. It was likely that milk supply to either the singles or twins was not limiting in the later study.

Season of birth has influence on weights during the preweaning period (Siddiqui et al. 1981; Peacock 1982; Nagpal and Chawla 1985; Naik, Patro and Mishra 1985; Malik, Kanaujia and Pander 1986; Wilson and Murayi 1988). In these studies, it was found that, kids born during the wet season were heavier than kids born in other seasons. This was a reflection of the availability of good quality pasture to the lactating dams and their kids and minimum heat stress during the wet season which brought about better growth rates. Contrarily, Fall et al. (1982) showed a strong negative correlation between lamb weight at various ages and corresponding rainfall, indicating that with increased rainfall growth rate is reduced. Similarly, Vallerand and Branckaert (1975) reported that the major rainy season in

South Cameroon had a depressive effect on daily gains of lambs. During heavy rains there is an increase in prevalence of worms and disease and this might have contributed to retarded growth of kids.

Variation in preweaning growth traits is also attributed to year of birth (Mukundan, Bhat and Khan 1982; Mukundan et al. 1983; Nagpal and Chawla 1985; Malik, Kanaujia and Pander 1986; Roy, Prakash and Khan 1989). This was perhaps due to change in climatic circumstances, feed or managerial practices from year to year.

2.1.2.3 Postweaning weights (weaning to adult)

Variation among breeds in postweaning growth traits have been recorded by several workers (e.g Mchau 1978; Mukundan, Bhat and Khan 1982; Raghavan 1988; Karua and Banda 1990). Mukundan, Bhat and Khan (1982) revealed genetic group difference between Malabari goats and their crosses on weights at 6, 9 and 12 months of age. They found that Saanen halfbreds grew faster by 13 g/day, in all periods than purebred Malabari goats. Crossbreeding of Beetal with Alpine and Saanen goats also resulted in twofold improvement in growth rate over 12 months period. Likewise Alpine x Malabari and Saanen x Malabari showed improvement in weights at postweaning periods (Raghavan 1988). Karua and Banda (1990) studied Malawi goats and their Saanen crosses and reported that, at weaning and one year of age, Saanen crosses were heavier than Malawi goats. Mchau (1979) found Boer crosses to be superior over SEA up to 2 years of age. This improvement in postweaning growth is mainly a consequence of heterosis.

Sex has been reported to have influence on weight at postweaning period (Siddiqui et al. 1981; Mukundan, Bhat and Khan 1982; Nagpal and Chawla 1985; Raghavan 1988 ; Roy, Prakash and Khan 1989). Siddiqui et al. (1981) studied the effect of sex on weight during postweaning period in Osmanabandi goats and found significant effects of sex on weights from birth to 10 months. The superiority of crossbred males over females was observed in Saanen x Beetal and Alpine x Beetal goats after 9 months of age and the difference increased with advancing of age (Nagpal and Chawla 1985). The effect of sex on kid weight in favour of males at 5 and 12 months of age has been reported by Wilson (1983) and at 8 months of age by Khombe (1985). A poorer performance of females is to be expected. Females have few muscle cell numbers (Joubert 1956). In addition, Males also produce androgen whose potency to promote growth is greater than that of oestrogen from females (Brody 1945; Hafez 1962; Dass and Acharya 1970). In Contrast, Naik, Patro and Mishra (1985) failed to show any significant effect of sex on weights at different stages of postweaning period, although the males tended to be heavier. This was due to special feeding and management procedure provided for the females to make the females ready for mating early and hence narrowing the difference in postweaning growth traits.

Type of birth had significant influence on weight during postweaning period (Siddiqui et al. 1981; Wilson 1983,1987; Roy, Parkash and Khan 1989). All these studies showed that singles grew faster than twins. This was probably due to the fact that singles had higher birth weight and had access to more milk during preweaning period. This residual effect might have contributed to have heavier live weight during postweaning period. Contrary to these findings, Guha et al. (1968) and Mittal and Pandey (1978) failed to show any significant effect of type of birth on weight at postweaning weights.

Season of kidding had shown to have an effect on postweaning weights in various studies (Kyomo 1978 ; Naik, Patro and Mishra 1985; Nagpal and Chawla 1985; Wilson 1987; Roy, Parkash and Khan 1989). In most studies kids born in summer (dry season) were inferior in postweaning weights to kids born in spring and winter (wet season). The effect of season of birth on postweaning weight is associated with feed availability, heat stress and disease situation. Kids born during the start of rainy season and raised during the long rainy season may have heavier postweaning weights. During the dry season, scarcity of feed and the heat stress results in low growth rates and low postweaning weights.

The effect of year of birth on postweaning weights was reported by Kyomo (1978) at 52 and 72 weeks of age. Similarly Khombe (1985) and Nagpal and Chawla (1985) found significant effect of year of birth in postweaning weights at different ages which ranged from 150 to 720 days. This effect was due to year to year variation in climatic factors (rainfall, temperature and humidity) which influences forage availability, management and disease condition. In this aspect, Kyomo (1978) reported an association between amount of rain fall and growth performance. On the other hand a strong negative correlation between lamb weight at various ages and corresponding rainfall was reported by Fall et al. (1982).

2.1.2.4 Preweaning and postweaning growth rates

Rapid preweaning and postweaning growth rates of goats minimize the cost of rearing young stock to marketable age. Published reports indicated that the major limiting factor in meat production from goats is their inherent low growth rates. However, few studies have shown that one can improve these traits through genetic and environmental manipulation.

Recently many researchers (e.g Kyomo 1978; Mchau 1979; Malik, Kanaujia and Pander 1986; Mohd, Sulaiman and Othman 1988; Raghavan 1988) have studied breed differences in preweaning and postweaning growth rates. Malik, Kanaujia and Pander (1986) observed that under identical management situation, Beetal kids have higher preweaning liveweight gain (56.6 g/day) than Black Bengal (44.4 g/day) and Black Bengal x Beetal (48.27 g/days) kids, the difference being significant ($P<0.01$). Mohd, Sulaiman and Othman (1988) also reported significant differences in preweaning growth rate in the study carried out on Saanen x Katjang, Anglonubian x Katjang, British Alpine x Katjang and Katjang. In this study the highest daily weight gain was achieved in Saanen x Katjang (80.5 g/day) and the lowest in Katjang (43.8 g/day). Mchau (1979) showed the effect of crossbreeding on preweaning and postweaning weight gain of Boer, 3/4 Boer-1/4 SEA and SEA. In this study the preweaning growth rates (birth to 24 weeks) were 84, 75 and 59 g/day and the postweaning growth rates (24 to 52 weeks) were 50, 61 and 36 g/day for Boer, 3/4 Boer-1/4 SEA and SEA, respectively. These studies showed that cross breeding can be a rapid tool to improve growth rate of meat type goats in the tropics if properly planned.

Sex also had an effect an preweaning and postweaning growth rates (Wilson 1958; Sacker and Trail 1966; Guha et al. 1968; Kyomo 1978; Mohd, Sulaiman and Othman 1988;

Raghavan 1988; Lebbie and Manzini 1989). All these findings showed that males grew faster than females. However, when approach maturity, differences in growth rates between sexes tended to disappear.

The effect of birth type an preweaning and postweaning growth rate is reported by Kyomo (1978), Malik, Kanaujia and Pander (1986) and Mohd, Sulaiman and Othman (1988). Mohd, Sulaiman and Othman (1988) found average daily preweaning growth rate of 65.6 g/day for singles and 46.8 g/day for twins. Similarly, Kyomo (1978) found growth rate of 65.8 g/day for singles and 60.4 g/day for twins and the difference in growth rate after weaning in Kyomo's study disappeared and postweaning growth rates of singles and twins were almost the same. In Mubende goats, Sacker and Trail (1966) found growth rate to be influenced by birth type. In this study mean daily weight gain was 63.5 g for singles and 54.4 g for twins from birth to 5 months(weaning). While from weaning to one year the average growth rate of both singles and twines was similar.

Season and year have been reported to have an effect on preweaning and postweaning growth rate (Guha et al. 1968; Malik, Kanaujia and Pander 1986; Mohd, Sulaiman and Othman 1988). The study carried out by Malik, Kanaujia and Pander (1986) showed that kids born during February to April and 1982 had higher preweaning growth rate than kids born from

September to November and in 1979. The effect of season and year is related to nutritional aspects and disease prevalence in a specific year and season.

2.1.2.5 Body measurements

Several workers have conducted studies to determine the extent of variation on body measurements due to sex, breed, season of birth, birth type and other related factors. Interest in such studies are based on:

a. Breeds have their own specific body measurements at maturity. Knowledge of this characteristics can help to characterize breeds. Devendra and Burns (1970) and

Hass and Horst (1979) categorized the domestic goats using height at the withers as a criterion. This is especially important in the tropics where goat breeds are not well characterized.

b. Body weight and body measurements are closely associated. under field conditions, measuring external body measurements is simple and cheap. From this relationship body weight can be predicted from body measurements and can be used by the sellers, buyers, veterinary inspectors and breeders. The knowledge of factors affecting body measurements can be used as a guideline to develop uniform prediction equations for the factors which are not different (breed, sex) and to develop different predictions equation for the factors which are different.

Brody (1945) and Devendra and Burns (1970) reported that height at the withers is less affected by temporary environmental variations than other body measurements. Using this principle, Mchau (1979) studied the effects of breed (genetic group) on height at the withers and found 3/4 Boer-1/4 SEA to be taller than SEA goats. On the other hand, Kyomo (1978) found significant effect of breed on height at the withers, heart girth and body length, the Kamorai x SEA being taller than Boer x SEA and SEA In height at withers and Boer x SEA goats were wider at the hind quarters than Kamorai x SEA.

Sharma et al. (1977) studied Muzaffarnagari sheep and their Corriedale halfbreds and reported that body length and height at the withers were not affected by breed at any age. However, chest girth at birth and at 4 weeks of age was significantly affected by breed in favour of the crosses.

Another factor which affects body measurements is sex (Sharma et al. 1977; Kyomo 1978; Mchau 1979; Das, Joshi and Bisht 1989 ; Hassan and Ciroma 1990). Das, Joshi and Bisht (1989) reported the effect of sex on body length in Barbari goats at 3 months and in Jamunapari kids at 2 months of age,

[illegible]

[illegible]

[illegible]

[illegible]

linear relationships especially when a wide gap in liveweight has been discussed elsewhere (Huxley 1932; Berg and Butterfield 1976). In most cases,the relationship is quadratic and this led to Brody's (1945) equation as shown in equation 1.

$$W = a\ x^b \qquad (1)$$

where :

W = body weight

x = linear body measurement

a and b are constants

The logarithmic expression of the above equation is : Log W = Log a + b Log x, where both a and b can be estimated from simple regression of log W on log x.

Many workers have studied the relationship between body measurements and live weight (Kyomo 1978; Mchau 1979; Misra 1980; Bhat, Bhat and Garg 1980; Valdez, Fagan and Vicera 1982; Khan and Sahni 1983; Hassan and Ciroma 1990). The types of measurement used vary from worker to worker. Valdez, Fagan and Vicera (1982) considered heart girth, height at the withers and flank girth in purebred (Nubian, Saanen, Alpine and Toggenburg) and graded goats and developed a prediction equation by pooling all breeds and separate equations for different breeds. In this study the highest coefficient of determination (R^2) was obtained when all breeds were combined (90%) whereas the coefficient of determination was 50 to 87% when the analyses were taken separately for each breed.

When body length, height at the withers, width at the hind quarter and heart girth were considered, the value for R^2 were found to be 89%, 93%, 88% and 90% for Boer x SEA, Kamorai x SEA, SEA and all genetic groups pooled togather, respectively (Kyomo 1978). Similarly Mchau (1979) taking the above 4 body measurements found coefficients of determination ranging from 70 to 80% in crossbred and SEA goats. Misra (1980) divided Sirohi goats into different age groups and found coefficient of determination of 70 to 83%. In sheep, Bhat, Bhat and Garg (1980) ran regression analyses of body weight on body length, height at the withers and heart girth and found a coefficient of determination of 35, 38, 50 and 78% at birth, 4, 8, and 13 weeks of age respectively.

Most of these workers concluded that heart girth alone was almost as efficient as the combination of other linear measurements in predicting liveweight. On the other hand, Bhat, Bhat and Garg (1980), Hassan and Ciroma (1990) found that body length can explain most of the variation in body weight.

Some workers like Misra (1980), Bhat, Bhat and Garg (1980), and Hassan and Ciroma (1990) developed prediction equations for body weight in specific age groups to avoid an extended range of variation and found an increasing trend of R^2 value with advancement of age, indicating that body weight can be accurately predicted from linear body measurements at older ages. Other workers, like Kyomo (1978), Mchau (1979) and Valdez, Fagan and Vicera (1982) developed prediction equations regardless of age grouping.

It can be concluded that, some body measurements can be used as indirect indicators of body weight better than others. Therefore, it must be stressed that whatever measurement is used,it must be simple with minimum error during the process of measuring. For example, body length is a very variable measurement. Such selected measurements must be accurate and precise in predicting body weight. The equations should preferably apply across age, breeds and sex groups to be fully utilized under different management systems.

2.3 Reproduction

2.3.1 Introduction

Reproduction rate is an important parameter, as it influences the efficiency of production of meat, milk and fibre. One of the most favourable attributes of goats as meat producing animals is their high rate of reproduction. The attributes of reproduction in goats were summarised by Haas and Horst (1979) as follows:

a. In case of dairy goats economic utilization starts after kidding.

b. In case of meat production, the kidding rate and frequency of kidding decides the attainable economic profit as reproduction rate influences the annual offtake rate.

c. It influences current and future production, as reproduction affects culling rate and availability of replacement animals for future production.

d. It contributes to rapid genetic progress expected because selection intensity increases with increase in reproduction efficiency.

Reproduction efficiency in goats is determined by many processes, including rate of sexual maturity, ovulation rate, embryo and fetal development. Reproductive performance in goats can be expressed as litter size, kidding interval, age at first kidding and length of reproduction life. It is well documented in literature that these reproductive parameters are determinants of the reproductive efficiency of goats (Kyomo 1978; Mchau 1979; Riera 1982; Wilson and Durkin 1983; Kiwuwa 1986; Wilson and Murayi 1988; Bhattacharya 1988).

2.3.2 Age at first kidding

Age at first kidding which is a response of age at puberty and post puberty fertility is an important factor in determining life time productivity. Thus, it is believed that best does are those which have their first kid at early age in life as the earlier the doe starts to kid the longer the productive life span. Wilson and Durkin (1983) also suggested that early age at first kidding in African small ruminants can lead to increased total lifetime production. Riera (1982) noted that the potential for improvement in reproduction efficiency increases as the age at first kidding decreases. On the contrary, several researchers discouraged early mating (Shelton 1961, 1986; Haas and Horst 1979; Devendra and McLeroy 1982 ; Devendra 1987) for the reason that pregnancy at early age would affect growth and irreversibly impair future performance. This is of particular importance for goat breeds of dry tropics raised under extensive range conditions and which have very low weight at their first oestrus.

Devendra (1987) recommended mating of the doe at the first time at 12 months to kid at 17 months. Similarly Shelton (1961) and Haas and Horst (1979) suggested mating of the doe at first time when they have attained 60 - 75% of adult live body weight. Delaying of mating of does until they are near to mature weight guarantees full body development of the female so that pregnancy does not coincide with the period when the does are actively growing. Furthermore, it increases conception rate, frequency of multiple births and survival rate of the kids (Singh and Singh 1974; Devendra 1987). Shelton (1961), Haas and Horst (1979) and Riera (1982) put more emphasis on weight of the doe at first mating than the age of the doe. There is therefore a need to balance between chronological and physiological maturity in deciding at what age to mate the females for the first time.

Reports on age at first kidding in some tropical goats are summarized in Table 3. These reports show considerable variation ranging from 12 months as a minimum to 39 months as the maximum in age at first kidding. In Small East African goats and their crosses there is also a wide range of variation on age at first kidding where the highest was 773 days (Kyomo 1978) and the lowest was 570 days (Sacker and Trail 1966) and 598 days (Wilson and Murayi 1988).

Table 3 : Summary of age at first kidding (AFK) of some tropical goats

Breed	Location	AFK(days)	Source
Baladi	Egypt	584	Ahmed and Tantawy (1960)
Mubende (SEA)	Uganda	570	Sacker & Trail (1966)
Sudan desert	Sudan	291	Wilson (1976)
SEA	Tanzania	773	Kyomo (1978)
Boer x SEA	Tanzania	742	"
Kamorai x SEA	Tanzania	744	"
Sahel	Nigeria	401	Gerbaldi(1978)
Beetal	India	544	Mhela & Mishra(1980)
Alpine x Beetal	India	489	"
Saanen x Beetal	India	475	"
Jamunapari	India	752	Khan _et al_.(1981)
Mali goats	Mali	431	Wilson & Durkin (1983)
Mali goats	Nigeria	529	Mack (1983)
Ganjam goats	India	1165	Mohanty, Patro & Mishra (1985)
Chiangthan goats	India	988	Prakash & Singh (1985)
Black Bengal	India	456	Lal _et al_. (1987)
Sahel goat	Burkina Faso	455	Wilson (1987)
Sahel	Burkina Faso	423	Wilson (1988)
SEA	Rwanda	598	Wilson & Murayi (1988)
Anglonubian x SEA	Rwanda	766	"
Alpine x SEA	Rwanda	557	"
SEA	Rwanda	640	Wilson, Murayi &Rocha (1989)
Mozambique goats	Mozambique	693	"
Blended	Tanzania	780	Das and Sendalo (1990)
Blended x Galla	Tanzania	766	"
Kamorai x SEA	Tanzania	757	"
Malawi Local (SEA)	Malawi (Lilongwe)	468	Karua (1989)
Malawi Local (SEA)	Malawi (Salima)	630	"
Swaziland (Local)	Swaziland	301	Lebbie & Manzini (1989)

A study carried out to show breed (genetic group) differences in age at first kidding by Wilson and Murayi (1988) showed that the mean age at first kidding of 640 days. In this study, SEA (598 days) and Alpine x SEA (557 days) were younger than Anglonubian x SEA (766 days) days of age at first kidding. Kyomo (1978) reported age at first kidding for SEA, Boer x SEA and Kamorai x SEA of 773, 742 and 744 days respectively, the difference in age at first kidding between crosses and SEA being highly significant. However, there was no significant difference among crosses.

Reports from the traditional sector on age at first kidding by Wilson (1988) in Burkina Faso showed that it was 423 days. Similarly, Wilson and Durkin (1983) reported 431 days of age at first kidding in central Mali. Adu, Buvanendran and Lakpini (1979) showed age at first kidding of the Red Sokoto goats ranging from 8 to 29 months. In Niger Gerbaldi (1978) reported 401 days for Sahel goats. The younger at first kidding in the traditional sector clearly indicates that in the traditional sector, there is no management practice to control the age at first kidding.

The effect of type of birth on age at first kidding in tropical goats is well documented (Ali, Hague and Hasnath 1973, Singh and Singh 1974, Wilson and Murayi 1988). Ali, Hague and Hasnath (1973) reported that does born as singles kid about 30 days earlier than those born as twins. Wilson and Murayi (1988) also found that females born as twins or triplets were older at first kidding than those born as singles, the difference amounting to 117 days. This was partly due to lower growth rate, as does which were born as twins or triplets were lighter at birth and partly due to limited amount of milk provided during preweaning period which contributed to delay in sexual maturity.

Age at first kidding is related to season of birth of the female. This is because, when the female is born in seasons where feed availability is promising it will grow faster and attain sexual maturity earlier resulting in earlier age at first kidding. This was clearly indicated by Wilson and Durkin (1983) in a study carried out in Central Mali. Similarly, Haumesser (1975) studied the relation of age at first kidding and their season of birth and found that female born during September to April kidded for the first time at 10.5 to 11.6 months of age while, those born during May and June kidded 9.96 to 10.23 months of age and those born during July and August kidded at 8.5 to 8.6 months of age. Wilson, Peacock and Sayer (1984) failed to show the effect of season on age at first kidding and suggested that there is little to be gained by endeavouring to control breeding season with view of decreasing age at first parturition.

The year at which the female was born is also the source of variation for age at first kidding. Wilson and Murayi (1988) showed significant effect of year of birth of female kid, that animals born in 1976 (841 days) were older than those born 1977 (736 days).

2.3.3 Length of kidding interval

Kidding interval is defined as the period between two consecutive kiddings. Shorter kidding interval contributes to faster population turnover which increases the total output of product per year and gives more room for increased selection pressure in order to achieve faster genetic progress. In addition, longer kidding intervals not only reduce output but it also associated with increase in cost of replacement and high depreciation.

According to Hass and Horst (1979), two kiddings per dam per year is possible. However, in practice three kiddings in two years is more realistic. Data on kidding interval of tropical goats is summarized in Table 4. There is considerable variation in kidding interval ranging from 219 days in Black Bengal goats to 408 days in Landim goats in Mozambique. Wilson (1989) reviewed reproductive efficiency of goats in 10 African countries and found that most of the records showed kidding intervals of less than a year. Furthermore, he found the shortest kidding interval in the traditional sector where uncontrolled breeding is the norm. The longest kidding interval was found in research stations

Table 4 : Summary of length of kidding interval (KI) in some tropical goats

Breed	Location	KI (days)	Sources
Local	Malaysia	240	Devendra (1962)
A. Nubian x local	Malaysia	351	"
3/4 A.Nubian-¼ local	Malaysia	357	"
Anglonubian	Malaysia	480	"
Mubende (SEA)	Uganda	297	Sacker & Trail (1966)
Darfur (Sudan desert)	Sudan	238	Wilson (1976)
SEA	Tanzania	302	Kyomo (1978)
Boer x SEA	Tanzania	299	"
Kamorai x SEA	Tanzania	304	"
Jamunapari	India	229	Khan *et al*.(1981)
W. African dwarf	Nigeria	267	Mack (1983)
SEA	Kenya	306	Wilson, Peacock & Sayer (1984)
W. African dwarf	Nigeria	261	Adeoye (1985)
Ethiopian highland	Ethiopia	351	Kiwuwa (1986)
Boer	Kenya	285	"
SEA	"	289	"
Galla	"	285	"
Sahel goats	Burkina Faso	285	Wilson (1987)
Mali goats	Mali	296	Wilson & Durkin (1988)
Sahel	Burkina Faso	312	Wilson (1988)
SEA	Rwanda	323	Wilson & Murayi (1988)
Anglonubian x SEA	"	384	"
Alpine x SEA	"	323	"
SEA	Rwanda	343	Wilson, Murayi& Rocha(1989)
Landim goats	Mozambique	408	"
Black Bengal	India	219	Ray,Pyne & Maitra (1990)
Blended	Tanzania	379	Das and Sendalo (1990)
Blended x Galla	"	388	"
Kamorai x SEA	"	373	"
Zimbabwe (Indigenous)	Zimbabwe	324	Ndlovu (1990)
W. African dwarf	Ghana	284	Tuah *et al*.(1990)
Malawi (SEA)	Malawi (Lilongwe)	315	Karua (1989)
Malawi (SEA)	Malawi (Salima)	246	"
Swaziland (indigenous)	Swaziland	268	Lebbie & Manzini (1989)

and government farms which practise single breeding seasons annually. Similarly Wilson, Peacock and Sayer(1984) observed control mating system in traditional sector in Masai area of Kenya. This seasonal mating system was reflected in longer kidding intervals. From this observation, Wilson (1989) came to the conclusion that policies practised on research stations with regard to "best" period for breeding reduces the overall reproductive rate. Wilson and Durkin (1988) and Naude· and Hofmeyr (1981) recommended that, where goats are kept primarily for meat production, restricted breeding season is disadvantageous and therefore continuous mating should be adopted.

Corteel, Gonzalez and Nunes (1982) on the other hand advocated control of reproductive activity. In this ways one can synchronize kidding to occur during time of feed availability and minimum disease and parasite load. However, Further research is required on implications of controlled and uncontrolled mating systems in reproductive efficiency.

Breed difference is a source of variation in kidding interval. Smaller tropical goat breeds have shorter kidding intervals than European dairy goats and the crossbred being intermediate between exotic and local breeds (Devendra 1962; Devendra and Burns 1970; Wilson and Murayi 1988). Kyomo

(1978) showed almost similar kidding interval among SEA, Boer x SEA and Kamorai x SEA. Crossbreeding improves the milk production per lactation and growth rate at the expense of increased kidding interval. Kidding interval should, *therefore, be carefully evaluated and be incorporated into productive indices rather than considering it as a single parameter.*

Type of previous birth has also an effect on kidding interval of goats. According to Lima et al. (1990), females giving birth to single kids had an average of 274 days of kidding interval and females giving twins had an average of 305 days. This might be due to the fact that the does which gave birth twins had more stress and this leads to suppressed ovulation rate for the next conception.

Previous season of birth has impact on kidding interval (Haumesser 1975; Wilson 1988; Wilson and Durkin 1988 ; Ray, Payne and Maitra 1990). Ray, Payne and Maitra (1990),studying factors affecting reproductive performance of Bengal goats, found that does kidding in monsoon and winter had longer (203 to 219 days) kidding interval than those kidding in summer (177 days). Similarly, Wilson (1988) studied non genetic factors affecting kidding interval in the traditional sector in Burkina Faso and reported that kidding intervals following previous births in hot dry and rainy seasons were shorter than those following previous births in post rains and cold dry season. Similar trend was observed by Haumesser (1975) and Wilson and Murayi (1988). In most studies, shorter kidding intervals were achieved, when previous birth was in the rainy season. This was attributed to seasonal availability of good quality and quantity feed in the rainy and immediate post rainy season. In contrast, Raja and Mukundan (1974) failed to show the influence of season of previous birth on kidding interval and partly attributed this to uniform management procedures throughout the year.

Year of previous kidding also influences kidding interval. This was clearly shown by Wilson and Durkin (1988) in Central Mali under traditional management conditions. Similarly, Adeoye (1985) showed significant effect of year of kidding on kidding interval in West African goats. Wilson and Murayi (1988) studied the effect of year, birth type, parity and genotype on kidding interval. In this study the year of previous parturition was the only source of variation in kidding interval. This variation in kidding interval due to year of previous birth might be due to managerial inconsistency and limitations of feed from year to year.

Age and parity have a confounded effect on kidding interval. According to Adeoye (1985) kidding interval appears to decrease with increasing age or parity. He further found that the optimal kidding interval was obtained between the age of 36 and 48 months. Devendra and McLeroy (1982), however, found optimal reproductive performance of tropical goats between five and six years. Wilson, Peacock and Sayer (1984) failed to show the influence of parity on kidding interval in either sheep or goats, although there was a general tendency of reduction of kidding interval with increasing parity.

2.3.4 Litter size

Litter size which is a function of ovulation rate and prenatal survival rate of fertilized ova has significant influence on reproduction efficiency. Difference in litter size occurs within and between breeds (Wilson 1987,1989; Wilson and Murayi 1988) as shown in Table 5. Wilson (1989) reported a wide range of variation in litter size among African breeds of goats. In his review the lowest litter size was observed in Small Adal (lowland of Ethiopia) goats with litter size of about 1.10. The first crop of the doe of the same breed at Melkaworer research station (Ethiopia) averaged 1.02 kids per birth and the highest was 1.75 in Burundi University Farm.

In Malawi goats, of the Small East African type have an average litter size of 1.15 under traditional management (Kasowanjete, Stotz and Zerfas 1987). Lebbie and Manzini (1989) in Swaziland found litter size of 1.18. The litter size was smaller (1.07) in first parity than in subsequent paritys (1.24). In this study involving 408 kiddings 82% were singles, 17% were twins and less than 1% were triplets. Khan et al.(1981) showed a frequency of 62% single, 33% twins and 5% triplets in jamunapari goats in India. The wider variation in litter size among the tropical goat types is a great advantage as reproductive performance could easily be improved by crossbreeding without affecting their innate adaptation characteristics to hot and harsh environment. In this respect Wilson and Durkin (1988) indicated the possibility of improving production indices in tropical goats by increasing litter size, either by selection or by crossbreeding among the existing tropical goats. However, an increase in litter size may result in higher early mortality rates (Wilson and Light 1986; Wilson and Murayi 1988; Lima et al. 1990), and therefore special management needs to be given for such kids.

Season had influence on litter size (Prasad, Roy and Pandey 1971; Wilson, Peacock and Sayer 1984; Wilson and Durkin 1988; Wilson, Murayi and Rocha 1989). Wilson, Peacock and Sayer (1984) reported a marked effect of season on litter size in the traditional sector in Kenya. In this study goats which kidded in the dry season had greater litter size than those which kidded in the rainy season. Furthermore, Wilson and Durkin (1988) found that does which kidded in cold dry season (December to February) had higher (1.23) litter size than those which kidded after rains (1.04) in Central Mali. Prasad, Roy and Pandey (1971) showed a higher (59.03 %) incidence of multiple birth in Barbari goats in Winter than those in summer (45.6%). From the study carried out in Burkina Faso, Wilson (1988) reported larger (1.13) litter size in sheep in the hot dry season. The larger litter size observed in the hot dry season is related to conceptions in the late rains or post rainy season. This is because, during rains there is availability of pasture for the doe and this facilitates ovulation rate of the dam and increased fertility which contributes to increased litter size. Unfortunately, mortality in twins or triplets born in hot and dry season is higher as there is a limited amount of feed for the dam and the kids. In contrast, Haumesser (1975) and Wilson (1988) working with tropical and subtropical goats failed to show the effect of season on litter size. This was attributed to continuous and extremely hot and dry condition encountered during the experimental periods.

Litter size is influenced by year of birth (Shelton 1960 Moulick et al. 1966; Wilson 1988; Wilson, Murayi and Rocha 1989). Wilson, Murayi and Rocha (1989) found that litters during 1984 were bigger (2.55) than those in 1983 (1.37) in Rwanda and litter size in 1974 was bigger (1.65) than 1972

Table 5 : Summary of litter size of some tropical goats

Breed	Location	Litter size	Source
Red Sokoto	Niger	1.47	Haumesser (1975)
Sudan Desert	Sudan	1.57	Wilson (1976)
West African dwarf	Nigeria	1.52	Mack (1983)
"	"	1.46	"
SEA	Kenya	1.26	Wilson, Peacock & Sayer (1984)
West African dwarf	Nigeria	1.65	Adeoye (1985)
Mozambique (local)	Mozambique	1.62	Mckinnon & Rocha (1985)
Sahel	Burkina Faso	1.21	Wilson (1987)
"	"	1.08	Wilson (1988)
Sahel	Mali	1.55	Wilson & Durkin (1988)
"	"	1.18	"
SEA	Rwanda	1.75	Wilson & Murayi (1988)
Blended	Tanzania	1.32	Das and Sendalo (1990)
Blended x Galla	"	1.21	"
Kamorai x Galla	"	1.43	"
Adal	Ethiopia	1.10	Wilson (1975)
SEA	Malawi	1.15	Kasowanjete, Stotz and Zerfas (1987
Boer	Kenya	1.57	Kiwuwa (1986)
SEA	"	1.16	"
Galla	"	1.06	"
Mubende	Uganda	1.30	"
Sudan Nubian	Sudan	1.57	"
Swaziland (local)	Swaziland	1.18	Lebbie and Manzini (1989)

(1.20) in Mozambique goats. This was associated with the variation in management practices in feeding and disease control from year to year.

Parity number has influence on litter size (Prasad, Roy and Pandey 1971; Kyomo 1978; Wilson 1983; Wilson and Durkin 1988; Wilson and Murayi 1988; Wilson, Murayi and Rocha 1989). Wilson and Murayi (1988) reported that dams in their first parity gave birth to fewer kids than all other parities, and dams in second parity gave birth to fewer kids than the overall mean. Second parity dams did not however have litter sizes that were significantly different from litter size of later parity dams, though the trend was linear up to parity six. Furthermore, Wilson and Murayi (1988) revealed larger litter sizes in the middle age goats at fourth and fifth parity and the trend fall at sixth parity. This evidence was supported by Wilson and Durkin (1988) in the traditional sector of Mali where they realized that higher (1.31) litter size in the fourth parity and lower (1.02) in the first parity. Kyomo (1978) also reported similar trends. Prasad, Roy and Pandey (1971) found 21 % multiple birth at first parity and 80 % in the fourth and 77 % in fifth parity. Generally, in most studies litter size reached a peak at the middle (fourth and fifth) parity and dropped in late parities. It has been suggested that for commercial purpose goats which reached beyond fifth parity should be culled (Wilson and Murayi 1988).

The effect of age on litter size has been reported by Adeoye (1985) and Devendra and McLeroy (1982). Adeoye (1985) reported an increase of litter size with advancement of the age of dam and the optimal litter size was obtained at 36 and 48 months of age. This finding contradicts the results of Devendra and McLeroy (1982) who revealed optimum rate reproduction of tropical goats at the age of 5 and 6 years. This variation is expected as these findings were from different locations and environmental situations, though both reports were from the tropics.

It has been reported that liveweight of the dam has influence on litter size in goats (Ahmed and Tantawy 1960; Moulick et al. 1966; Devendra 1987). Does which were heavier at kidding tend to produce larger litter sizes.

2.4 Viability

Kid mortality in the dry tropics is one of the main factors adversely affecting goat production and it remains the major form of reproductive wastage resulting into sizable economic losses in goat farming. Higher survival rates are essential for replacement of stock and efficiency of selection. The causes of mortality are directly related to the production and management systems. Factors which can affect mortality include breed, birth weight of the kid, type of birth, season and year of birth. They are aggravated by poor management practices such as:

- Kid exposure to predators;
- Naval infection as they are unattended during kidding;
- Dehydration, as they are allowed to join the dams and travelling a long distances without water;
- Heat stress;
- Lack of veterinary services such as vaccination and antiparasitic treatments.

Some examples of mortality rate data are shown in Table 6 and these examples are mainly from experimental stations where there is a possibility of registration of the flock. As indicated in Table 6, there is a wide range of variation in mortality rate from location to location in the tropics. This is a reflection of different management and macro climatic conditions. Table 6 shows the crosses with exotic breeds had medium mortality rate, while mortality rate was lowest for local goats.

Knowledge on factors affecting mortality can help in devising economically efficient and sound management schemes and breeding strategies. There is breed variation in mortality rate of kids (Mittal 1976; Chawla, Bhatnagar and Mishra 1982; Wilson and Murayi 1988; Singh, Mishra and Singh 1990). Among 1921 kids born at a research station in Rwanda, mortality rates up to the age of five months

Table 6: Summary of kid mortality rate in tropical goats from birth to various ages

Breed	Age[1]	Location	Mortality rate %	Sources
Baladi	4	Egypt	33.7	Ahmed and Tantawy(1960)
East African Mubende	5	Uganda	45.8	Sacker & Trail (1966)
Boer	4	Botswana	34.6	Botswana (1977)
Tswana	4	Botswana	18.9	"
Boer x Tswana	4	Botswana	9.7	"
Adal	3	Ethiopia	14.2	Gallal, Gebrelul & Feleke (1977)
Adal	6	Ethiopia	23.1	"
Jamunapari	1	India	39.1	Mittal (1976)
Barbari	1	India	49.5	"
SEA (Tanzanian)	6	Tanzania	7.0	Mchau (1979)
Boer x SEA	6	"	13.0	"
3/4 Boer-¼ SEA	6	"	19.0	"
Boer	6	"	32.0	"
Pashmina	1	India	15.0	Mazumdar,Mazumdar Goswami(1980)
Assam local	3	"	33.0	Sarmah et al. 1981
Mozambique (Indigenous)	8	Mozambique	20.0	Mckinnon & Rocha (1985)
Cameroon (Indigenous)	4	Cameroon	3.0	Ndamukong (1985)
Cameroon Dairy	4	"	32.4	"
Mali goats	5	Mali	40.0	Wilson & Light (1986)
Boer	4	Botswana	25.0	Senyatso (1986)
Tswana	4	"	9.0	"
Tswana x Boer	4	"	11.0	"
Black Bengal	3	India	31.4	Singh, Mishra & Singh (1990)
Beetal x Black Bengal	3	"	31.7	"
Brazil (non discrept)	4	Brazil	26.8	Lima et al. (1990)
SEA	5	Kenya (Nguvunit)	24.0	Carles, Gachuiri & Schwartz (1987)
SEA	5	Kenya (Isiolo)	15.0	"

[1] Shows the age in months from birth at which mortality was calculated

were 26.3, 11.3 and 16.0% for Anglonubian x SEA, Alpine x SEA and SEA, respectively (Wilson and Murayi 1988). However,there was no significant difference between Anglonubian x SEA and SEA nor between the latter and Alpine x SEA. Likewise, the overall mortality rate was 17.8% which is lower than that was found in the traditional systems of management where mortality rates of 25 to 35% in Masai ranches of Kenya (Wilson, Peacock and Sayer 1984; Wilson and Light 1986) and 47% in Sudan (Wilson 1976) are common. In other studies in India, Chawla, Bhatnagar and Mishra (1982) found relatively higher death rates in exotic (Alpine and Saanen) and 3 breed crosses (Alpine x Saanen) x Beetal and (Saanen x Alpine) x Beetal.

Mortality rate of 23% before weaning and 13% after weaning was recorded by Kyomo (1978) working with SEA, Boer x SEA and Kamorai x SEA goats. Mchau (1979) recorded preweaning mortality rate of SEA, Boer x SEA, 3/4 Boer - ¼ SEA, 7/8 Boer - 1/8 SEA and Boer goat to be 7, 13, 19, 36 and 32%, respectively. The postweaning mortality rates of kids in this study were 4, 8, 13, 19 and 18% in that order. This indicates that both preweaning and postweaning mortality rate increases with repeated backcrossing to the purebred Boers. This was mainly due to progressive deterioration in adaptation to climatic, disease and nutritional conditions with increasing Boer blood (Mchau 1979; Senyatso 1986). It was concluded that, crossbreeding of indigenous goats with exotic breeds results in improvement in productive traits at the expense of fitness traits (Olayiwole and Adu 1989; Kiwuwa 1990).

Losses reported to maturity are usually divided into losses at birth, from birth to weaning and from weaning to maturity (Devendra and Burns 1970; Tuah 1989). Sarmah et al. (1981) analyzed 172 kids of Assam local breed born at Bunihat (India) and found that 47.7% of kids died up to one year of age and the preweaning mortality rate was 33.14%. Similar preweaning mortality rates were reported by Ahmed and Tantawy (1960). In another study, Mittal (1976) reported mortality rates of 39.4, 30.4, 21.7 and 4.3% from birth to one month, one to three months, three to five months and five to seven months respectively. Rajan, Maryamma and Nair (1976) reported a kid mortality of 44.3 % from birth to third month, 13% from three to six months.

Thus the highest mortality rate was registered below 30 days of life. This calls for extra care to the kids to minimize neonatal losses by providing proper prophylactic and health measures and wind breaks or shelters against exposure to cold and adequate nutrition for the kid and the dam. In some African pastoralist systems, traditional attempts have been made to reduce kid mortality by separating new born kids from their dams and maintaining them in small baskets until one to two months of age and the kids are allowed to suckle in the morning and evening to ensure maximum survival for the first one to two months of age (Carles 1985).

Of the factors affecting kid mortality especially during preweaning periods, birth weight is the most important (Mittal 1976; Mazumdar, Mazumdar and Goswami 1980; Singh, Mishra and Singh 1990). Mittal (1976) reported the average birth weight of Barbari and Jamunapari kids of 2.0 and 3.5 kg, respectively. The mortality rates were 24.0 and 37.5% respectively for kids that were lower than the breed average in the two breeds. On the other hand the kids that were heavier than breed average had mortality rates of 6.2% and 9.0% for Barbari and Jamunapari kids, respectively. In another study, Mazumdar, Mazumdar and Goswami (1980) revealed 100% mortality rate of kids with birth weight of 1.0 to 1.5 kg while kids with birth weight between 2.0 and 2.5 kg had lowest (32.2%) mortality rate. Wilson and Murayi (1988) found that an increase of 100 g in birth weight over the mean, reduced mortality rate by 1.08%. Singh, Mishra and Singh (1990) also reported the importance of birth weight on mortality rate of kids and found, kids weighing 2.0 to 2.5 kg at birth had significantly lower mortality rate (12.6%) than those weighing less than 2.0 kg (31.9%) during 0 to 90 days of age. These findings imply that the mortality rates can be reduced by improving birth weight.

Birth type is also a source of variation in mortality rate of kids (Sarmah et al. 1981; Wilson and Murayi 1988). In a Masai group ranch, Wilson, Peacock and Sayer (1984) found significant effect of birth type on mortality rate, whereby twins had higher (37.7%) mortality rate than singles (21.3%). In most studies, singles had higher survival rates than twins. These differences were partly explained by difference in body weight at birth and milk availability from the dam. It was suggested that twins and triplets should be supplied extra milk feeding and care, especially those from does with poor milk yield.

Variation in kid mortality is also affected by season of birth (Mazumdar, Mazumdar and Goswami 1980; Sarmah et al 1981; Chawla, Bhatnagar and Mishra 1982; Wilson 1988 ; Singh, Mishra and Singh 1990). Singh, Mishra and Singh (1990) reported the influence of season of birth on survival rate of kids from 16 to 30, 60 to 90 and 0 to 90 days of age. In their study, kids born during summer had significantly higher mortality rate than those born during winter and monsoon seasons. The mortality rates from 0 to 90 days were 28.7, 37.1 and 26.3% during winter, summer and monsoon, respectively. Poor survival rate of summer born kids was due to malnutrition and increased susceptibility to disease during summer. Mazumdar, Mazumdar and Gaswami (1980) reported the influence of season of birth on mortality rate of kids. The study showed mortality rate of

20.8, 31.8, 56.8 and 63.7% for kids born in October to December, January to March, April to June and July to September,respectively. In another study, Sarmah *et al*. (1981) reported higher (29.3%) mortality rate during October to December and lower (18.6%) mortality rate during January to March.

Year of birth has been reported to have had significant effect on mortality rate of kids (Ahmed and Tantawy 1960; Chawla, Bhatnagar and Mishra 1982; Wilson and Murayi 1988). Chawla, Bhatnagar and Mishra (1982) showed significant effect of year of birth on kid mortality which varied from 16.5% in 1976 to 39.8% in 1979. Wilson and Murayi (1988) reported higher (24.6%) rate of mortality for kids born in 1979 than other years. This was due to differences in management practices and disease prevalence situation which varied from year to year.

The influence of sex on survivability of kids was studied by Mittal (1976), Sarmah *et al*. (1981), Khombe (1985), Singh, Mishra and Singh (1990). In most studies sex differences in mortality rate were not significant although females tended to have better survival rates than males.

To reduce mortality rate some authors (Haans and Horst 1979; Sarmah _et al_. 1981) have suggested measures to be taken from the management point of view and these include:

a. Avoid kidding to occur in the middle of rainy period, since permanent dampness creates an increased risk for the kids.

b. Ensure availability of fodder of high quality during the time of kidding so that suckling kids can obtain adequate amount of milk and have access to high quality fodder for the kids.

c. Plan prophylactic measures against endoparasites and ecto parasites as well as control of epidemics to reduce the effect of parasites and diseases on kids.

CHAPTER 3

MATERIALS AND METHODS

3.1 Description of the study area, Source and management of animals

3.1.1 Description of the area

The data used in this study were collected at Sokoine University of Agriculture (SUA), Department of Animal Science and Production, Morogoro, Tanzania covering 18 years (1972 - 1989 inclusive).

The Sokoine University of Agriculture is located 3 km from Morogoro town and it lies at the slope foot of Uluguru mountains at an altitude of 500 - 600 m above sea level, 37° 39'E longitude and 06° 50'S latitude. The maximum temperature varies between 27.6°C and 32°C. The minimum temperature can be as low as 15.1°C during the cool and dry season and 23°C during the rainy season. Rainfall averages about 800 mm per year. The late rainy season begins in February and ends in April while early rainy season starts from the beginning of November till the end of January. Relative humidity averages about 60% in the rainy season and 44% in the hot season.

The dominant indigenous and exotic flora found at Sokoine University Agriculture farm according to Kyomo (1978) are:

a. Grasses: Panicum maximum, Bracharia spp, Cenchrus ciliaris, Chloris gayana, Tripsacum laxum, Pennisetum purpureum, Hyparrhenia spp , Arundinacea spp, and Sporobolus spp.

b. Herbaceous legumes: Glycine javanica, Centrosema pubescens, Stylosanthes spp and Phaseolus spp.

c. Tree legumes : Lantana camara, Leucaena glauca, Acacia albida, Acacia robusta, Brachystegia spp Cassia abbreviata, C. burtii Tamarindus indica, Crotolaria laburniflora and Hibiscus spp.

3.1.2 Source of animals

The genetic groups involved in this study were Small East African (SEA), Boer x SEA and Kamorai x SEA goats. The SEA goats were used as a dam line. The SEA goats have been characterized by Mason and Maule (1960) to have 25-40 kg and 60 cm height at the withers at maturity. The source of this SEA goats as a foundation stock was Dodoma, Dar es Salaam and Morogoro.

3.1.3 Management of animals

The bucks and does introduced into the station were identified individually at time of acquisition. Males and females were grazing separately between 08.00 and 18.00 hours. As soon as they returned from grazing they were all sorted into their mating groups and kept in separate large pens between 18.00 and 08.00 hours. Therefore mating took place at night only.

The kids born at the station were also identified individually by metal ear tags. In addition, tattoos of the same numbers were imprinted inside each ear to ensure if the ear tag dropped out the animal could still be identified.

The goats were grazing on natural pasture. In addition, the goats were provided with concentrates from 1972 to 1974 regularly according to the plan (Kyomo 1978). The ingredients of the concentrate were (80% maize bran, 18% cotton seed cake and 2% mineral supplement). This feeding plan has not usually been rigidly adhered. Due to scarcity of concentrate from 1975 to 1989 the goats were supplemented twice a week and sometimes they were totally deprived of concentrates. The amount of concentrate given was about 100 g/day for does ready for mating, bucks and does which gave birth, whereas kids were given about 50 g /day when concentrates are available.

All the kids were reared naturally. From birth to one month of age kids were suckling from afternoon to the next morning. In the morning the does were taken for grazing while kids were retained indoors. From 4 weeks to 16 weeks (weaning) the kids were running with the dams throughout. At weaning the kids were separated into two groups (males and females), each group was kept in a separate flock regardless of the genetic group. At 72 weeks of age the female kids were drafted for mating and males were sold for slaughter or breeding purpose. Mating took place all year round.

Routine disease control measures were practised. Deworming was taking place once a month. External parasites were controlled by spraying the animals with acaricide once per week. Anthrax and Black quarter were controlled by using combined vaccines administered once a year. Goats were also vaccinated against various strains of foot and mouth disease twice per year.

3.2 Data collection

The station had some accumulated data on some productive and reproductive parameters like live weight at different ages, reproduction,body measurements and mortality. The data was extracted from individual record cards, whereas the records on mortality rates were collected from liveweight record and yearly inventory books. The first task to handle the data was to sort the records which have complete information for further data analyses on the above parameters. Irregularity in recording was the main problem identified. Therefore some records and independent variables like parity which had incomplete information were excluded.

3.2.1 Liveweight at different ages

Liveweight in kilogram at birth was recorded within 18 hours after birth. The kids of both sexes were weighed every fourth week up to the age of 72 weeks. Weaning took place at 16 weeks of age. For purposes of this study only weight at birth 16, 24, 52 and 72 weeks were considered.

3.2.2 Body measurements

Body measurements in centimeter were taken at 4 weeks of age and thereafter at 12 weeks intervals up to 72 weeks of age. These included height at the withers, length from pin bone to point of shoulder, heart girth and width at the hind quarters between the centre point of both haunches, using measuring tapes for heart girth and calliper-like graduated metal road for the rest of the measurements (Kyomo 1978).

3.2.3 Reproduction

The parameters considered in this category were age at first kidding, length of kidding interval and twinning rate.

Age at first kidding was considered as the number of days from birth to first kidding. Kidding intervals were computed as the period between two consecutive kiddings. Twinning rate was computed as the proportion of the number of twin births to the total number of births. Still births were considered as births and it was included in the formula.

3.2.4 Viability

From the yearly inventory and liveweight records, the dates at which the kids were born and died was noted. Kids' genetic group, sex,birth type,season of birth,period of birth and birth weight and the age at which the kid died were the independent variables of interest identified. For further data analyses the data were organized to calculate mortality rate for each sub class at different ages (from 0 to 16 weeks, >16 to 52 weeks and 0 to 52 weeks).

3.3 Data analyses

3.3.1 Liveweight at different ages and growth rates

As indicated in section 3.1.3 the goats used in this study were regularly provided concentrates from 1972 to 1974, where as there was irregular provision of concentrates from 1975 to 1989. This nature of managerial inconsistency necessitated to handle the data in the following way:

1. The data was partitioned into two sets i.e data set I (1972-1974) and data set II (1975-1989) and cross tabulation was carried out for each data set. This procedure revealed empty cells when genetic group, sex, birth type,season of birth, year of birth combination frequency was tabulated in case of data set I. This was due to small number of observations which could not be represented across the subclasses. For example birth weight in period I had 142 observations and 5 factors and different levels with 192 cross classifications (3 x 2 x 2 x 4 x 4). This implies, as the number of observation is less than the number of cross classifications, the occurrence of empty cells is inevitable. Therefore, least squares means computation would have been inappropriate. Data set II also had the unbalanced distribution of records which could not represent enough genetic groups across 15 years in relation to season.

2. Preliminary analysis was carried out, considering period at two levels i.e from 1972 to 1974 (supplemented period) and from 1975 to 1989 (un supplemented period). In this case the problem of empty cells was overcome. However, it was noted that the supplemented period covered only 3 years with a very small number of observations while the unsupplemented period covered 15 years and involved a

large set of data. Expecting the existence of variation in climate, management and disease conditions among the wide range of years it was not justifiable to lump records into one factor level and hence the following method of data handling was chosen.

3. Though it is worthwhile to identify the effect of year on growth traits across 18 years, the small numbers of observations across the 18 years in relation to genetic groups, sex, birth type and season did not allow the inclusion of year effects in the model. Therefore, to get a general picture of possible year effects a suitable year interval was identified and it turned out that a 3 year interval was the minimum interval found for the first 3 periods without empty cells. However, the last period category covered 9 years on account of small number of observation at the later stages. In addition, period I consisting 1972 to 1974 (supplemented period) was included in the model as one level and it was considered that this effect could be isolated and comparison of this supplemented period with other periods would be possible. Therefore periods rather than years were used in the analyses.

Liveweight at different stages and growth rates analyzed included weight at birth, 16 weeks, 24 weeks, 52 weeks,72 weeks, preweaning and postweaning growth rates.

Genetic group, sex, birth type, season of birth and period of birth were the independent variables considered. As indicated in section 3.1.3 most of the dams were acquired from villages where record keeping is non existent hence factors like parity and age of the dam could not included in the model. Moreover, irregularity of record on dam kidding weight also necessitated the omission of this factor as a covariate, thought it is a well known fact that parity, dam kidding weight and age of the dam have an effect on growth traits. The effect of genetic group, sex, type of birth, season of birth and period of birth as fixed effects and interaction effect of genetic group and season and genetic group and period of birth on weight at birth, at 16 weeks, 24 weeks, 52 weeks, 72 weeks of age, preweaning growth rate (0 to 16 weeks) and postweaning growth rate (16 to 72 weeks) were analyzed using General Linear Models procedure (GLM) of the Statistical Analysis System (SAS 1988). The statistical model used in the analyses was as described bellow:

$$Y_{ijklmn} = \mu + B_i + S_j + T_k + M_l + R_m + (BM)_{il} + (BR)_{im} + e_{ijklmn} \quad (2)$$

Where Y_{ijklmn} = Observation for a given growth trait of n^{th} kid of i^{th} genetic group, j^{th} sex, k^{th} type of birth, l^{th} season of birth, m^{th} period of birth.

μ = overall mean

B_i = the effect of i^{th} genetic group(i= 1, 2, 3)

S_j = the effect of j^{th} sex (j = 1, 2)

T_k = the effect of k^{th} birth type (k = 1, 2)

M_l = the effect of l^{th} season of birth (l = 1, 2, 3, 4)

R_m = the effect of m^{th} period of birth (m=1, 2, 3, 4)

$(BM)_{il}$ = interaction between i^{th} genetic group and l^{th} season of birth

$(BR)_{im}$ = interaction between i^{th} genetic group and m^{th} period of birth

eijklmn = Random error element associated with growth measurements on the n^{th} kid of the i^{th} genetic group, J^{th} sex, k^{th} birth type, l^{th} season of birth and m^{th} period of birth.

Due to the reasons indicated above the data was organized by grouping the study period into shorter periods in the following manner:

Period 1 = 1972 - 1974

Period 2 = 1975 - 1977

Period 3 = 1978 - 1980

Period 4 = 1981 and later.

Season of the year were also categorized into 4 groups depending on weather pattern.

Season 1	=	February, March, April (Late rainy season
Season 2	=	May, June, July (Cool and dry season)
Season 3	=	August, September, October (hot and dry season)
Season 4	=	November, December, January (early rainy season).

The correlation between weight at birth, 16 weeks, 24 weeks, 52 weeks and 72 weeks were analyzed using the Multivariate Analyses (MANOVA) option of the SAS (1988) General Linear Models procedure.

3.3.2 Body measurements

A preliminary analysis was carried out by including genetic group x sex interaction effects in the model and it was found that the interaction effects were small and nonsignificant. Therefore, the interaction effects were ignored and the effects of genetic group (Kamorai x SEA, Boer x SEA, SEA and Boer) and sex (male and female) on external body measurements were analyzed using SAS (1988) GLM procedure across 7 age groups. The age groups under study were 4, 12, 24, 36, 48, 60 and 72 weeks. The model was described as follows:

$$Y_{ijk} = \mu + B_i + S_j + e_{ijk} \qquad (3)$$

where:

Y_{ijk} = the external body measurements at different ages of k^{th} kid of i^{th} genetic group and j^{th} sex

μ = overall mean

B_i = the effects of i^{th} genetic group ($i = 1....4$)

S_j = the effects of j^{th} sex ($j = 1, 2$)

e_{ijk} = Random error associated with body measurements on the k^{th} kid of the i^{th} genetic group and j^{th} sex

3.3.3 Prediction equations

Preliminary analyses was carried out in order to learn whether the data used in this study follows the following assumptions of regression analyses about errors (Draper and smith 1966; Snedcor and Cochran 1989).

a. error have zero mean

b. a constant variance

c. follow a normal distribution

To test the constancy of variance, residuals against predicted value were plotted and showed a constant trend of residuals as predicted value increased. It was also observed that the errors had a mean of zero. The normality of the data was checked using a normal probability plot and it was noted that a plot lies approximately in a straight line. The same procedure of examination of residuals was carried out after transforming the values into natural logarithmic values. The mean of residuals was zero, normal plot approximately lies straight line and the plot of the residuals against predicted values showed constant variance as predicted values increased. It seemed, therefore, there was no advantage, hence no justification for transforming of the data. Thus it appears the fitted model using untransformed value was appropriate, since the residuals exhibited tendencies that confirmed to the above assumptions regarding residuals of regression. Therefore on the basis of the data used in the present study the analyses was carried out using untransformed values for different ages groups (4, 12, 24, 36, 48, 60, 72 weeks), genetic groups (Kamorai x SEA, Boer x SEA, Boer and SEA) and pooled data (regardless of age and genetic group).

The model was described as:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + e \qquad (4)$$

Y = live weight

b_0 = constant

b_1, b_2, b_3, b_4 = parameter estimates for each independent variable

x_1 = width at the hind quarter in cm

x_2 = body length in cm

x_3 = height at the withers in cm

x_4 = heart girth in cm

e = error term

3.3.4 Reproduction

The reproductive traits considered in this study were age at first kidding (AFK), kidding interval (KI) and twinning rate. For age at first kidding the effect of genetic group, birth type , season of birth and period of birth of the first kidding doe were considered. For kidding interval the effect of genetic group, parity, season of previous kidding and period of kidding were considered.

Twinning rate (TR) for SEA goats was obtained by using the following formula and it covered 18 years (1972 - 1989):

$$TR = \frac{\text{Number twin births including still birth} \times 100}{\text{Total number of births including still births}}$$

Detailed statistical analyses to test factors affecting twinning rate or litter size were not carried out due to limited data.

Age at first kidding and kidding interval were analyzed using the GLM SAS (1988) procedure. The model used for analysis of AFK was:

$$Y_{ijklm} = \mu + B_i + T_j + M_k + R_l + e_{ijklm} \quad (5)$$

Where:

Y_{ijklm} = Age at first kidding in days of m^{th} doe of i^{th} genetic group, j^{th} type of birth k^{th} season of birth, l^{th} period of birth

μ = overall mean

B_i = the effect of i^{th} genetic group (i = 1, 2, 3)

S_j = the effect of j^{th} type of birth (j = 1, 2, 3)

M_k = the effects of k^{th} season of birth (k = 1...4)

R_l = the effect of l^{th} period of birth (l = 1....4)

e_{ijklm} = Random error associated with AFK computation of m^{th} kid of i^{th} genetic group j^{th} type of birth k^{th} season of birth l^{th} period of birth.

The model used for analysis of KI was:

$$Y_{ijklm} = \mu + B_i + P_j + M_k + R_l + e_{ijklm} \quad (6)$$

Where

Y_{ijklm} = KI in days of m^{th} doe of i^{th} genetic group j^{th} parity k^{th} season of previous birth and l^{th} period of birth.

μ = overall mean

B_i = i^{th} effect of genetic group (i = 1, 2, 3)

P_j = j^{th} effects of parity (j = 1, 2, 3)

M_k = k^{th} effects of season of previous birth (k = 1...4)

R_l = l^{th} effects of period of birth (l = 1...4)

e_{ijklm} = Random error associated with KI of m^{th} doe of

i^{th} genetic group, j^{th} parity , k^{th} season of previous birth and l^{th} period of birth.

Season and period for AFK and KI were divided similar to growth trait for the reasons given in section 3.3.1. Parity categories greater than 3 were lumped and treated as parity 3 due to limited data.

3.3.5 Mortality rate

Mortality rates in the present study were expressed as percentage of kids died from birth to weaning and from birth to 52 weeks age. Mortality rate from >16 to 52 weeks was expressed as number of kids died from weaning to one year of age as a percentage of kids exposed in this period. Mortality rate was computed as:

$$\text{Mortality rate\%} = \frac{\text{Number of kids died up to a designated age x 100}}{\text{Number of kids born or exposed to risk}}$$

The mortality rate was computed for factors of genetic group, sex, birth type, season of birth, period of birth, and birth weight. The subclasses within factors were:

Genetic group = Kamorai x SEA , Boer x SEA and SEA

Sex= male and female.

Birth type = singles and twins.

Birth weight= 1 to 1.5, 1.6 to 2.0, 2.1 to 2.5, 2.6 to 3.0 and 3.1 to 3.5 kg.

Season and period of birth were classified in the same way as for growth analysis.

Statistical analyses were carried out on the effect of the above factors on mortality rates from birth to 16 weeks, from birth to 52 weeks and >16 to 52 weeks using Chi square test (X^2) in a 2 x C contingency table (Snedecor and Cochran 1989) as explained by the following formula.

$$X_c^2 = \frac{\Sigma(f-F)^2}{F}$$

where X_c^2 = Calculated chi-square value

F = expected values

f = Observed value

The expected values in any cell were obtained by multiplying the corresponding column and row totals and dividing by grand total (Snendecor and Cochran 1989)

CHAPTER 4

RESULTS

4.1 Growth

4.1.1 Birth weight

The analysis of variance to test the effect of genetic group, sex, type of birth, season of birth, period of birth, interaction between genetic group and season of birth and interaction between genetic group and period of birth is presented in Appendix Table 1. Least squares means and their standard errors for different factors affecting birth weight are shown in Table 7.

The overall mean for birth weight was 2.33 kg with standard deviation of 0.58 kg. The effects due to genetic group, sex, birth type and period of birth were all significant ($P<0.05$, $P<0.01$, $P<0.001$ and $P<0.001$, respectively). The Kamorai x SEA kids were heavier than SEA kids by 0.14 kg whereas Boer x SEA crosses were not significantly ($P>0.05$) different from Kamorai x SEA and SEA. The growth pattern for different genetic groupsis shown in Appendix fig.1. The weight of male kids at birth (2.41 kg) was significantly ($P<0.05$) greater than that of females (2.30 kg). The kids born as singles were heavier than those born as twins, the difference of 0.19 kg being highly significant ($P<0.001$).

Table 7.: Least squares means and standard errors for liveweight at different ages and for pre-weaning and post-weaning growth rates[1,2]

Effect	Weight (kg)					Growth rate (g/day)	
	Birth	16 weeks	24 weeks	52 weeks	72 weeks	Pre-weaning	Post-weaning
Overall	2.33 ± 0.58 (1197)	7.83 ± 2.20 (624)	8.95 ± 2.70 (576)	13:50 ± 3.80 (338)	16.76 ± 4.68 (275)	48.39 ± 19.57 (621)	22.59 ± 10.84 (262)
Genetic group							
Kamorai x SEA	2.41 ± 0.06[a] (170)	7.41 ± 0.30 (115)	8.67 ± 0.38 (110)	12.77 ± 0.77 (59)	18.26 ± 1.46 (46)	44.88 ± 2.68 (114)	24.62 ± 3.40 (45)
Boer x SEA	2.38 ± 0.05[ab] (164)	8.25 ± 0.25 (114)	9.24 ± 0.31 (108)	13.79 ± 0.60 (61)	16.44 ± 0.88 (54)	50.49 ± 2.24 (113)	20.22 ± 2.48 (50)
SEA	2.27 ± 0.03[b] (863)	7.57 ± 0.15 (395)	8.90 ± 0.20 (358)	13.76 ± 0.38 (218)	16.75 ±0.49 (175)	46.82 ± 1.37 (394)	22.37 ± 1.15 (167)
Sex							
Male	2.41 ± 0.03[a] (616)	7.87 ± 0.17 (321)	9.05 ± 0.22 (298)	13.67 ± 0.43 (175)	17.10 ± 0.71 (118)	48.38 ± 1.53 (320)	21.84 ± 1.70 (115)
Female	2.30 ± 0.03[b] (581)	7.62 ± 0.17 (303)	8.83 ± 0.22 (278)	13.21 ± 0.42 (163)	17.20 ± 0.64 (157)	46.41 ± 1.54 (301)	22.97 ± 1.59 (147)
Birth type							
Single	2.45 ± 0.03[a] (896)	8.13 ± 0.15[a] (483)	9.22 ± 0.18[a] (447)	13.86 ± 0.36 (265)	17.54 ± 0.60 (209)	49.21 ± 1.30 (480)	23.12 ± 1.48 (197)
Twins	2.26 ± 0.04[b] (301)	7.35 ± 0.21[b] (141)	8.66 ± 0.27[b] (129)	13.01 ± 0.53 (73)	16.75 ± 0.80 (66)	45.58 ± 1.91 (141)	21.69 ± 1.92 (65)

[1]Figures in parenthesis are the number of observations

[2]Means of the same trait with no subscript in common within a column are significantly different ($P < 0.05$)

Table 7 cont.

Effect	Weight (kg)					Growth rate (g/day)	
	Birth	16 weeks	24 weeks	52 weeks	72 weeks	Pre-weaning	Post-weaning
Overall	2.33±0.58 (1197)	7.83±2.20 (624)	8.95±2.70 (576)	13.50±3.80 (338)	16.76±4.68 (275)	48.39±19.57 (621)	22.59±10.84 (262)
Season of birth							
Feb.-April	2.45±0.06 (230)	8.28±0.26[a] (124)	9.28±0.33 (111)	13.96±0.65[ab] (56)	17.53±0.97 (46)	52.92±2.33[a] (123)	19.72±2.40 (42)
May-July	2.28±0.05 (295)	8.02±0.25[ab] (166)	8.90±0.32 (151)	14.41±0.57[a] (93)	17.62±0.90 (76)	49.25±2.27[ab] (166)	22.62±2.15 (74)
Aug.-Oct.	2.33±0.05 (302)	7.05±0.25[b] (137)	8.65±0.31 (131)	12.86±0.52[b] (89)	16.87±0.79 (65)	40.92±2.20[c] (137)	24.50±1.92 (62)
Nov.-Jan.	2.36±0.05 (370)	7.62±0.22[b] (197)	8.91±0.27 (183)	12.54±0.60[b] (100)	16.56±0.83 (88)	46.48±1.94[b] (195)	22.77±1.99 (84)
Period of birth							
1972-1974	2.25±0.05[bc] (142)	8.78±0.22[a] (110)	10.13±0.29[a] (105)	18.48±0.55[a] (55)	22.08±0.64[a] (62)	56.37±2.04[a] (109)	33.56±1.50[a] (62)
1975-1977	2.19±0.03[c] (521)	7.64±0.17[b] (291)	8.73±0.22[b] (261)	12.65±0.40[b] (155)	15.80±0.60[b] (119)	48.89±1.54[b] (290)	18.73±1.45[b] (109)
1978-1980	2.60±0.07[a] (213)	8.16±0.34[ab] (118)	9.50±0.43[ab] (109)	12.71±0.68[b] (81)	15.36±1.02[b] (65)	48.76±3.05[b] (117)	16.98±2.38[b] (63)
> 1981	2.37±0.07[b] (321)	6.38±0.35[c] (105)	7.39±0.43[c] (101)	10.50±0.97[c] (47)	15.36±1.90[b] (29)	35.56±3.08[c] (105)	20.34±4.70[b] (28)

Figures in parenthesis are the number of observations

Kids born from 1978 to 1980 were significantly heavier than kids born in the other periods, whereas kids born in period 2 (1975-1977) were the lightest (Appendix Fig.5). The interactions between genetic group and season of birth and between genetic group and period of birth were non significant (P > 0.05).

4.1.2 Weaning weight

The analysis of variance to test the effect of genetic group, sex, type of birth, season of birth, period of birth, interaction between genetic group and season of birth and genetic group and period of birth is presented in Appendix Table 1. Least squares means and their standard errors for different factors affecting weaning weight are presented in Table 7. The overall mean for weaning weight was 7.83 kg with standard deviation of 2.20 kg. It is noteworthy from Table 7 that Boer x SEA were significantly (P<0.05) heavier than SEA and Kamorai x SEA kids, the difference being 0.68 and 0.84 kg, respectively. Singles maintained their superiority over the twins in weaning weight, the difference being 0.78 kg (P<0.001). Season exerted a significant (P<0.01) effect on weaning weight. Kids born in season 1 (late rainy season) were heavier than those born in season 3 (hot and dry season) and season 4 (early rainy season). Season effects on weaning weight is also illustrated in Appendix Fig.4. Period of birth significantly (P<0.001) influenced weaning weight. The kids born in period 1 (1972-

1974) were heavier at weaning than those born in period 2 (1975 - 1977) and period 4 (>1980), the difference being 1.14 and 2.4 kg, respectively. Kids born in period 2 and 3 were also significantly (P<0.05) heavier at weaning than those born in period 4, the differences being 1.26 and 1.78 kg, respectively. Period effect on weaning weights is also illustrated in Appendix Fig.5.

4.1.3 Postweaning weights (24, 52 and 72 weeks weight)

Appendix Table 1 shows the analysis of variance to test the effect of genetic group, sex, birth type, season of birth, period of birth, interaction between genetic group and season of birth and genetic group and period of birth. Least squares means for different factors affecting postweaning weight were presented in Table 7. Using the least squares means the data are presented graphically from Appendix Fig.1 to Appendix Fig.5. Birth type had significant (P<0.05) effect on weight at 24 weeks. Single kids were on the average 0.56 kg heavier than the twins. Season of birth had significant (P<0.05) effect on weight at 52 weeks, where kids born in season 1 (late rainy season) and season 2 (cool and dry season) were heavier than those born in other seasons. Period of birth exerted a significant (P<0.001) effect on weight at 24 weeks of age. In this age group, kids born in period 1 (1972 - 1974) were significantly heavier than kids born in period 2 (1975 - 1977) and period 4 (>1980). Genetic group x season interaction had significant (P<0.05) effect on weight at 72 weeks where Boer x SEA goats performed well in season 2 (cool and dry season) as shown in Table 8. Genetic group x period interaction had a significant (P<0.001, P<0.01, respectively) effect on weight at 52 and 72 weeks. This interaction effect was due to very poor performance of the crosses in period 4 (>1980) at 52 weeks and poor performance of Boer x SEA in period 4 at 72 weeks (Table 9).

4.1.4 Preweaning and postweaning growth rates

Analysis of variance and least squares means showing different factors affecting preweaning and postweaning growth rates are presented in Appendix Table 1 and Table 7 respectively.

The overall mean of preweaning and postweaning growth rates were 48.39 g/day and 22.59 g/day, in that order. Of the genetic groups Boer x SEA had higher (50.49 g/day) preweaning growth rate than Kamorai x SEA (44.88 g/day) and SEA (46.82 g/day). However, the differences in preweaning growth rates between genetic groups were not significant (P>0.05). Of the non-genetic factors affecting preweaning growth rate season of birth and period of birth had significant effect both at P<0.001.

Table 8 : Least squares means and standard errors of 72 week weight (kg) of different genetic groups in four seasons

Genetic group	Season	Mean	s.e
	1	20.54	2.02
	2	17.11	2.26
Kamarai x SEA	3	17.84	1.62
	4	17.55	1.92
	1	14.34	1.73
	2	19.84	1.23
Boer x SEA	3	16.11	1.49
	4	15.46	1.41
	1	17.70	0.99
	2	15.93	0.77
SEA	3	16.69	0.79
	4	16.68	0.75

Table 9 : Least squares means and standard errors of 52 and 72 weeks weight (kg) for different genetic groups in four periods

Genetic group	period	52 weeks weight		72 weeks weight	
		Mean	s.e	Mean	s.e
	1	18.07	0.99	21.07	1.13
	2	12.43	0.71	16.37	1.13
Kamorai x SEA	3	12.88	1.50	15.63	2.43
	4	7.77	2.29	19.96	4.87
	1	19.57	0.82	23.78	0.97
	2	14.26	0.83	17.65	1.17
Boer x SEA	3	13.32	1.21	16.00	1.58
	4	8.00	1.63	8.32	2.79
	1	17.84	1.03	21.38	1.23
	2	11.26	0.44	13.34	0.61
SEA	3	11.94	0.54	14.45	0.73
	4	14.02	0.66	17.79	0.98

Kids born in season 1 had higher (52.92 g/day) preweaning growth rate than those born in season 3 (40.92 g/day) and season 4 (46.48 g/day). Likewise, kids born in period 1 (1972 - 1974) had higher (56.37 g/day) preweaning growth rate than those born in other periods. Period of birth was the only factor which exerted a significant effect on postweaning growth rate. The kids born in period 1 (1972 - 1974) grew faster than kids born in other periods.

4.1.5 Phenotypic correlation between weights at different ages

Table 10 shows the phenotypic correlation (r) between weights at different stages namely at birth, 16 weeks, 24 weeks, 52 weeks and 72 weeks.

Birth weight was significantly ($P<0.01$) correlated with weaning weight. Correlations between weaning weight and weight at 24, 52 and 72 weeks of age were higher and significant ($P<0.05$, $P<0.001$ and $P<0.001$, respectively). These values were 0.72, 0.52 and 0.40, respectively. The correlations between 24 week weight and 52 week weight and 72 week weight were medium and significant ($P<0.001$) with a value of 0.59 and 0.36, respectively. The correlation between weight at 52 weeks and weight at 72 weeks was 0.54 and was significant ($P<0.001$). The highest correlations were found between consecutive weights.

Table 10 : Phenotypic correlation between weights (kg) at different ages [1,2]

Traits		2	3	4	5
Birth weight	(1)	0.14** (624)	0.08NS (576)	0.03NS (338)	0.02NS (275)
16 weeks weight	(2)	-	0.72* (576)	0.52*** (338)	0.40*** (275)
24 weeks weight	(3)	-	-	0.59*** (338)	0.36*** (275)
52 weeks weight	(4)	-	-	-	0.54*** (275)
72 weeks weight	(5)	-	-	-	-

[1] Figures in parenthesis are numbers of pairs of observations

[2] In this and subsequent tables:

NS = not significant (P>0.05)

* = significant (P<0.05)

** = significant (P<0.01)

*** = significant (P<0.001)

4.1.6 Body measurements

Analysis of variance to show the effects of genetic groups and sex on external body measurements is presented in Appendix Table 2. The least squares means and the standard errors across different genetic groups and sexes are presented in Table 11 and Table 12, respectively. These data are also presented graphically from Appendix Fig.6 to Appendix Fig.13.

Body length was the only measurement significantly ($P<0.05$) influenced by genetic group at 4 weeks of age, Boer being shorter than other genetic groups. Although the body measurements were not significantly ($P>0.05$) different among genetic groups at 12 and 24 weeks of age, the Boer tended to be bigger than other genetic groups at 24 weeks and the crosses tended to be bigger than other genetic groups at 12 weeks of age (Appendix Fig.6 to Appendix Fig.13).

The differences in body measurements between genetic groups was pronounced in later ages. From 36 weeks onwards, crosses were bigger than SEA in all body measurements. Boer was not significantly ($P>0.05$) different from SEA at 48, 60 and 72 weeks in most of body measurements. However, it was intermediate between the crosses and SEA (Appendix Fig.6 to Appendix Fig.9).

Sex had no significant ($P > 0.05$) effect on external body measurements at any stages except heart girth and width at the hind quarter at the age of 72 weeks. However, males tended to have bigger body measurements than females (Appendix Fig.10 to Appendix Fig.13).

4.4.7 Phenotypic correlations among body measurements

Phenotypic correlation between body weight and various external body measurements and correlation among body measurements at different ages (4, 12, 24, 36, 48, 60 and 72 weeks) are presented in Table 13 and Table 14, respectively. Heart girth had the highest correlation with body weight at 4, 12 and 36 weeks of age. Height at the withers had the highest correlation with body weight at the ages of 24, 48 and 72 weeks. At 60 weeks of age, body width had the highest correlation with body weight (Table 13). In general, heart girth and height at the withers had higher correlation with body weight than other measurements (Table 13).

The correlation coefficients among body measurements were on the average above 0.50 and highest correlation coefficients were observed between height at the withers and heart girth irrespective of age group (Table 14).

Table 11 : Least squares means and standard errors for body measurements (cm) by genetic group at different ages

Age (week)	n	Genetic group	Width at hind quarters	Body length	Height at withers	Heart girth
4	32	Kamorai x SEA	6.30 ± 0.21	30.90 ± 0.68[a]	36.38 ± 0.70	37.40 ± 0.86
	19	Boer x SEA	6.84 ± 0.27	34.22 ± 0.89[a]	37.79 ± 0.92	38.79 ± 1.12
	68	SEA	6.51 ± 0.14	30.99 ± 0.47[a]	36.79 ± 0.48	38.84 ± 0.59
	3	Boer	5.70 ± 0.69	28.38 ± 2.26[b]	36.97 ± 2.32	32.97 ± 2.84
12	43	Kamorai x SEA	8.31 ± 0.27	36.74 ± 0.72	42.13 ± 0.70	43.54 ± 0.80
	36	Boer x SEA	8.36 ± 0.29	36.70 ± 0.79	42.51 ± 0.77	43.62 ± 0.87
	84	SEA	8.15 ± 0.19	36.12 ± 0.51	41.65 ± 0.50	44.51 ± 0.57
	5	Boer	6.74 ± 0.78	33.99 ± 2.12	40.95 ± 2.07	38.66 ± 2.34
24	24	Kamorai x SEA	8.84 ± 0.34	38.08 ± 0.96	44.62 ± 1.01	46.33 ± 0.94
	28	Boer x SEA	9.45 ± 0.29	38.40 ± 0.88	45.19 ± 0.94	47.62 ± 0.87
	46	SEA	8.99 ± 0.23	38.57 ± 0.70	45.27 ± 0.74	46.55 ± 0.69
	5	Boer	9.66 ± 0.69	41.08 ± 2.09	47.16 ± 2.22	48.34 ± 2.07
36	40	Kamorai x SEA	10.90 ± 0.29[a]	42.16 ± 0.79[a]	49.60 ± 0.07[a]	51.24 ± 0.64[a]
	33	Boer x SEA	11.15 ± 0.32[a]	43.48 ± 0.87[a]	49.80 ± 0.74[a]	52.90 ± 0.70[a]
	54	SEA	8.85 ± 0.25[b]	38.79 ± 0.68[b]	45.16 ± 0.58[b]	47.86 ± 0.55[b]
	5	Boer	11.99 ± 0.83[a]	43.09 ± 9.23[a]	52.75 ± 1.99[a]	52.79 ± 1.80[a]

Table 11 cont.

Age (week)	n	Genetic group	Width at the hind quarter	Body length	Height at the wither	Heart girth
48	25	Kamorai x SEA	12.44 ± 0.46^{a}	45.05 ± 1.43^{ab}	51.33 ± 2.27^{a}	54.62 ± 1.28^{ab}
	23	Boer x SEA	12.35 ± 0.48^{a}	49.09 ± 1.50^{a}	54.43 ± 1.33^{a}	57.64 ± 1.34^{a}
	37	SEA	10.52 ± 0.38^{b}	41.71 ± 1.19^{b}	47.89 ± 1.06^{b}	52.78 ± 1.07^{b}
	7	Boer	11.09 ± 0.87^{ab}	45.06 ± 2.70^{ab}	54.75 ± 2.40^{a}	55.99 ± 2.40^{ab}
60	9	Kamorai x SEA	11.84 ± 0.84^{ab}	44.00 ± 2.17^{b}	51.12 ± 2.36^{b}	58.00 ± 2.15^{ab}
	28	Boer x SEA	12.81 ± 0.47^{a}	49.18 ± 1.22^{a}	56.99 ± 1.34^{a}	60.85 ± 1.22^{a}
	36	SEA	10.45 ± 0.43^{b}	43.92 ± 1.12^{b}	50.39 ± 1.20^{b}	54.65 ± 1.10^{b}
	4	Boer	12.37 ± 1.24^{ab}	46.95 ± 3.23^{ab}	54.63 ± 3.51^{ab}	61.23 ± 3.20^{a}
72	7	Kamorai x SEA	14.33 ± 0.87^{a}	53.21 ± 2.47^{a}	60.48 ± 2.30^{a}	64.69 ± 2.44^{a}
	15	Boer x SEA	14.99 ± 0.59^{a}	54.03 ± 1.68^{a}	61.07 ± 1.57^{a}	68.40 ± 1.66^{a}
	18	SEA	11.97 ± 0.52^{b}	45.91 ± 1.47^{b}	51.98 ± 1.37^{b}	58.08 ± 1.45^{b}
	4	Boer	13.85 ± 1.16^{ab}	50.37 ± 3.29^{a}	57.64 ± 3.06^{ab}	63.17 ± 3.24^{ab}

Means of the same trait with no subscript letters in common within column are significantly different ($P < 0.05$)

Table 12 : Least squares means and standard errors for body measurements (cm) by sex at different ages

Age	Sex	n	Width at the hind quarter	Body length	Height at the wither	Heart girth
4	M	68	6.51 ± 0.21	31.74 ± 0.68	37.19 ± 0.86	37.34 ± 0.70
	F	55	6.18 ± 0.24	30.49 ± 0.79	36.62 ± 0.82	36.38 ± 1.00
12	M	85	7.99 ± 0.75	36.06 ± 0.68	41.90 ± 0.67	42.48 ± 0.75
	F	84	7.80 ± 0.82	35.71 ± 0.74	41.71 ± 0.72	42.68 ± 0.82
24	M	43	9.28 ± 0.27	38.94 ± 0.84	46.37 ± 0.84	46.91 ± 0.83
	F	61	9.20 ± 0.25	39.13 ± 0.75	44.75 ± 0.75	47.51 ± 0.74
36	M	61	10.85 ± 0.30	41.82 ± 0.80	49.80 ± 0.67	51.68 ± 0.65
	F	66	10.59 ± 0.29	41.93 ± 0.77	48.87 ± 0.65	50.72 ± 0.62
48	M	59	11.55 ± 0.33	45.70 ± 1.04	52.19 ± 0.93	55.44 ± 0.93
	F	34	11.65 ± 0.43	44.75 ± 1.35	52.01 ± 1.19	55.08 ± 1.21
60	M	46	12.14 ± 0.49	46.68 ± 1.28	53.33 ± 1.39	59.19 ± 1.27
	F	32	11.60 ± 0.51	45.35 ± 1.33	53.22 ± 1.44	58.18 ± 1.32
72	M	15	14.64 ± 0.70^{a}	52.38 ± 1.98	59.56 ± 1.85	66.25 ± 1.96^{a}
	F	30	12.93 ± 0.43^{b}	49.38 ± 1.23	56.02 ± 1.15	60.92 ± 1.22^{b}

Means of the same trait with no subscript letters in common with in column are significantly different ($P<0.01$)

4.2 Prediction equations

Prediction equations for liveweight from external body measurements at different age groups (4, 12, 24, 36, 48, 60, 72 weeks) and all age groups pooled together regardless of genetic groups are presented in Table 15. The prediction equation for different genetic group (Kamorai x SEA, Boer x SEA, SEA and Boer) is presented in Table 16. Prediction equations showing one, two, three best variables in estimating liveweight and all four independent variables together is presented in Table 17.

Table 15 shows that as age advances the total variation in body weight explained by body measurements increased almost linearly. The total variation explained by body measurements (R^2) among genetic group ranges from 85 to 88 % (Table 16).

The coefficients of determination (R^2) were 78, 77,74 and 72 % for heart girth, height at the withers, width at the hind quarter and body length when one variable is included in the model one at a time in that order (Table 18). Inclusion of height at the withers in addition to the heart girth improved the coefficient of determination (R^2) by 5 %. The inclusion of the third parameter (body width) in addition to the two best variables improved R^2 by 3 %. Improvement in R^2 was 9 % when all three parameters were added to the one best variable model.

Table 13 : Phenotypic correlation between body weight and different body measurements [1]

Age (weeks)	Width at the hind quarter	Body length	Height at the withers	Heart girth
4	0.47	0.48	0.46	0.58
12	0.73	0.67	0.77	0.77
24	0.60	0.63	0.73	0.55
36	0.66	0.63	0.62	0.69
48	0.72	0.66	0.79	0.71
60	0.84	0.77	0.77	0.82
72	0.65	0.81	0.84	0.79

[1] All significant ($P<0.01$)

Table 14 : Phenotypic correlation of width at the hind quarter (x_1) body length (x_2), height at the withers (x_3) and heart girth (x_4) in cm at different age groups [1]

Age (weeks)	x_1 and x_2	x_1 and x_3	x_1 and x_4	x_2 and x_3	x_2 and x_4	x_3 and x_4
4	0.42	0.47	0.48	0.48	0.66	0.58
12	0.56	0.64	0.56	0.60	0.57	0.68
24	0.61	0.63	0.55	0.61	0.67	0.59
36	0.57	0.55	0.62	0.49	0.58	0.56
48	0.47	0.56	0.51	0.45	0.52	0.62
60	0.76	0.75	0.80	0.70	0.73	0.73
72	0.73	0.78	0.73	0.80	0.72	0.86

[1] All significant ($P<0.05$)

Table 15 : Prediction equation for body weight (kg) at various ages from width at the hind quarter (X_1), body length (X_2), height at the withers (X_3), heart girth (X_4) in cm considering the variables which are significant [1,2]

Age (weeks)	No. of observation	Constant	Regression coefficient					Prediction error
			X_1	X_2	X_3	X_4	R^2 (%)	
4	123	-3.33 (0.99)	0.26 (0.11)	0.11 (0.04)	-	0.10 (0.03)	42	1.22
12	169	-13.24 (1.06)	0.47 (0.03)	0.08 (0.03)	0.17 (0.03)	0.17 (0.02	77	1.34
24	104	-10.86 (1.76)	-	0.17 (0.05)	0.30 (0.05)	-	57	1.81
36	133	-15.80 (2.08)	0.38 (0.12)	0.11 (0.04)	0.16 (0.05)	0.23 (0.05)	71	1.77
48	93	-20.19 (1.81)	0.53 (0.11)	0.17 (0.03)	0.29 (0.04)	0.12 (0.04)	85	1.92
60	78	-20.65 (3.02)	0.88 (0.02)	-	0.16 (0.07)	0.32 (0.08)	82	2.59
72	46	-29.09 (3.65)	-	0.35 (0.12)	0.58 (0.12)	-	83	2.87
Pooled	746	-17.91 (0.54)	0.50 (0.06)	0.15 (0.02)	0.21 (0.02)	0.19 (0.02)	87	2.12

[1] All significant ($P < 0.01$)

[2] Figures in parenthesis are standard errors for parameter estimates

Table 17 : Prediction equations for body weight considering one external body measurement, two best estimators, three best estimators and four estimators regardless of genetic and age group[1] (n = 746)

No. of parameters	Constants	Regression coefficients					Prediction error
		X_1	X_2	X_3	X_4	R^2 (%)	
1	- 18.47 (0.60	-	-	0.65 (0.01)	-	77	2.77
1	- 14.46 (0.60)	-	0.64 (0.01)	-	-	72	3.06
1	- 17.02 (0.55)	-	-	-	0.60 (0.01)	78	2.70
1	- 6.02 (0.38)	1.81 (0.04)	-	-	-	74	2.92
2	- 14.29 (0.51)	0.87 (0.06)	-	-	0.35 (0.02)	83	2.35
3	- 17.10 (0.54)	0.62 (0.06)	-	0.24 (0.02)	0.24 (0.02)	86	2.19
4	- 17.91 (0.54)	0.50 (0.06)	0.15 (0.02)	0.21 (0.02)	0.19 (0.02)	87	2.12

[1]Figures in parenthesis are standard errors

Where: X_1 = width at the hind quarter
X_2 = body. length
X_3 = height at the withers
X_4 = heart girth
All significant ($P < 0.05$)

4.3 Reproduction

4.3.1 Age at first kidding

The analysis of variance on effect of genetic group, birth type, season and period of birth on age at first kidding is presented in Appendix Table 3. The overall mean of age at first kidding during the whole period of study was 810.78 days with standard deviation of 172.73 days. Of the factors studied, only period of birth significantly ($P<0.001$) affected age at first kidding. It can be observed from Table 18 that the does kidded at younger age in period 1 (1972-1974) and period 4 (>1980) than in other periods. Although, the difference on age at first kidding was not affected significantly ($P>0.05$) by birth type, female kids born as twins were 50.88 days older at first kidding than those born as singles.

4.3.2 Kidding interval

The analysis of variance to test the effect of genetic group, number of parities, season of previous kidding and period of kidding on kidding interval is presented in Appendix Table 4. The least squares means for factors affecting kidding interval are presented in Table 19. Season of previous kidding and period of kidding had significant ($P < 0.05$ and $P < 0.01$, respectively) effect on the intervals between successive kiddings. The does which kidded their previous kids in season 1 (late rainy

Table 18 : Least squares means and standard errors (days) for age at first kidding [1,2]

Effect	Age at first kidding (days) Mean	s.e
Overall mean	810.78 (291)	172.73
Genetic group		
Kamorai x SEA	828.05 (50)	28.00
Boer x SEA	806.34 (61)	26.31
SEA	790.44 (180)	18.47
Birth type		
Single	782.83 (210)	15.83
Twins	833.71 (81)	27.11
Season of birth		
February-April	833.36 (49)	28.63
May - July	832.99 (75)	25.33
August-October	798.08 (88)	23.34
November-January	768.67 (79)	24.15
Period of birth		
1972 - 1974	762.54[b] (90)	16.70
1975 - 1977	883.0[a] (75)	27.08
1978 - 1980	860.20[a] (78)	26.47
> 1980	728.26[b] (48)	37.45

[1] Figures in parenthesis are number of observations
[2] s.e=standard error

Table 19 : Least squares means and standard errors (days) for kidding interval [1]

Effect	Kidding interval (days) Mean	s.e
Overall mean	355.89 (336)	63.3
Genetic group		
Kamorai x SEA	350.09 (59)	8.9
Boer x SEA	355.86 (68)	8.0
SEA	350.77 (209)	5.67
Parity		
1	349.41 (163)	5.75
2	352.68 (91)	7.76
3	354.63 (82)	8.27
Season of previous kidding		
February-April	331.31[a] (44)	10.16
May-July	359.69[b] (79)	7.78
August-October	362.08[b] (85)	8.16
November-January	355.88[b] (128)	6.54
Period of kidding		
1972 - 1974	369.75[a] (32)	12.66
1975 - 1977	365.83[a] (166)	6.02
1978 - 1980	342.92[a] (69)	8.12
> 1980	325.45[b] (69)	8.33

[1] Figures in parenthesis are the numbers of observations
s.e = standard error

season) had shorter (331.31 ± 10.16 days) kidding interval than those kidded in other seasons. Does which kidded their kids in period 4 had shorter (325.45 ± 8.33) kidding interval than those does kidded their kids in other periods. The differences in kidding interval due to period of kidding was not significant ($P > 0.05$) among period 1, period 2 and period 3.

4.3.3 Twinning rate

The overall twinning percentage for SEA goats was 14.2%. Data on the factors affecting twinning rate was limited therefore further statistical analyses was not made as to study their effect on twinning percentage.

4.4 Mortality

Distribution of births and mortality rates at different age groups by genetic group, sex, birth type, season of birth, period of birth and birth weight category is presented in Table 20. Effects of different factors on mortality rate of kids is presented in Appendix Table 5.

The chi-square test indicated that, the differences in mortality rates among genetic groups was not significant ($P > 0.05$). However, there was a tendency for Boer x SEA to have highest mortality rates (46.7, 37.5 and 66.6%) and SEA to have lowest mortality rates (40.0, 24.6 and 54.8%) and Kamorai x SEA (41.7, 28.6 and 58.3%) being intermediate at the age of 0 to 16, >16 to 52 and 0 to 52 weeks, respectively.

There was significant (P < 0.05) effect of birth type on mortality rate of kids from birth to weaning. There was no significant difference (P>0.05) in mortality rate between singles and twins at >16 to 52 and 0 to 52 weeks of age. However, there was a tendency of twins to encounter more deaths than singles in all age groups. Season of birth had significant effect (P < 0.05, P < 0.01, respectively) on mortality rate of kids at the age of 0 to 16 weeks and from birth to one year. Kids born is season 1 had higher mortality rate than other seasons followed by season 2. Sex had no significant (P > 0.05) effect on mortality rate.

Birth weight had significant effect on mortality rate of kids from 0 to 16 weeks (P < 0.01) and from 0 to 52 weeks of age (P < 0.05). Mortality rate decreased by increasing birth weight up to 2.0 to 2.5 kg. The kids weighing 2.6 to 3.0 kg at birth had lower mortality rate (29.8%) than those weighing 1.0 to 1.5 kg (57.9%) from birth to weaning. The same pattern in mortality rate was reflected from birth to one year of age.

Preweaning mortality rate in kids was also significantly (P<0.05) affected by period of birth of the kids. However, it was not affected from weaning to one year. The percent mortality rates were highest in period 4 (49.3%, 30.0% and 60.5%) and were the lowest in period 1 (26.7%, 27.3% and 46.6%) from 0 to 16, >16 to 52 and 0 to 52 weeks of age, respectively.

CHAPTER 5

DISCUSSION

5.1 Growth

5.1.1 Birth weight

Results obtained in the present study showed that the Kamorai x SEA goats were superior to SEA in birth weight. This difference between genetic groups comes from the sire and this is directly due to genetic differences. This supports earlier findings of Devendra and Burns (1970), Mchau (1979), Malik, Kanaujia and Pander (1986) and Wilson and Murayi (1988). Boer x SEA were not different in birth weight when compared with SEA and Kamorai x SEA. Birth weight of Boer x SEA kids were expected to be heavier compared to kids of SEA due to higher genetic potential of the sire. Birth weight of the kids may have been restricted by small maternal environment of the SEA dams. Similar trends has been reported by other worker with sheep (Hunter 1956). However, there was no record on the difficulty of kidding in the present study.

The higher birth weight of males over females in the present study is in agreement with findings from other studies on goats in the tropics (Siddiqui et al. 1981; Khan and Sahni 1983; Naik, Patro and Mishra 1985; Malik, Kanaujia and Pander 1986; Wilson and Murayi 1988). Joubert (1956) and Dass and Acharya (1977) commented that the males tend to be heavier than females due to greater muscle cell number and this may be the case in the present study. It is also evident from the results of this study that singles were heavier than the twins. Many workers, for example Moulick and Syrstad (1970), Devendra and Burns (1970), Roy, Prakash and Khan (1989) and Das, Joshi and Bisht (1989) have also made the same observation. This may probably be due to limited supply of some blood nutrients from the mother to the foetal environment for twins (Hafez 1969).

The season during which kidding take place did not seem to affect birth weight. This is in line with the findings of Moulick and Syrstad (1970), Singh (1973), Sarma et al. (1981) but not in agreement with the findings of Nagpal and Chawla (1985), Naik, Patro and Mishra (1985) and Sivaiah Sadasiva and Raghava Rao (1988). The lack of a season effect on birth weight is interesting. This is because does kidding in wet season are likely to get comfortable weather condition (low heat stress) and good access of forage during late pregnancy and this would have also resulted in higher birth weight. It would seem that birth weight relative to subsequent weights is less sensitive to environmental influences such as season, even with severe maternal under nourishment, the foetus continue to grow and will achieve birth weight which is close to normal (Hafez 1969).

The difference in birth weight between periods in this study was partly due to age and weight of the doe in different years. The low birth weight of 2.19 kg at interval of 1975 to 1977 was from younger does. In 1978 to 1980 interval the goats may have reached ages or parity for maximum birth weight. It is known that birth weight increases with the age and parity of the dam (Kyomo 1978; Nagpal and Chawla 1985). Unfortunately, parity and age of the dam were not included in the model in the present study due to limited data.

5.1.2 Weaning weight

There was an improvement in weaning weight for SEA goats through crossing with Boer and this is in agreement with findings of Kyomo (1978), Mchau (1979), Senyatso (1986) and Kiwuwa (1986). It is reasonable to assume that the maternal contribution was about the same because the dam breed is similar for all the kids. Thus the difference in weaning weight could be as a result of either additive genetic effect or heterosis or both. The phenomenon of heterosis in crossing two different breeds has been well explained by Falconer (1989) and Cunningham and Syrstad (1987).

The difference in weight between males and females disappeared at weaning, though males had a tendency of being heavier than females. This observation is similar to that reached by Mittal and Pandey (1978), Naik, Patro and Mishra (1985), Patnaik and Sukadev Nayak (1988).

The data also showed the existence of differences in weaning weight between singles and twins. This is in line with the works of Malik, Kanaujia and Pander (1986), Patnaik and Sukadev Nayak (1988), Wilson (1988) and Roy, Prakash and Khan (1989). It is possibly a reflection of maternal environment in a form of milk provision for the kids where singles had more access to milk than twins hence heavier weaning weight.

It is also evident from the result of the present study that weaning weight is affected by season. This corresponds with the findings of Siddiqui et al. (1981), Nagpal and Chawla (1985) and Malik, Kanaujia and Pander (1986). In the present study it was noted that kids born in late rains (February to April) were heavier than kids born in cold and dry season (August to October) and early rains (November to January). This may probably be due to availability of good quality and quantity of pasture for the dam in the long rains which indirectly increased milk yield of the dam on which the kids depended for nutrient supply up to weaning. Moreover, the kids also had access to good quality forage on the top of their dam's milk. It appears optimum time of attaining higher weaning weight is when birth is at beginning of late rains. This conclusion is similar to that reached by Wilson, Peacock and Sayer (1984) working on sheep and goat in Kenya who reported optimal time of good growth rate when kidding is at the start of late rainy season.

Period (year) to period variation in weaning weight in the present study is in close agreement with other workers in the tropics (e.g. Mukundan, Bhat and Khan 1982; Mukundan et al. 1983; Nagpal and Chawla 1985; Malik, Kanaujia and Pander 1986; Roy, Prakash and Khan 1989). In the present study kids born in periods between 1972 and 1974 were remarkably heavier than those born in other periods except those born from 1978 to 1980 and this may have been due to relatively good management procedures followed towards provision of supplementary feeds. However, with time there was deterioration in management practices especially on the provision of concentrates to the kids and the dams. The importance of nutrition in weaning weight and subsequent weights has been well documented in literature by Wilson (1958) where, under a high plane of nutrition kids reached 15 kg in 20 weeks. Kids under low plane of nutrition in Wilson's study reached 15 kg after 48 weeks. It seems reasonable to consider improvement of nutrition of the animals in order to fully utilize the genetic potential of the animal.

5.1.3 Postweaning weights

The general impression presented by the data from the present study is that there was no significant genetic group difference in postweaning weights, though Boer x SEA had a tendency of being heavier at 24 and 52 weeks weight and Kamorai x SEA being heavier at 72 weeks weight. Since unimproved pasture and browse were the main source of the bulk of feed supply and with very limited amount of concentrate supplementation offered for the crosses, the larger and potential genetic groups most probably failed to express their genetic potential in such poor management conditions. Unfortunately, nutritive value of the pasture and stocking density of the study area was not stated. Therefore, there was no enough information to come up with definite conclusion.

In the present study sex had no significant effect on postweaning weights, which is in accordance with the findings of other workers (Mittal and Pandey 1978; Naik, Patro and Mishra 1985). It is however generally known that males tend to be heavier than females for postweaning weight. It is also worth mentioning that under poor management conditions, the difference in weight-for-age between sexes tends to be narrower.

Continuous superiority in weight of twins up to 24 weeks of age is in accordance with the findings of Siddiqui et al. (1981), Wilson (1983) and Roy, Prakash and Khan (1989). This was probably due to the fact that singles had higher birth weights and more access of milk during preweaning period. These residual effects were carried over to 24 weeks weights. However, the influence of birth type disappeared at 52 and 72 weeks. As age advances maternal influences for the kids is reduced as they entirely depend on their aggressiveness and adaptive ability (Misra,Singh and Jain 1985).

Effects of season on 24 and 72 week weights were not significant, although there was a tendency for kids born from February to April being heavier than those born in other seasons. However, significantly higher yearling weight of kids was recorded for those kids born from May to July. This might be due to the fact that those kids might reached that age at the end of the rainy season and therefore have had access to good pasture. This confirms the earlier findings of Kyomo (1978). The lack of significant effect of season on 24 weeks may also be due to weaning shock. Similar explanation has also been advanced by Solo (1984) in sheep and Morand-Fehr (1981) in goats.

The period of birth influenced postweaning weights. Similar findings have been reported by Kyomo (1978), Khombe (1985) and Nagpal and Chawla (1985). For these year to year variation in postweaning weights two, explanations may be put forward. First,inconsistent management procedures followed in nutrition and general husbandry practices from one year to another may cause this variation. Secondly the variation in climatic factors (rainfall, humidity and temperature) from one year to another also have a direct effect on plant growth thus affecting the quality and quantity of pasture for animals and the level of parasitic and disease conditions. Similar conclusions have also been drawn by Wilson and Murayi (1988) and Carles (1985). It is therefore important that management procedures should be as uniform as possible when comparing genetic groups over a period of years.

Season x genetic group interaction recorded in this study was as a result of higher live weight recorded for Boer x SEA in season 2 at 72 weeks weight. The controversial picture presented by the present data in this aspect is difficult to explain. However, period x genetic group interaction shown in this study is due to very poor performance of the crosses in period 4 at 52 week weight and poor performance of Boer x SEA in period 4 at 72 weeks weight. There was small number of observations in the two genetic group - period combinations and this is reflected by higher standard errors of the mean. Therefore, this result is not conclusive and it must be interpreted with caution on account of small number of observations in which analysis was based.

5.1.4 Preweaning and postweaning growth rates

The effect of genetic group on preweaning and postweaning growth rate was small and non-significant. This is in accordance with Kyomo's (1978) observation using the same genotypes. However, it is not in line with several other workers using Boer as sire breed in crossbreeding studies with other breeds of goats in the tropics (Naude and Hofmeyr 1981; Senyatso 1986; Kiwuwa 1986).

The data for preweaning and postweaning growth rate in the present study showed that growth rate was relatively rapid up to weaning (48.39 g/day) but decreased by more than half (22.59 g/day) thereafter. The preweaning growth rate of 46.82 g/day for SEA goats is close to that of 50 g/day from birth to 6 months reported by Lebbie and Manzini (1989) for Swaziland goats and those reported from India by Malik, Kanaujia and Pander (1986) of 52.80 and 48.27 g/day up to 3 months for Beetal x Black Bengal and Black Bengal x Beetal, respectively. However, it was different from that of 87 g/day up to 3 months and 67 g/day up to 6 months reported by Wilson (1976) in Sudan. In Ethiopia Mukasa-Mugerwa,Ephraim and Tadesse (1986) reported a decline in growth rates from 104 g/day to 44 g/day for preweaning (up to 3 months) to postweaning (from weaning to 24 months of age). The postweaning growth rate value of SEA goat of 22.37 g/day from weaning to 72 weeks weight is in agreement with the results of Kyomo (1978) who reported growth rate of 25.9 g/day from weaning to one year.

The significant effect of season on preweaning growth rate in this study was a reflection of availability of pasture which is a precondition for nutrition build up of the dam in late pregnancy and lactating dams which in turn influence the growth rate of kids through good mothering ability. This is in agreement with the findings of Guha et al. (1968), Malik, Kanaujia and Pander (1986) and Mohd, Sulaiman and Othman (1988). In the present study the highest growth rate was recorded during the late rains (February to April). There was however no significant difference in growth rate between kids born in season 1 (February to April) and those born in season 2 (May to July). The lack of difference in growth rate between kids born in the two seasons may indicate that nutrition was in the same condition in these two seasons. The lowest (35.6 g/day) growth rate was recorded for kids born in hot and dry season (August to October). Therefore, it is recommended from the present findings that kidding should be practised between

February and July of each year. Although supplementation could be practised in cases where kidding is taking place during hot and dry season, it is not a feasible proposition especially in the traditional sector due to the fact that supplements are expensive and not easily available. However, multipurpose legume trees can be grown and be used to supplement the does kidding in such season.

The variation in preweaning and postweaning growth rate due to variation in period of birth of the kids is in agreement with findings of Guha et al. (1968), Malik, Kanaujia and Pander (1986) and Mohd,Sulaiman and Othmans (1988). In the present study highest growth rate was experienced from 1972 to 1974 while the lowest growth rate occurred in periods 4 (> 1980). This may be due to the fact that management in terms of nutrition and disease control was relatively better for animals born from 1972 to 1974.

5.1.5 Correlation among weights at various ages

The association between two characters that can be directly observed is the correlation of phenotypic value or phenotypic correlation as described by Falconer (1989). Weaning weight and postweaning weights at 24, 52 and 72 weeks were positively correlated to each other at phenotypic level. However, birth weight was only significantly correlated with weaning weight.

The correlation between weaning weight and postweaning weights at 24, 52 and 72 weeks was moderately high (0.72, 0.52 and 0.40, respectively). These value were in agreement with values reported by Kyomo (1978) who found the correlation coefficient of weaning weight and weights at 52 and 72 weeks to be 0.40 and 0.50, respectively. It was generally noticed that the highest correlation coefficients were found between consecutive weights.

5.1.6 Body measurement

At the age of 4, 12 and 24 weeks genetic group had no significant effect on increase in body measurements except body length at 4 weeks. Similar findings were reported by Sharma et al. (1977). Lack of significant effect of genetic group in most of body measurements at early ages may probably be due to high measurement errors in proportion to the true value which contributes to higher residual sum of squares. However, at later ages, genetic group differences in body measurements become more pronounced. At these ages SEA were smaller than other genetic groups compared in most body measurements and Boer was intermediate and Boer x SEA was bigger. This may probably be due to true heterosis (Cunningham 1982; Cunningham and Syrstad 1987)

At ages of 4 to 60 weeks there was no difference between males and females in most of the body measurements, though males showed a tendency of being bigger than females. However, at the age of 72 week there was significant variation in width at the hind quarter and heart girth between males and females. The same conclusions were reached by Das, Joshi and Bisht (1989), who observed differences between sexes in heart girth to increase with increasing age. The tendency of males to be bigger in body measurements at later stages is associated with the difference in appearance of secondary sex characteristics. These differences are directly related to secretion of androgen which is a growth stimulation compound (Carlson 1969).

5.2 Association between body weight and external body measurements

5.2.1 Phenotypic correlation

The correlation coefficients between body weights and external body measurement were moderate. The magnitude of the correlation coefficients increased with age of the animal. This is in line with the findings of Misra (1980). With advancement of age, fluctuation in body measurements and body weight due to extraneous and temporary environmental factors is reduced. Therefore one can expect a close association between body weight and body measurements.

In the present study it was also noted that among the body measurements, heart girth and height at the withers were highly correlated with body weight. This is in agreement with the findings of Kyomo (1978) and Mchau (1979). This may imply that these two measurements may be used for prediction of body weight of goats.

5.2.2 Prediction equation

In the present study three prediction equations were developed to be used for different purposes. The first equation was developed for separate ages (all breeds combined) to be used if there are records on the age of the animal. The second was for separate genetic group (all ages combined) due to the existence of significant effect of genetic group on body measurements. The third equation considered all ages and genetic groups to be used at farmers level as the knowledge of age of the animal is not normally available due to lack of records in the farmers field.

In the current study it was observed that R^2 was lower at early ages. This may be due to higher measurement error in proportion to the true value (Misra 1980). The increasing value of R^2 with advancement of age suggests that body weight can be predicted from body measurements with higher accuracy at later stages. This confirms the earlier findings of Misra (1980), Bhat, Bhat and Garg (1980) and Hassan and Ciroma (1990). Some independent variables were not included in the model as they were not contributing significantly to the accuracy of the prediction equation.

In this study an effort was also made to develop a prediction equation considering one variable and from combinations of two best variables, three best variables and all four measurements to predict liveweight. From different combinations of variables to predict liveweight one can choose the equation depending on the precision needed, the ease of body measurement and the availability of records. This study showed that heart girth was the best one variable estimator of liveweight. Heart grith and width at the hind quarter were the two best variables and heart girth, height at the withers and width at the hind quarter were the best three variables. An extra advantage of R^2 of 5%, 8% and 9% was achieved when best one, two and three variables were included in addition to heart girth. This indicates that heart girth is as efficient as other combinations of variables in explaining the variation in body weight. Several other workers have also showed that heart girth is the best measurement in predicting liveweight (e.g. Kyomo 1978; Mchau 1979; Valdez, Fagan and Vicera 1982).

5.3 Reproduction

5.3.1 Age at first kidding

The average age at first kidding was 810.78 days with standard deviation of 172.73 days. This value is close to values reported by Kyomo (1978), Wilson and Murayi (1988) and Das and Sendalo (1990). These workers reported age at first kidding ranging from 600 to 780 days based on station studies. The present values are however very different from those reported from studies in the traditional sector of Subsaharan Africa ranging from 301 to 431 days (Gerbaldi 1978; Wilson and Durkin 1983; Wilson 1988; Lebbie and Manzini 1989). It appears that goats were younger at first kidding in the traditional sector than at the research stations. This might be due to the management practices imposed on research stations and multiplication centres to achieve mating at a given age or weight. For example, in the present study goats were purposely drafted for mating for the first time at 72 weeks age. It is also possible to give a reason that management practices in feeding and general husbandry practices were substandard under station conditions and this might also contribute to the delay in age at first kidding in the present study.

In the present study there was a tendency of SEA being younger than Kamorai x SEA and Boer x SEA at first kidding. Younger age at first kidding for tropical goats compared to crosses have also been reported in literature. For example, Raja and Mukundan (1974) showed purebred Malabari goats were younger at first kidding than Jamunapari x Malabari goats. Wilson and Murayi (1988) also found younger age at first kidding of SEA goats over the Anglonubian x SEA goats. Devendra and Burns (1970) reported little variation in age at first kidding between Indian native and crossbred goats. Kyomo (1978) did not find any difference between SEA and Kamorai x SEA goats in age at first kidding.

The observed tendency of the does born as single to have a younger (by 50.88 days) age at first kidding than twins is in agreement with other findings (Ali, Hague and Hasnath 1973; Singh and Singh 1974; Wilson and Murayi 1988; Wilson, Murayi and Rocha 1989). This was probably due to lower growth rate observed in females born as twins resulting in delay in reaching puberty (Singh and Singh 1974; Wilson and Murayi 1988; Wilson, Murayi and Rocha 1989). It is suggested that for twins to kid at the same age as singles, they may need to be supplemented in order to encourage faster growth rate. This is especially true for twins from low milk yielders.

Period of birth influenced age at first kidding. Similarly period (year) effects have been reported by Wilson and Murayi (1988) and Wilson, Murayi and Rocha (1989). It has been found that period effect on age at first kidding is mainly a reflection of change in management practices (Wilson and Murayi 1988) and was likely the case in this study.

5.3.2 Kidding interval

The overall mean kidding interval was 355.89 with standard deviation of 63.30 days. This value is closer to values reported in most studies carried out on experimental stations and multiplication centres. Intervals of 323 to 351 days have been reported on many stations in the tropics (Devendra 1962; Kiwuwa 1986; Wilson and Murayi 1988; Wilson, Murayi and Rocha 1989; Ndlovu 1990). It was however longer than reported values found in the traditional sector which ranges from 238 to 265 days (Wilson 1976; Wilson and Durkin 1988; Lebbie and Manzini 1989; Karua 1989). The longer kidding interval recorded in many stations is a result of controlled breeding policy imposed, to achieve best breeding season. Normally there is no imposition of seasonal breeding in the traditional sector and animals of all ages and sex run together during day and night. In the present study, though there was no well defined seasonal breeding policy, mating was taking place only during the evenings (between 1800 and 0800 hours) and this might have resulted to less exposure of the does for mating as compared to the traditional sector.

The results from present study show that season of previous birth and period of birth were the only main sources of variation contributing to differences in kidding intervals. The does having their previous kidding in long rains showed shorter kidding interval than does having their previous kidding in other seasons. This confirms the earlier findings of Wilson and Murayi (1988) who reported shorter kidding intervals for dams having their previous kidding during rainy season. Similarly, Wilson and Durkin (1988) also showed that dams having their previous birth in the rainy season had shorter kidding intervals than those in the cold and dry or post rainy season. This is possibly related to the availability of pasture. The availability of pasture in turn might have exerted an influence on ovulation rate and fertility. The effect of period (year) of kidding on kidding interval has also been demonstrated by Adeoye (1985), Wilson and Durkin (1988), Wilson and Murayi (1988). In the current study this period to period variation might be associated with inconsistency in management procedure followed in the station.

5.2.3 Twinning rate

The twinning rate found in the present study for SEA goats (14.2%) was similar to found by Wilson (1958), Mason and Maule (1960) and Kyomo (1978) who reported twinning rate of 10% to 15%. However, it was smaller than the values(17-30%) reported by Sacker and Trail (1966) and Mchau (1979) using the same genotype. The wide range of variation within this breed, implies the possibility of improving twinning rate of this goats through selection.

5.4 Mortality rate

The effect of genetic group on mortality rate was small and nonsignificant. However, Boer x SEA tended to show higher mortality rates. This is in agreement with findings by Mchau (1979) and Senyatso (1986). This may be due to poor adaptation characteristics of Boer goats to harsh and poor environmental conditions and increasing of susceptibility to disease conditions. Similar conclusions were also reached in crosses between Boer and indigenous tropical goats (Mchau 1979; Senyatso 1986). The major causes of mortality were not fully recorded. However, pneumonia caused a higher percentage death in kids than other causes.

In the current study mortality rate was higher in the preweaning period. Similar results were reported by Ahmed and Tantawy (1960), Mittal (1976), Rajan, Maryamma and Nair (1976), Kyomo (1978), Mchau (1979) and Sarmah et al. (1981). Younger animals probably have lower ability to withstand attack by both physical and biological agents due to their lack of immunity and hence they are very susceptible to certain enteric and respiratory infections (Ndamukong 1985). There is therefore the need to provide extra care to minimize losses in the preweaning periods through provision of proper shelter, prophylaxis and adequate nutrition.

In the present study twins were more prone to death than singles. This finding agrees with observations made by Sarmah et al. (1981), and Wilson and Murayi (1988). Two reasons may be advanced for higher mortality rates in twins. First the twins are smaller in birth weight and secondly the dams may have been poor milk yielder providing limited supply of nutrients and thus increasing susceptibility to diseases.

Kids born during the wet season had higher mortality rate than kids born in the dry season. Similar trends have been reported elsewhere (Mazumdar, Mazumdar and Goswami 1980; Sarmah et al. 1981; Chawla, Bhatnagar and Misra 1982; Wilson, Peacock and Sayer 1984; Wilson 1988). The higher mortality rate in the rainy season was associated with high rainfall and relative humidity percentage (Mazumdar, Mazumdar and Goswami 1980). However, Singh, Mishra and Singh (1990) found mortality rate to be higher in dry season. The latter authors argued that kids born in summer faced malnutrition accompanied by disease susceptibility.

Of the factors considered in this study, kid birth weight had a remarkable influence on preweaning and postweaning mortality rates. This confirms earlier findings in tropical goats (Mittal 1976; Mazumdar, Mazumdar and Goswami 1980; Singh, Mishra and Singh 1990). Mazumdar, Mazumdar and Goswami (1980) reported 100% mortality rate for kids weighing 1.0 to 1.5 kg and 32.2% for kids weighing from 2.0 to 2.5 kg. In the present study, mortality rate was 57.9% for kids weighing 1.0 to 1.5 kg. Animals with low birth weight have lower energy reserves and hence they can not cope with harsh environment of cold and winds (Curtis 1969).

The difference in viability of kids between periods of birth is in agreement with published results of Ahmed and Tantawy (1960), Chawla, Bhatnagar and Mishra (1982) and Wilson and Murayi (1988). In the present study kids born between 1972 and 1974 had lower preweaning and postweaning mortality rates. In this period management procedure in terms of disease prevention and feed provision was good. Thereafter, inconsistent management procedure contributed to higher mortality rate at later stages. It is suggested that there is a need of intensify control and care of kid rearing and improving the standard of flock hygiene and disease monitoring from year to year.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study was conducted to investigate the effects of genetic and nongenetic factors affecting growth, reproductive performance and mortality rates. Increase in body measurements and equations to estimate body weight from them were also studied.

The nongenetic factors were the most important sources of variation in postweaning growth traits, reproductive performance and mortality rates. There was no much improvement in liveweight due to genetic difference, except at birth and weaning weight though there was a general tendency of Boer x SEA being heavier. From the prediction equations developed, the equation with four variables had highest R^2 value and from one variable models studied heart girth showed highest R^2 value.

There was no significant advantage gained due to crossbreeding in age at first kidding and kidding interval. Generally SEA goats had shorter kidding interval and were younger at first kidding. Kids born as twins, or with below average birth weights, or in the wet season and during the period where concentrate feed was limiting, encountered high mortality rates. Birth weight was the most important factor which affected mortality rate.

It can be concluded that, among the factor studied, period of birth had a significant effect on growth, reproductive performance and mortality rate and this period effect is mainly associated with an inconsistent management system followed in the station. Taking into consideration the genetic merit of an animal can only be exploited under optimum management in feeding and disease prevention, under Morogoro conditions there is a need to maintain good management conditions in the process of evaluating local goats and their crosses. There is also a need to evaluate the crosses and locals under farm conditions.

6.2 Recommendations

1. It was apparent from the present study that there was no appreciable amount of gain in postweaning growth traits, reproduction and mortality by crossing SEA with Kamorai and Boer. This was attributed to inconsistent management provided for the crosses. Therefore to exploit the breed difference, under tropical conditions like in the present study there is a need to improve the management procedures.

2. Prediction equation for live weight using body measurements must be widely applicable across breeds and management systems. It would be desirable to test the prediction equations developed in this study under field conditions, before recommending widespread adoption.

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Appendix Table 1 : Analysis of variance for live weight at different ages, and for preweaning and postweaning growth rate

Source	df	Mean squares						
		Birth	Weaning	24 weeks	52 weeks	72 weeks	Preweaning growth rate	Postweaning growth rate
Genetic group	2	1.17*	15.69*	5.31 NS	11.30 NS	13.26 NS	574.29 NS	67.62 NS
Sex	1	3.11**	9.57 NS	6.91 NS	17.05 NS	0.55 NS	586.70 NS	77.25 NS
Birth type	1	8.55***	59.17***	29.10*	35.27 NS	25.95 NS	1317.73 NS	81.61 NS
Season of birth	3	0.58 NS	24.75**	5.40 NS	43.23*	11.57 NS	2201.03***	139.77NS
Period of birth	3	3.53***	62.60***	83.54***	482.06***	447.54***	4228.48***	2466.22***
Genetic group x season	6	0.64 NS	2.18 NS	2.81 NS	29.84 NS	53.29 *	162.65 NS	197.14 NS
Genetic group x period	6	0.55 NS	3.98 NS	12.44 NS	67.72***	77.24**	324.99 NS	218.26 NS
Error+		0.34 (1174)	4.82 (601)	7.76 (553)	14.50 (315)	21.92 (252)	383.18 (598)	117.43 (239)

Figures in parenthesis are error degree of freedom.

Appendix Table 2 : Analysis of variance for body measurements (cm) at different ages

Age	Source	df	Mean squares			
			Width at hind quarter	Body length	Height at the wither	Hear girth
4	Genetic group	3	1.79 NS	65.90**	9.57 NS	45.12 NS
	Sex	1	3.19 NS	45.29 NS	15.31 NS	4.23 NS
	Error	117	1.39 NS	14.93	15.74	23.75
12	Genetic group	3	4.09 NS	14.28 NS	8.39 NS	58.53 NS
	Sex	1	1.41 NS	4.98 NS	1.37 NS	1.73 NS
	Error	163	3.01	22.13	21.11	27.17
24	Genetic group	3	2.41 NS	12.58 NS	12.58 NS	12.74 NS
	Sex	1	2.41 NS	0.85 NS	0.84 NS	8.90 NS
	Error	98	2.37	21.72	24.60	21.37
36	Genetic group	3	53.45***	176.84***	251.42***	201.05***
	Sex	1	2.17 NS	0.39 NS	27.72 NS	29.72 NS
	Error	127	3.45	24.84	17.80	16.18
48	Genetic group	3	24.95**	259.22*	242.71***	115.52*
	Sex	1	0.19 NS	18.66 NS	0.69 NS	2.65 NS
	Error	87	5.18	50.38	39.78	40.39
60	Genetic group	3	30.33**	159.17**	244.38**	220.07**
	Sex	1	5.18 NS	30.97 NS	0.19 NS	17.98 NS
	Error	72	6.19 NS	41.70	49.38	41.09
72	Genetic group	3	23.94**	183.44**	232.95**	271.70***
	Sex	1	24.12*	73.76 NS	103.17 NS	234.28*
	Error	43	4.78	38.55	33.42	37.5

Appendix Table 3 : Analysis of variance for age at first kidding (AFK) in days

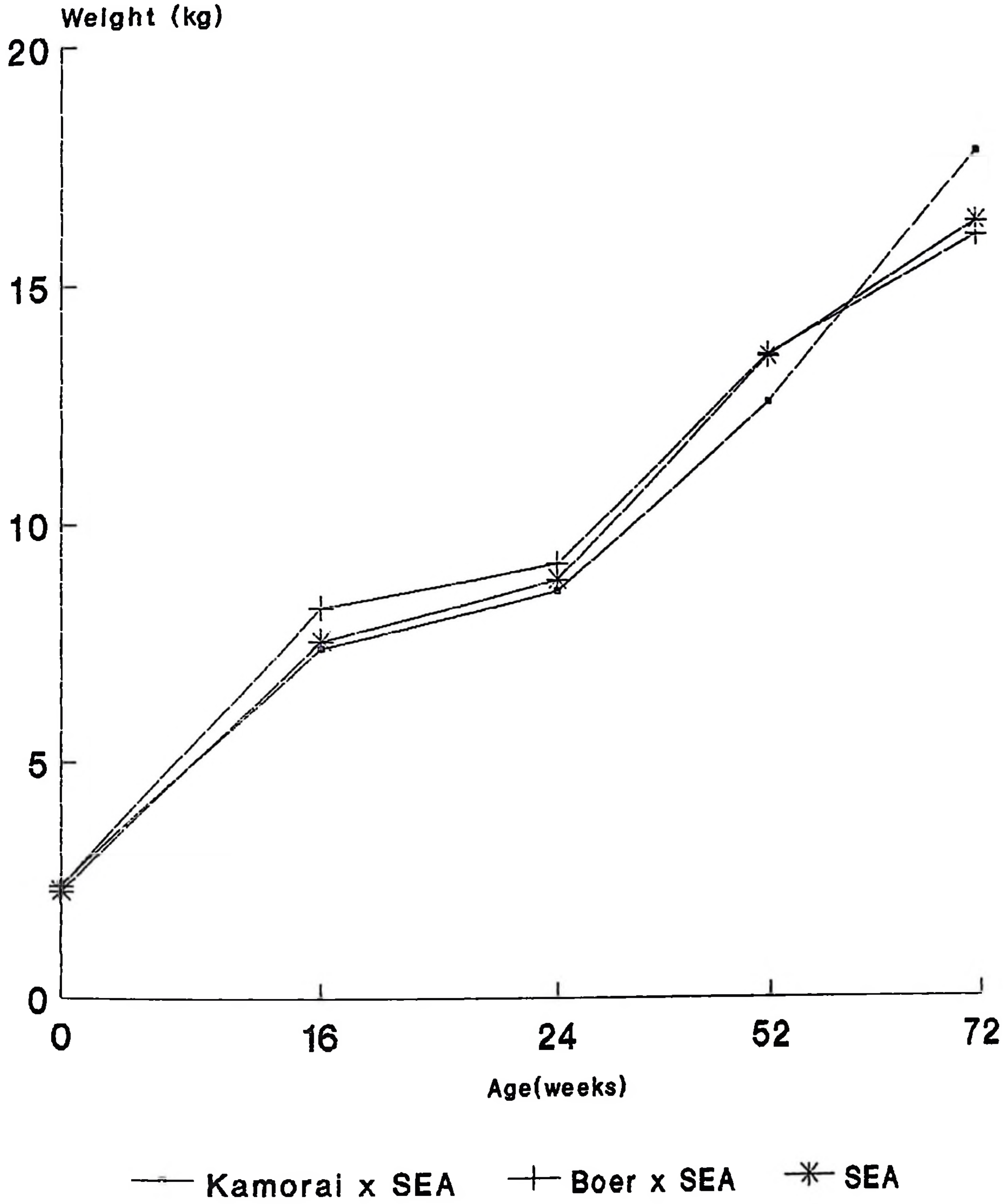
Source	df	Mean squares x 10^3
Genetic group	2	25.72 NS
Birth type	1	95.78 NS
Season of birth	3	63.42 NS
Period of birth	3	27.78***
Error	263	29.84

Appendix Table 4 : Analysis of variance for kidding interval (KI) in days

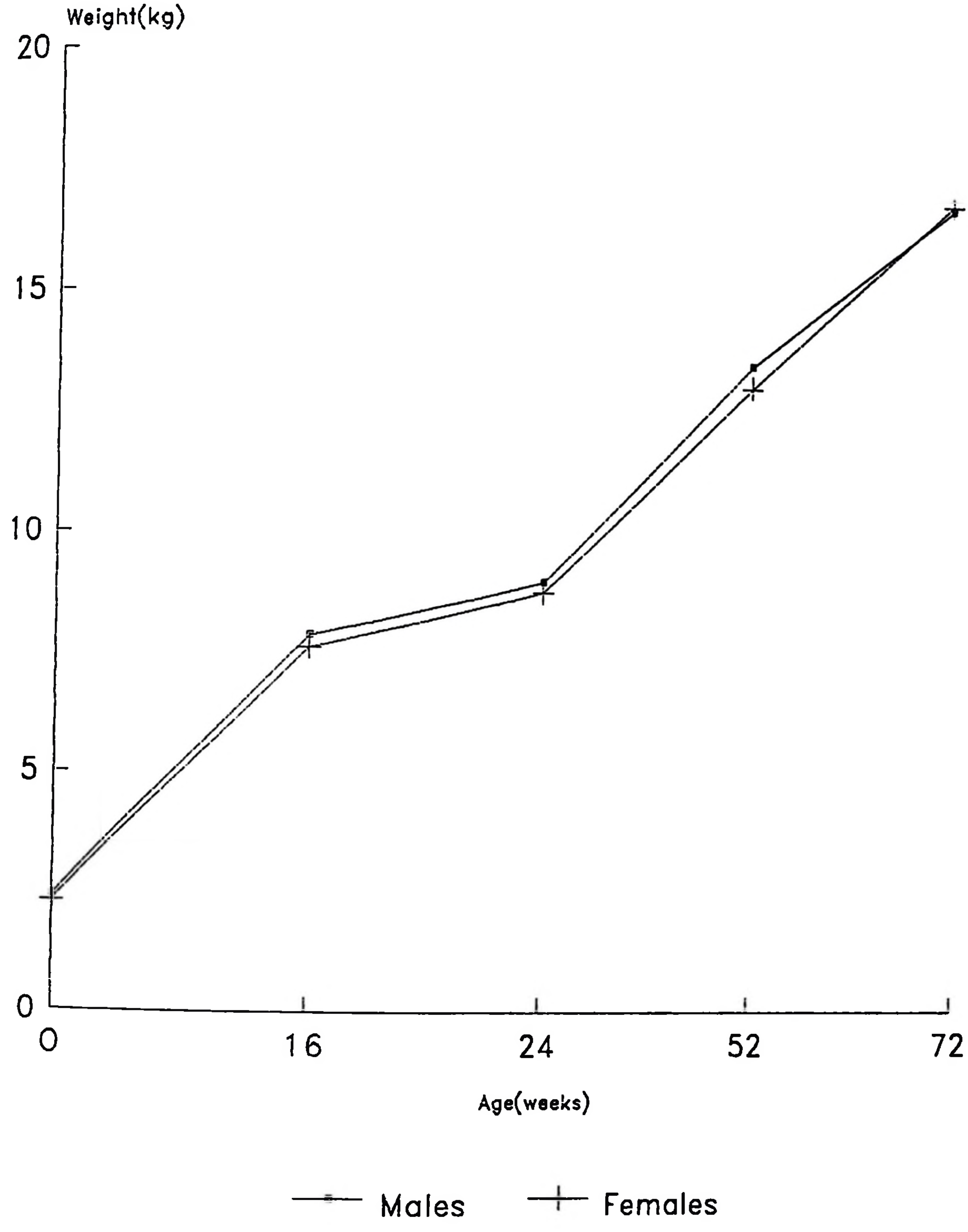
Source	df	Mean squares x 10^3
Genetic group	2	6.44 NS
Parity	2	6.76 NS
Season of previous kidding	3	100.91^{*}
Period kidding	3	255.57^{**}
Error	325	40.07

Appendix Table 5: Chi-square analysis of mortality rates at different ages

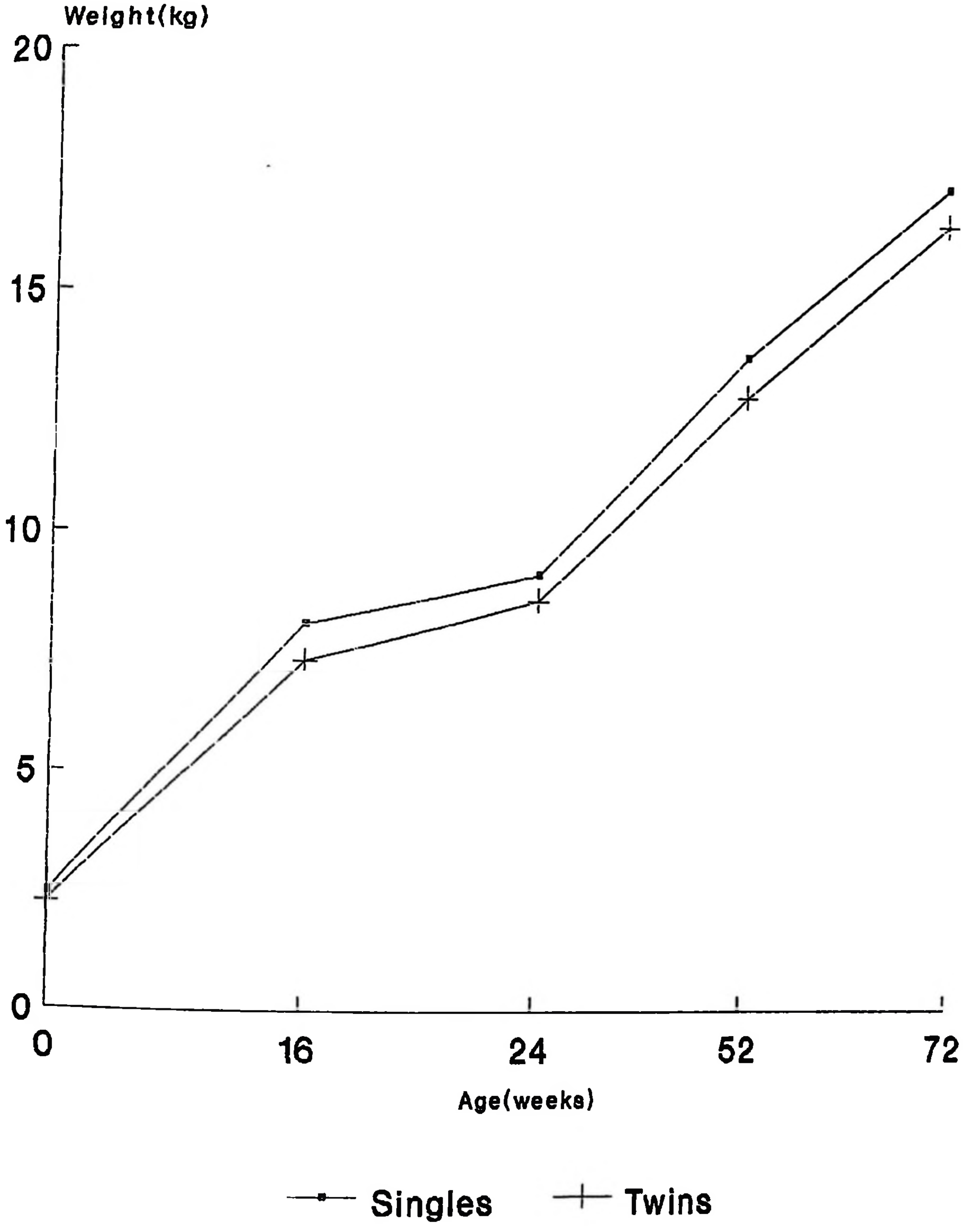
Factors	df	Birth to weaning x^2_c	Weaning to one year x^2_c	Birth to one year x^2_c
Genetic group	2	0.60 NS	1.44 NS	1.58 NS
Sex	1	0.04 NS	0 NS	0 NS
Birth type	1	2.99*	2.26 NS	4.84 NS
Season	3	12.60**	1.16 NS	10.41*
Period	3	8.07*	1.80 NS	6.96 NS
Birth weight	4	17.57**	0.54 NS	11.49*



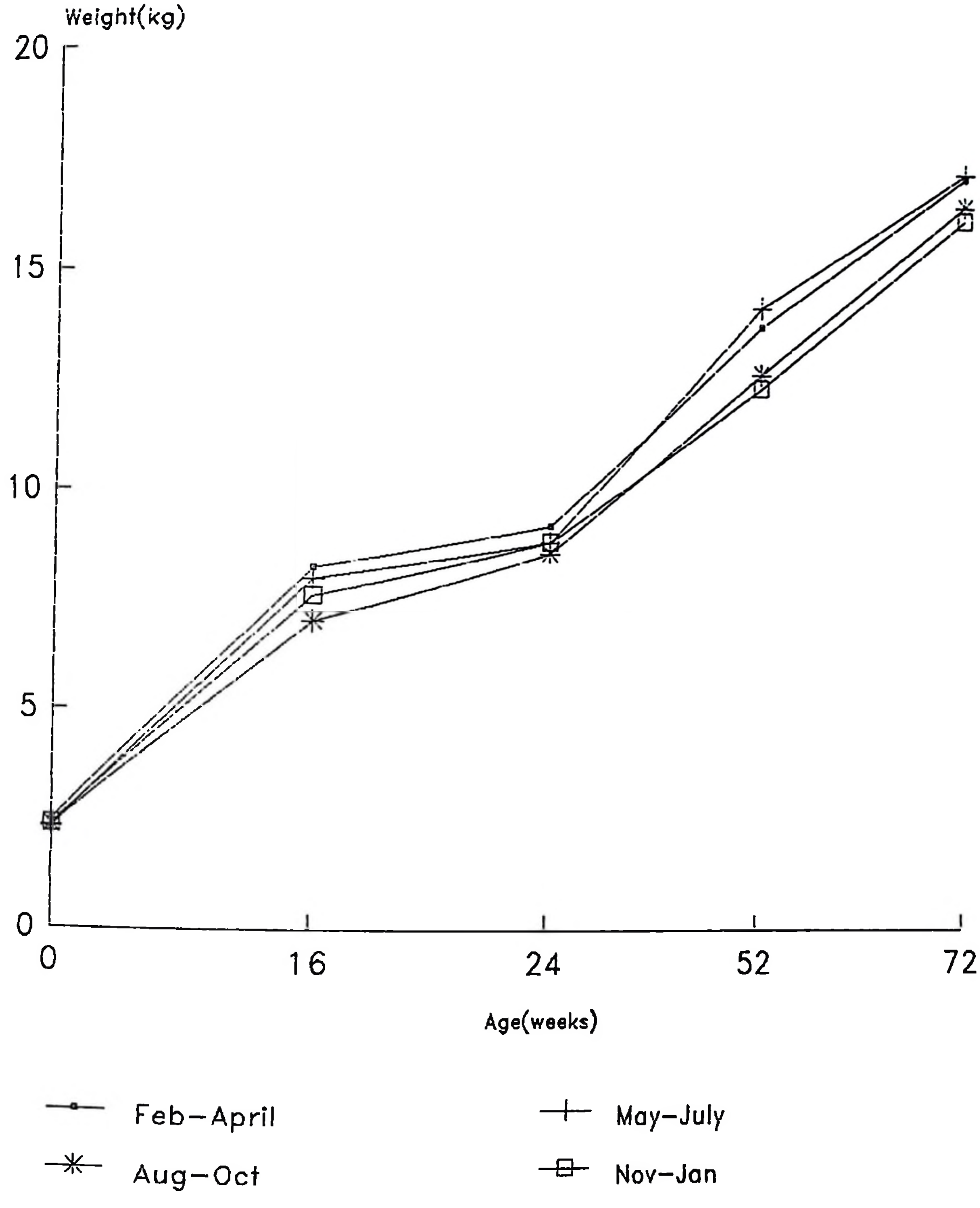
Appendix fig.1 Weight(kg) at different ages(weeks) for diferent genetic groups



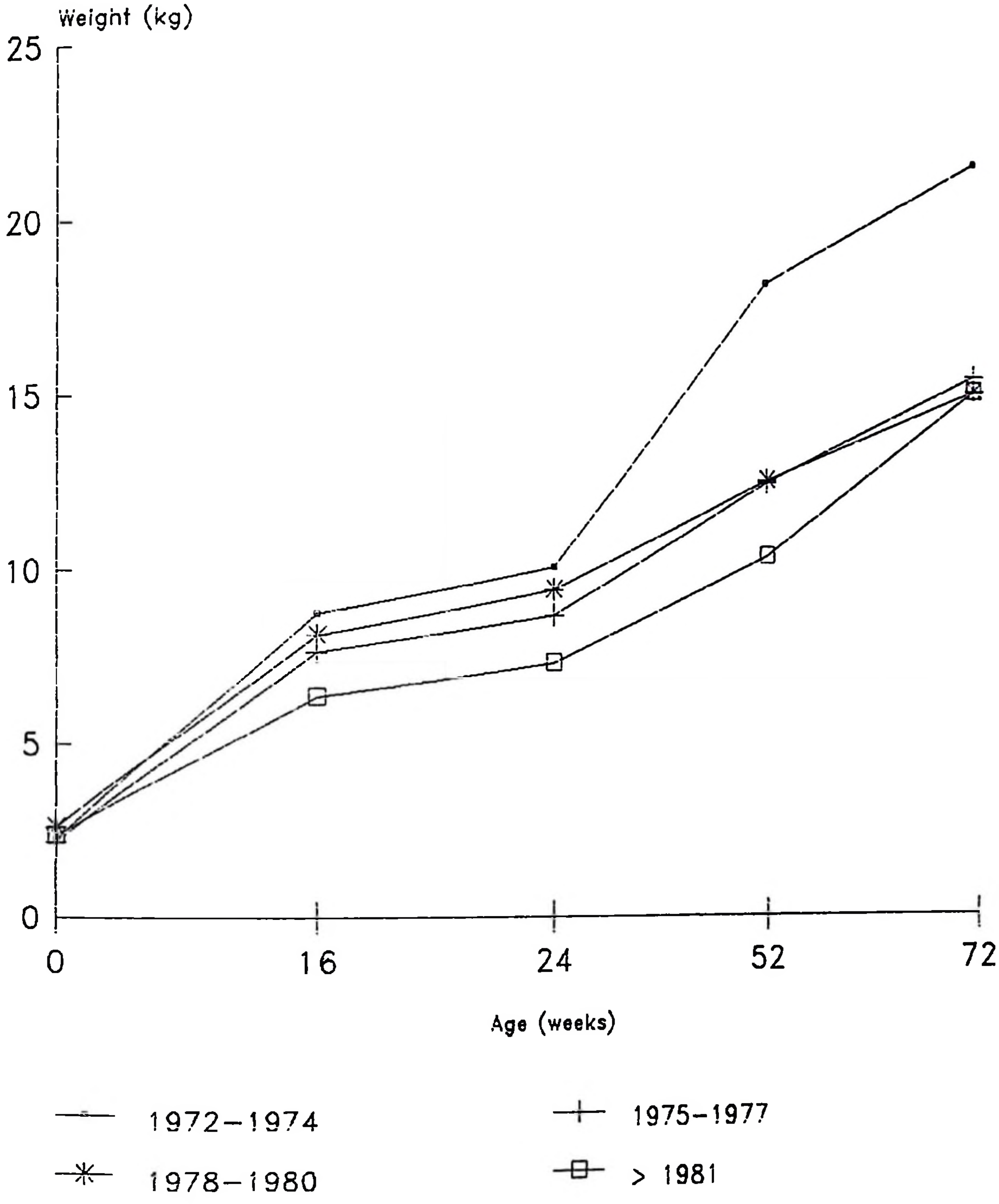
Appendix fig.2 Weight (kg) at different (weeks) for males and females



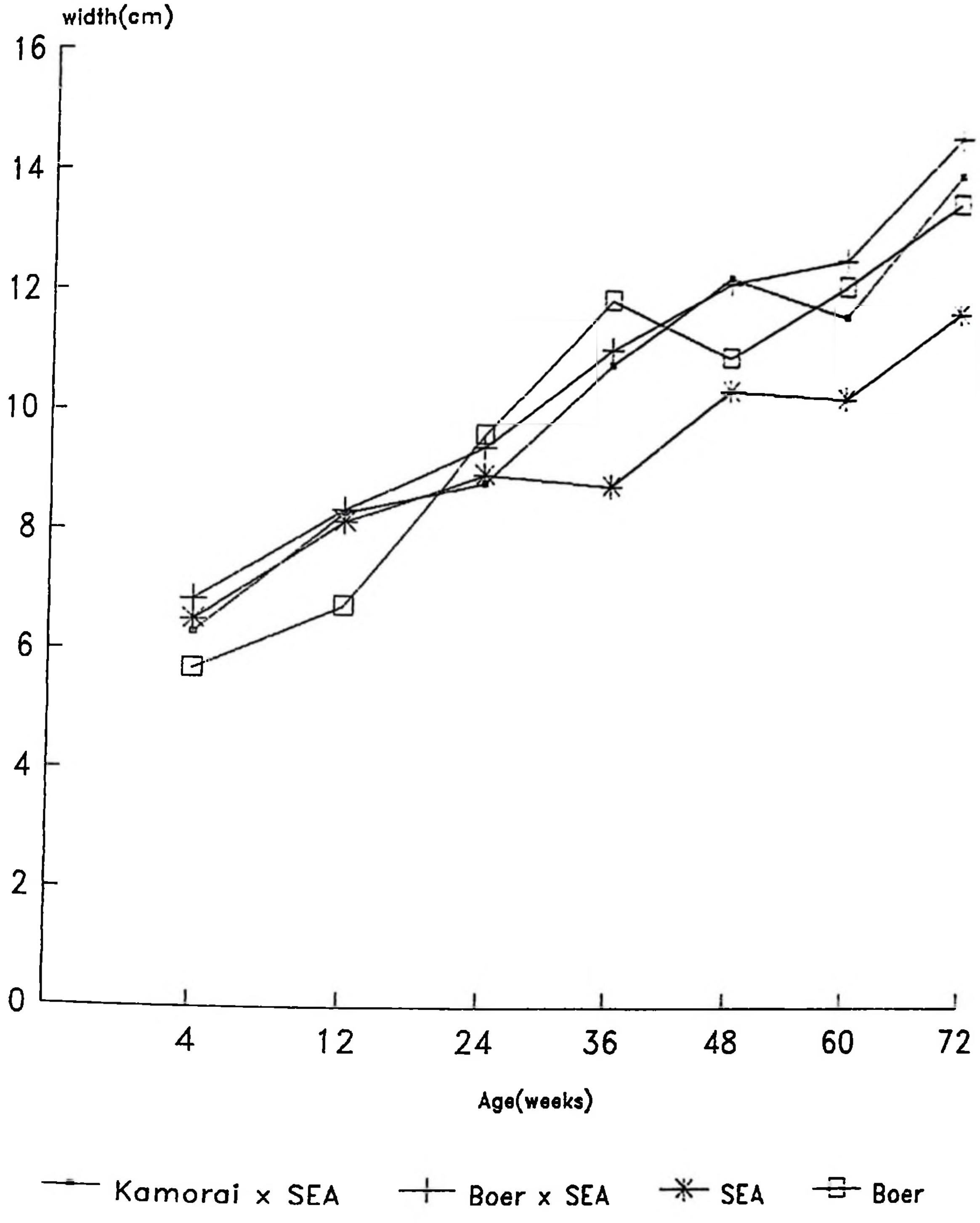
Appendix fig 3.Weight (kg) at different ages (weeks) for singles and twins



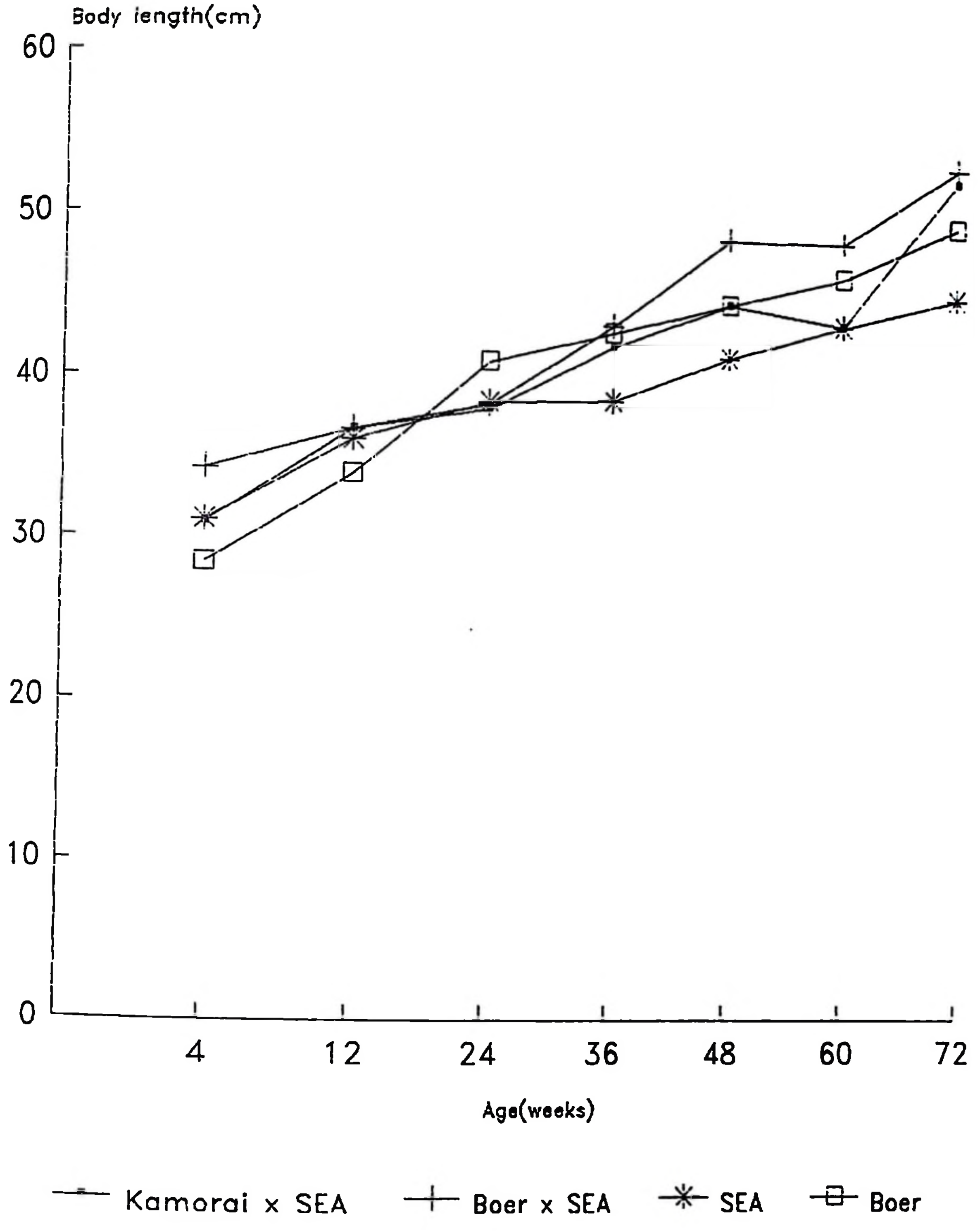
Appendix Fig.4 Weight(kg) at different age(weeks) for different seasons



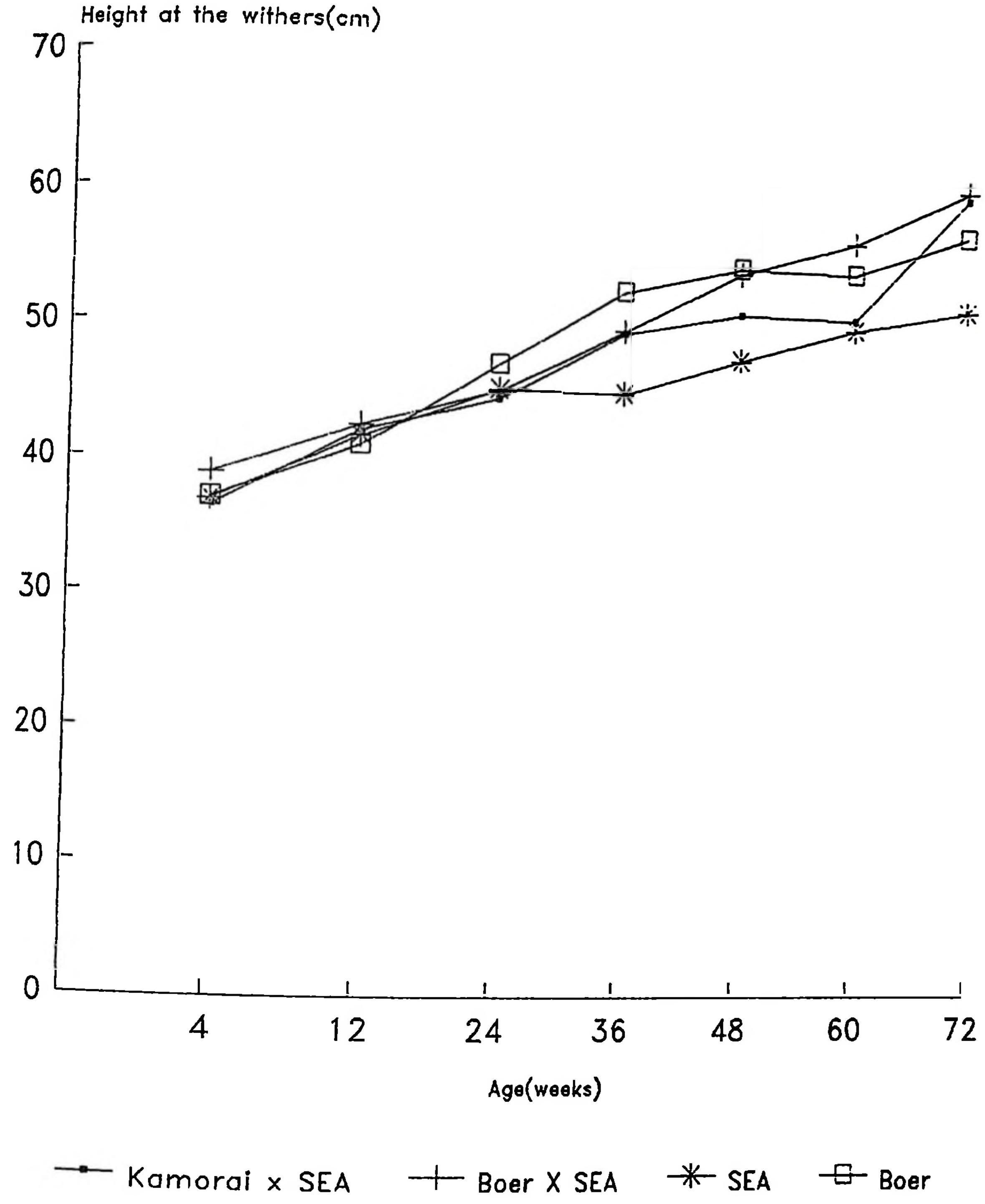
Appendix fig.5 Weight (kg) at different ages (weeks) for different periods



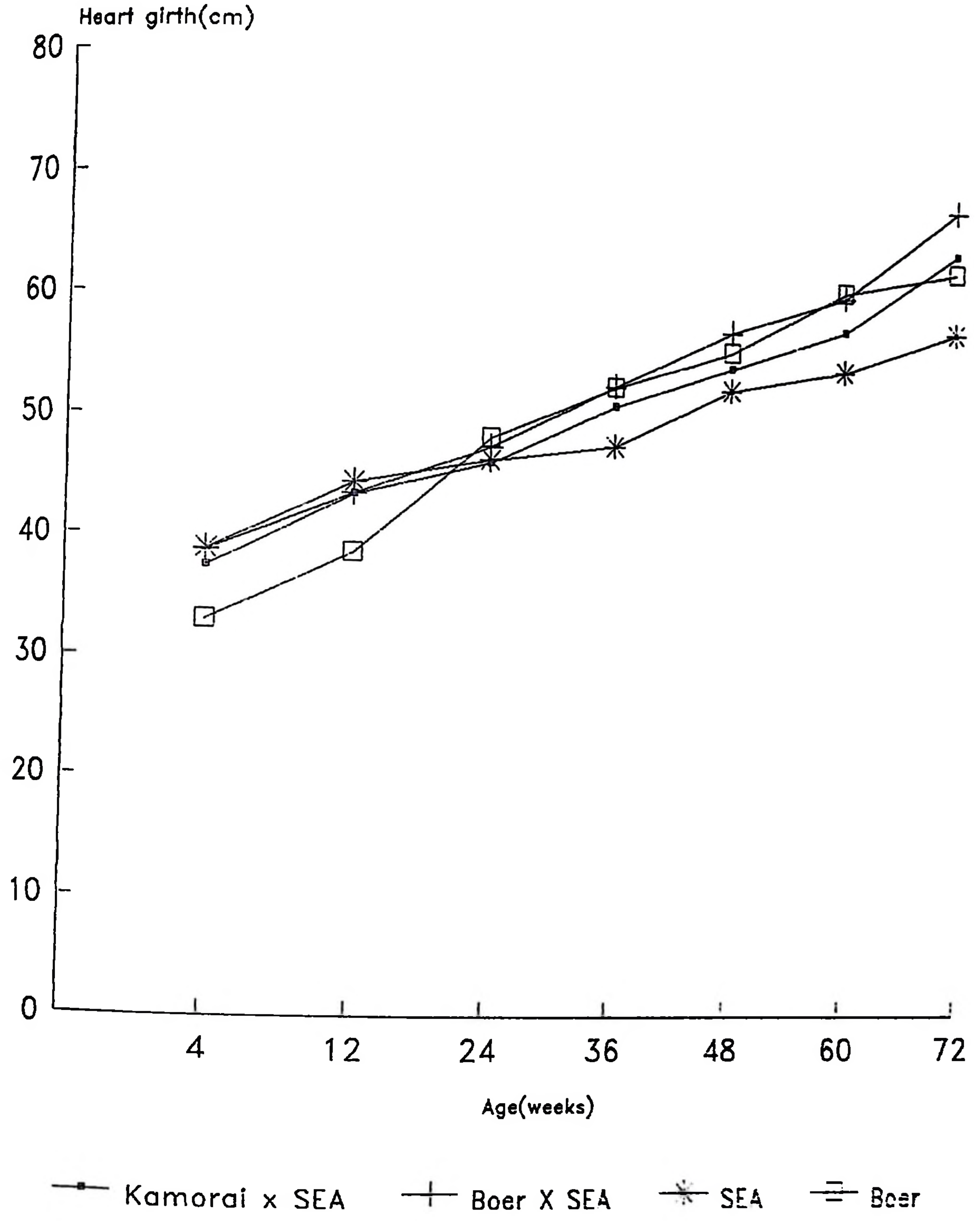
Appendix fig.6 increase in width at the hind quarter(cm) of different genetic groups



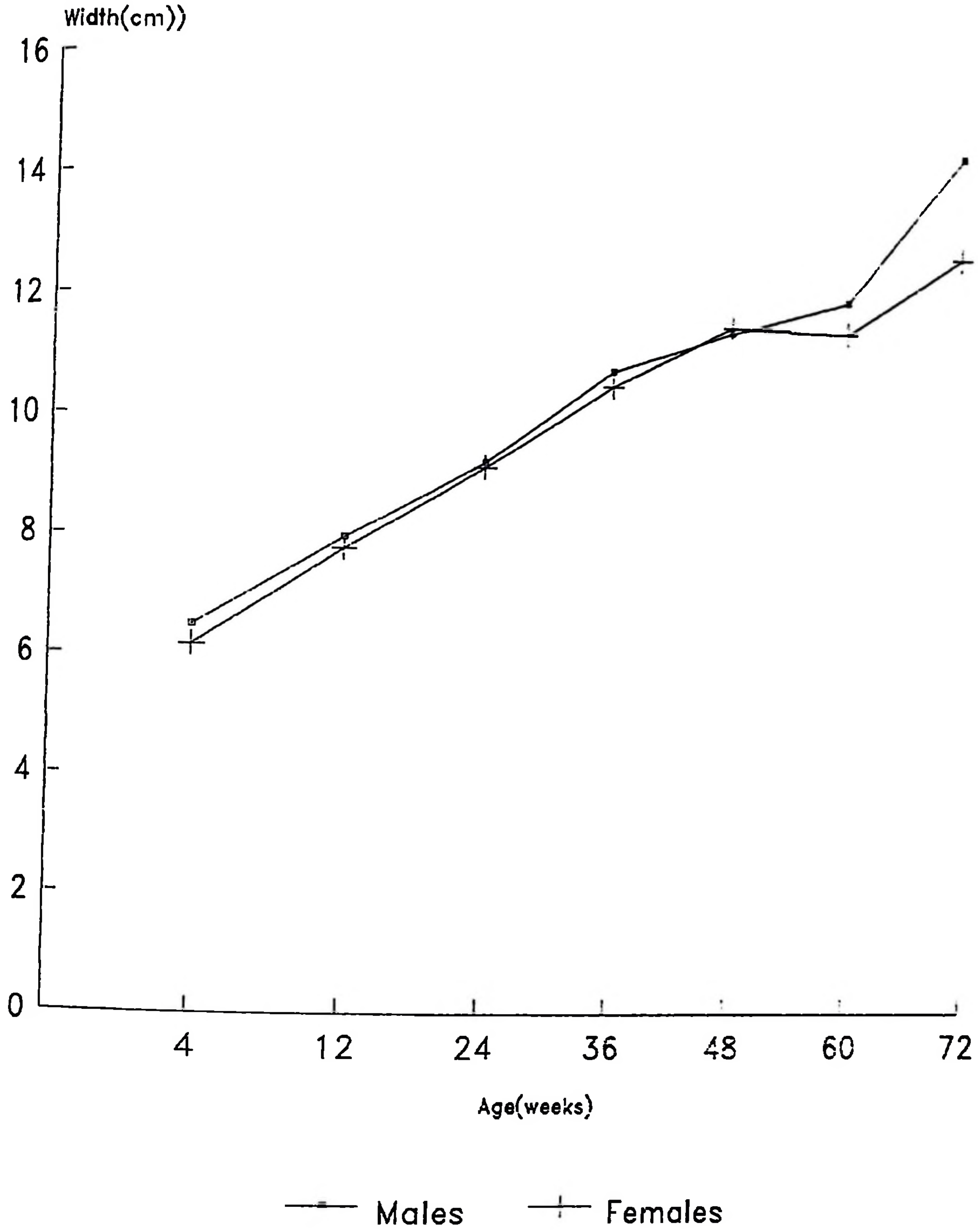
Appendix fig.7 Increase in body length
(cm) of different genetic groups



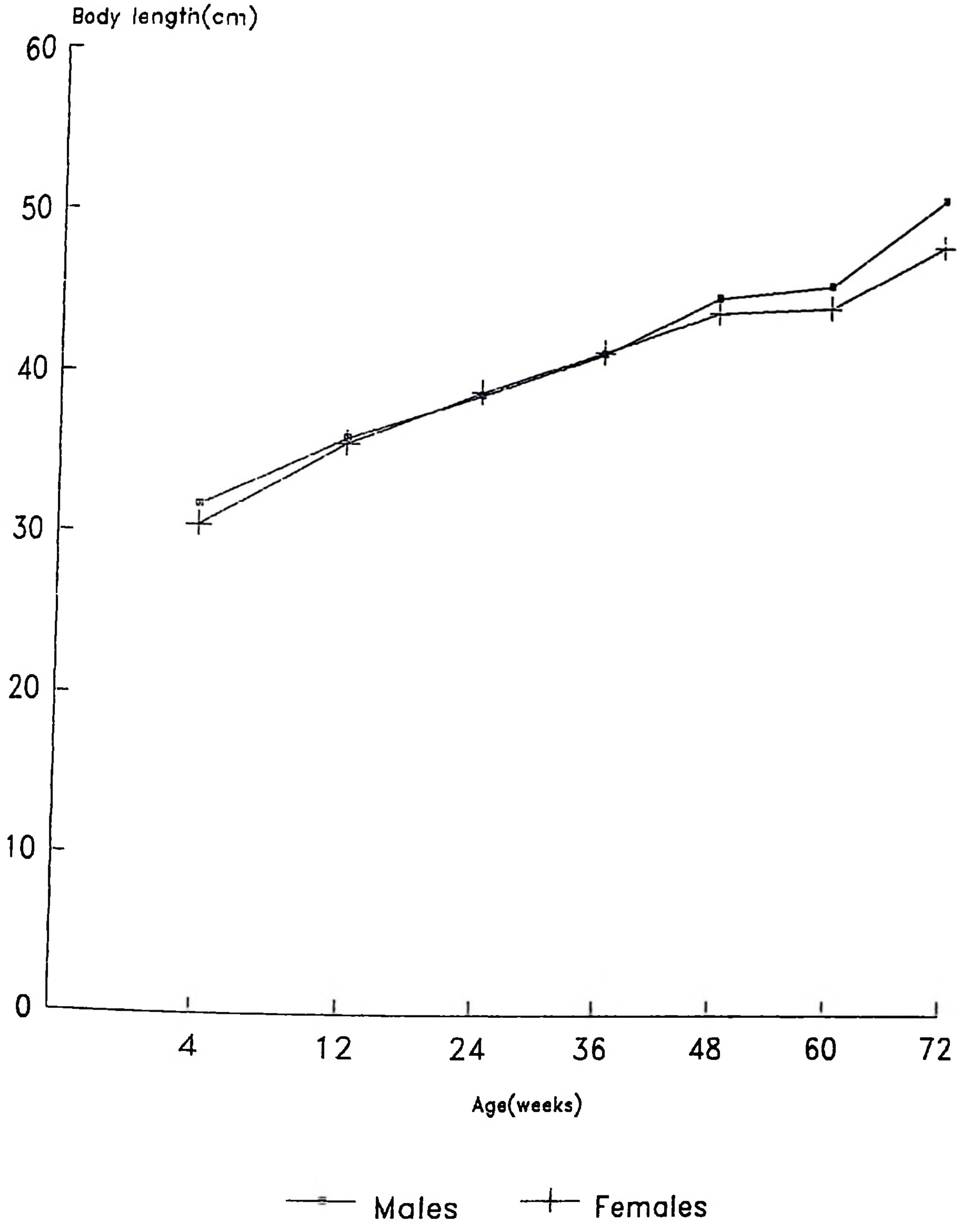
Appendix fig.8 Increase in height at the withers(cm) of different genetic groups



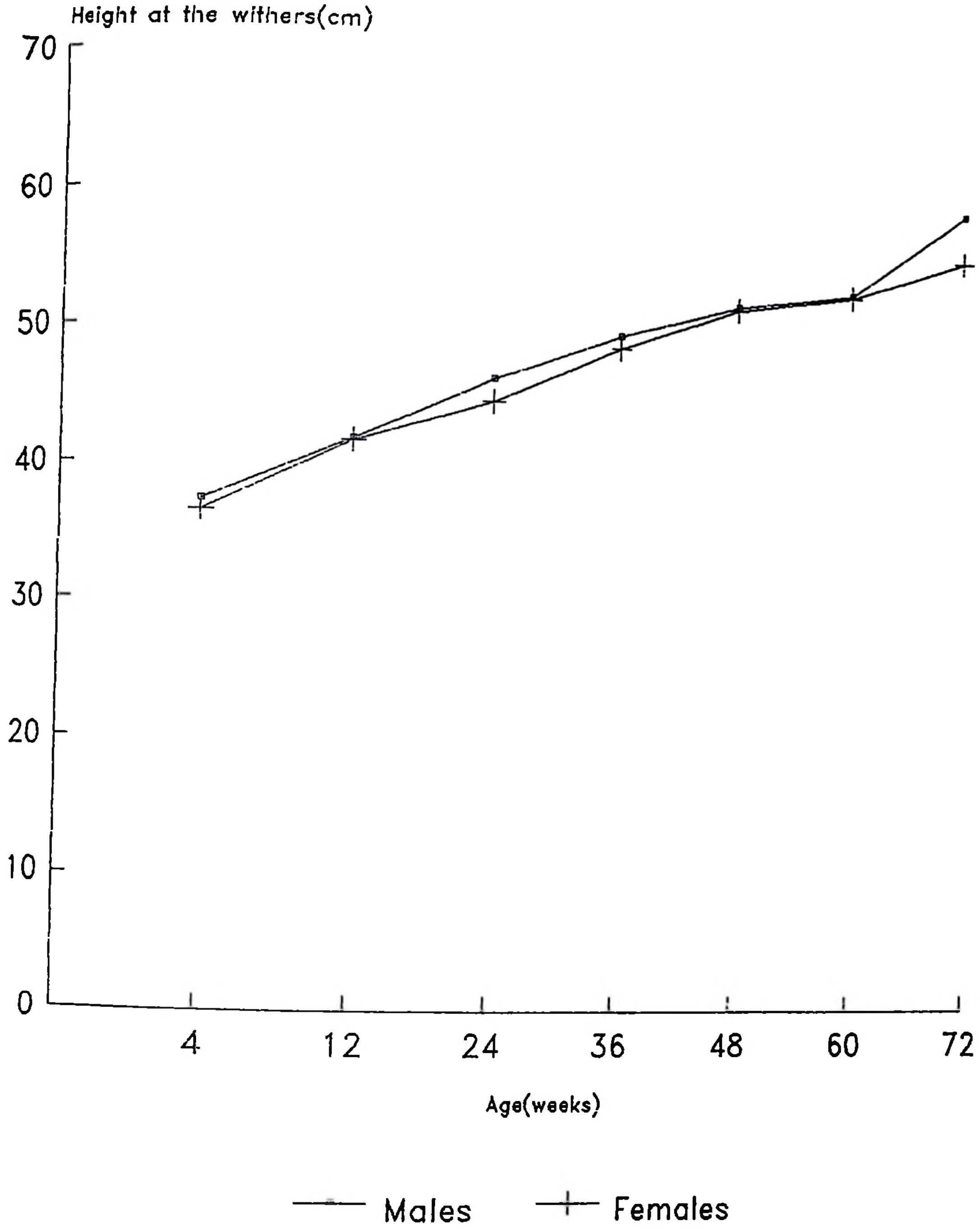
Appendix fig.9 Increase in heart girth (cm) of different genetic groups



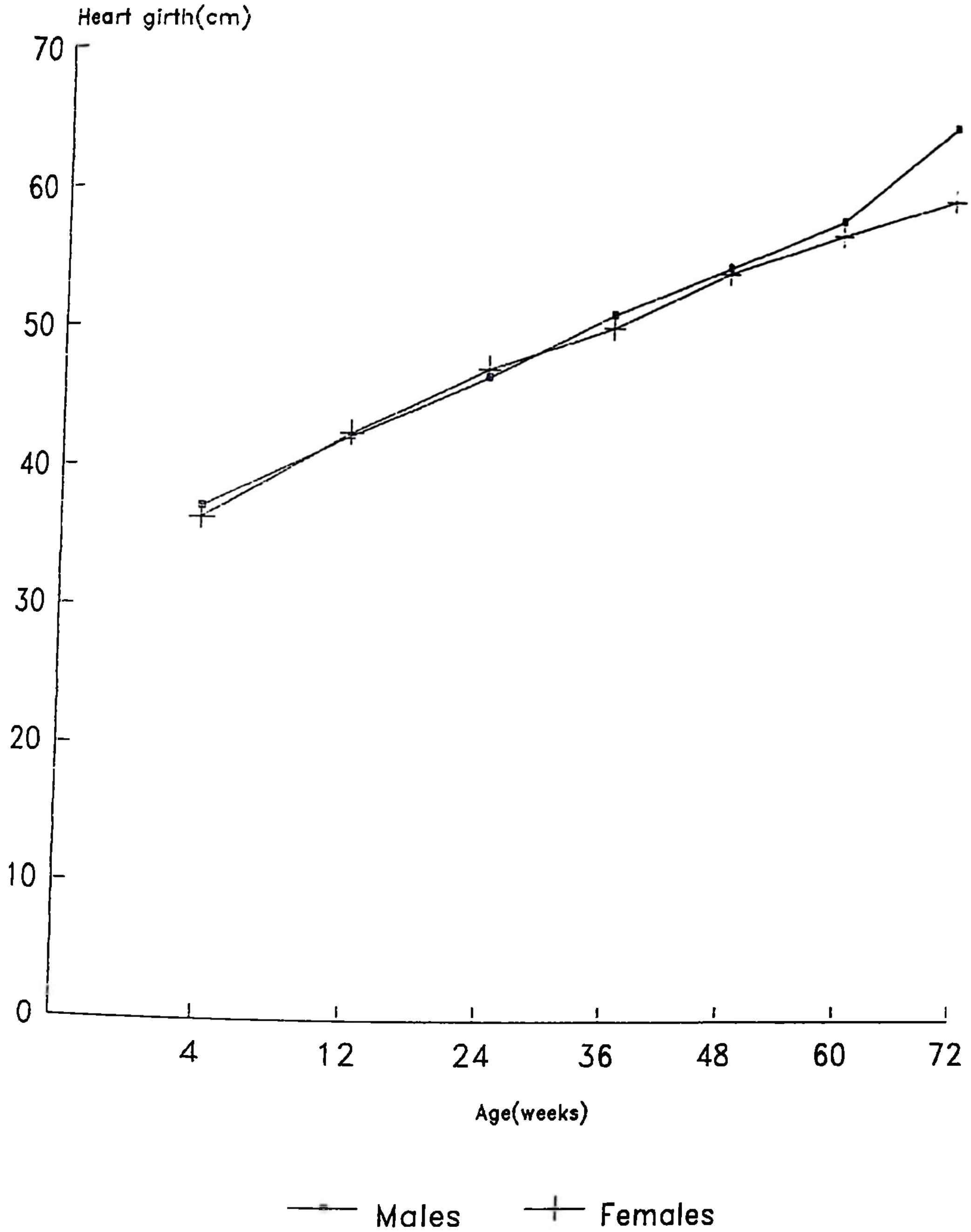
Appendix fig.10 Increase in width at the hind quarter(cm) for males and females



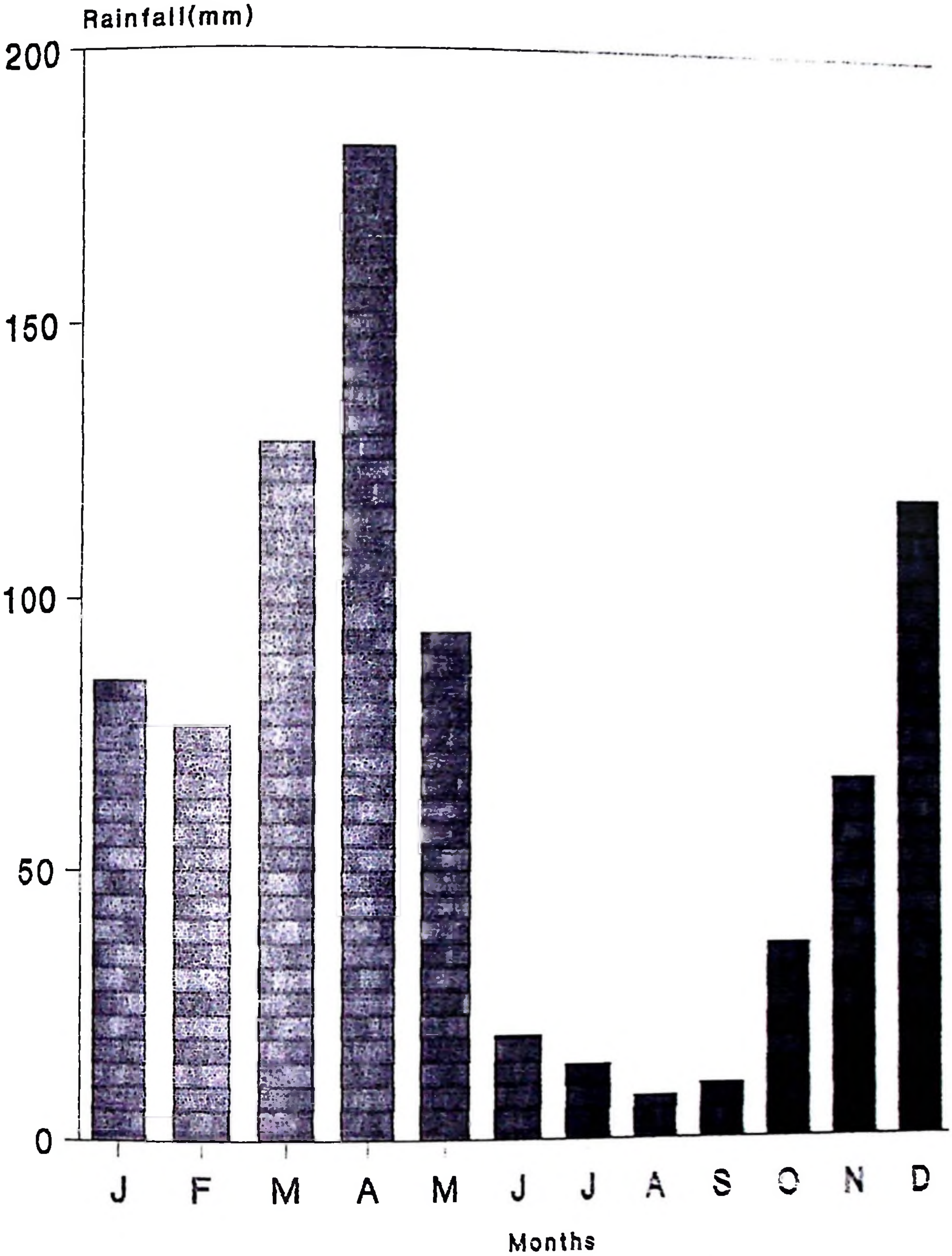
Appendix fig.11 Increase in body length for males and females



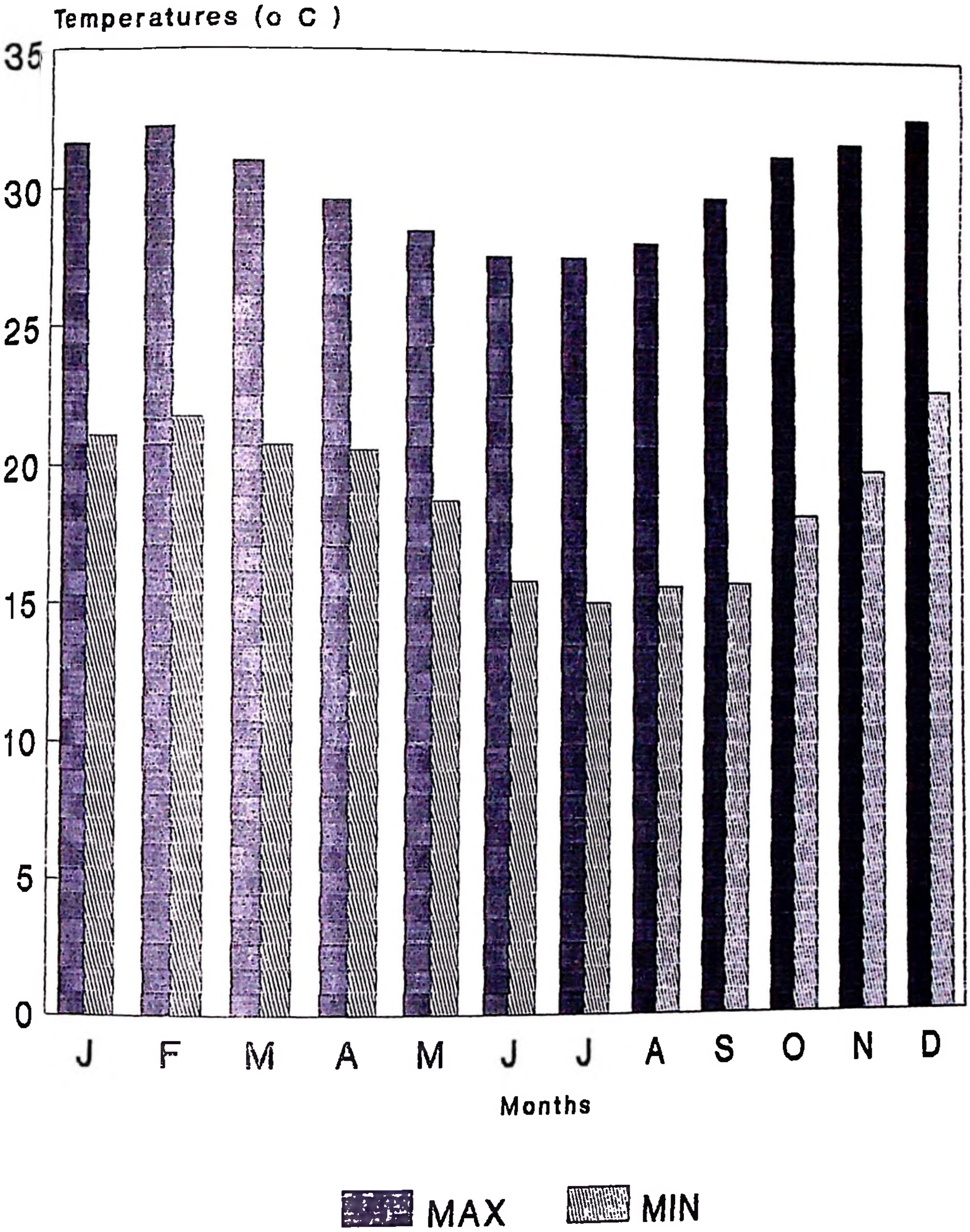
Appendix fig.12 Increase in height
at the withers(cm)
for males and females



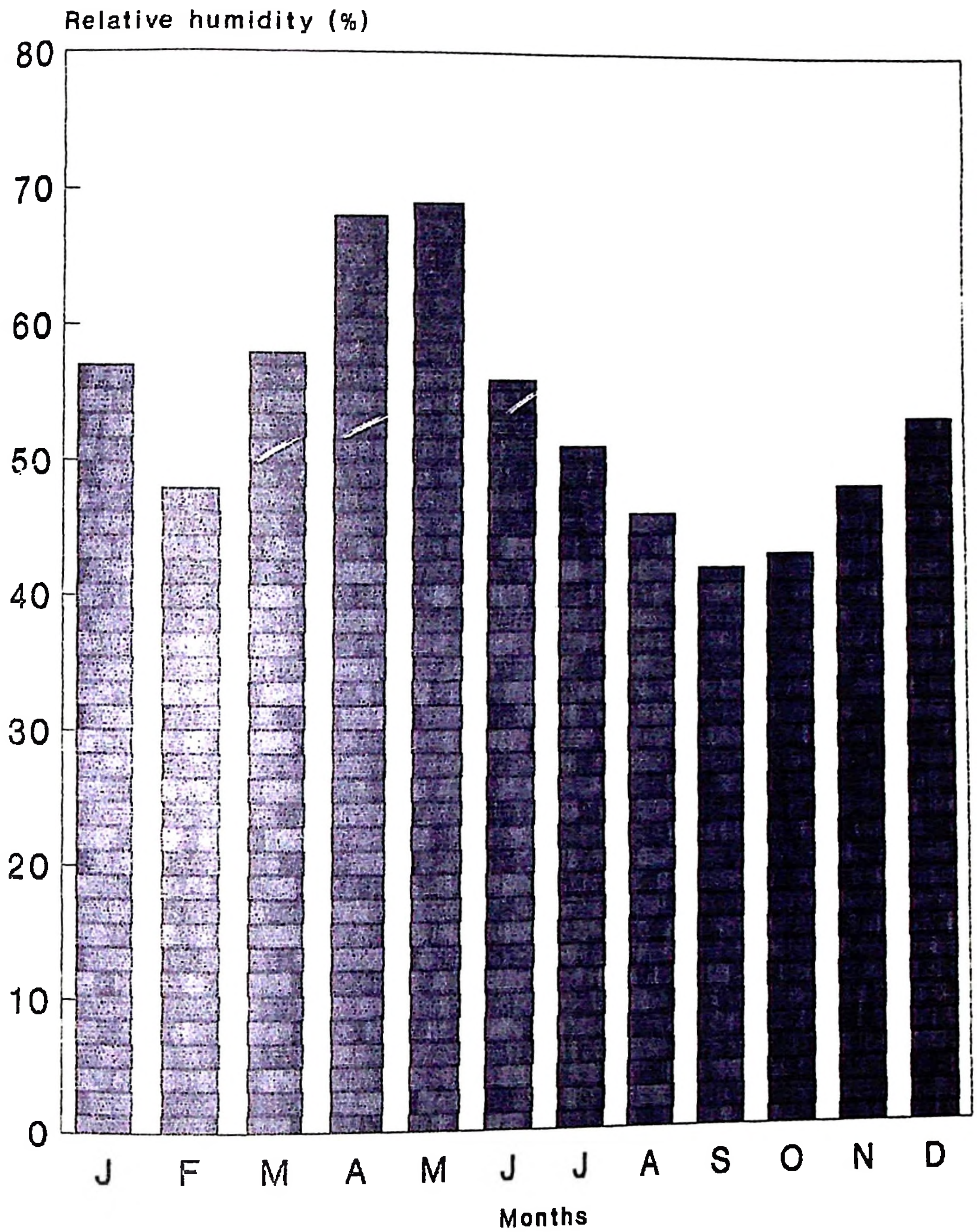
Appendix fig.13 Increase in heart girth (cm) for males and females



Appendix fig.14 Mean monthly rainfall in
at Morogoro (average for 18 years).



Appendix fig.15 Mean monthly maximum and minimum temperature (o C) at Morogoro (average for 18 years)



Appendix fig.16 Mean monthly relative humidity (%) at Morogoro (average