FACTORS AFFECTING MORTALITY IN FREE RANGING SMALL EAST AFRICAN GOATS

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DECLARATION

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

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b) This thesis has been submitted for examination with my approval as university supervisor.

Dr. A. B. Carles

DEDICATION

This thesis is dedicated to my parents whose great sacrifice made my education possible

and

my wife Wambui for her understanding.

ABSTRACT

The causes, levels and factors affecting mortality of the Small East African goat on a semi-arid thornbush savannah, at Isiolo, were determined.

A total of 40 deaths of immatures and adults were were used to determine causes of death and factors affecting cause of death. Factors affecting mortality of kids and adults were analysed using ordinary and weighted least squares.

The mortality levels for 156 kids aged 1-13 days was 16%, for 104 kids aged 14-160 days was 18%, for weaners (161-365 days) was 4% and adults was 12%. The causes of death in immatures and adult animals were : emaciation - 30%, miscellaneous causes - 20%, unexplained loss- 17.5%, pneumonia - 17.5% and predation - 15%.

In immatures and adults, forage condition 4 weeks prior to death, the weight of the animal before death and the weight change over 4 weeks before death, affected the cause of death (P<0.05). Sex, lactation, time period, and age did not affect cause of death (P>0.05). Low forage scores were associated with death due to emaciation while high forage scores were associated with death due to infectious conditions. Deaths from emaciation and non-specific causes were

associated with animals with low body weights and loosing weight while those from pneumonia were associated with high body weights and those which lost little or gained weight.

In kids of 1-13 days, birth weight ($P<0.001$), sex ($P<0.05$) and milk intake ($P<0.001$), significantly affected mortality. Forage score, type of birth, age of dam at kidding and weight of dam at kidding were not significant ($P>0.05$). The probability of survival was higher for kids with high birthweight, females, and kids with higher milk intake.

In kids of 14-160 days of age type of birth ($P<0.05$) and average weight gain ($P<0.001$), affected mortality. Birth weight, sex, dam weight and dam age at kidding were not significant ($P>0.05$). Twins and kids gaining weight faster had higher probability of survival.

In adults weight, the reproductive status and weight change affected mortality during the dry season ($P<0.001$) both linearly and curvilinearly. The age of the animal was non significant linearly ($P>0.05$) but was significant curvilinearly ($P<0.05$). Animals with a lower reproductive stress (neither lactating nor pregnant), higher body weight at start of dry season and gaining weight during the dry season had higher probability of survival.

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1. INTRODUCTION

Kenya has a total land area of 571,416 sq.km. (Kenya Statistical abstract, 1982) and of these 80% are arid or semi-arid. The population was 15,237,061 in 1979 (Kenya Statistical Abstract, 1982), is increasing at the rate of 4% per annum and is presently estimated to be 20 million. Of this population the largest proportion is of young people of less than 15 years. These, with pregnant and lactating mothers, require high amounts of protein. This large population has to be supplied with food, and particularly animal protein in the form of meat or milk. Livestock censuses over the last few years show that cattle, which are major suppliers of animal protein, are only increasing very slowly (Kenya Statistical Abstract, 1982).

The large population, 90% of which lives in the high potential areas, is putting pressure on arable land thus livestock are slowly being replaced with food crops.

These statistics call for the improvement of the arid and semi-arid areas for production of food to feed the people. At the present level of technology and economic infrastructure in the country, the only feasible way to produce food for human consumption from these areas is through domestic ruminants i.e.

cattle, camels, sheep and goats. Most of the semi-arid, arid and very arid areas, which are not under group ranching or national parks, are utilised by nomadic pastoralists of various ethnic groups. Their production system is still mostly subsistence oriented. The staple diet, milk, is produced primarily from cattle and camels whereas the small ruminants, sheep and goats, are kept to supply the pastoral household with meat in relatively small quantities at a time, for barter and for occasional sales (Schwartz and Said, 1981).

Although sheep and goats are commonly herded together and receive identical management inputs, one can observe an increasing proportion of goats in the pastoralist flocks with increasing aridity of the environment which indicates that goats (of the Small East African type) are better adapted to the conditions of the arid rangeland of Northern Kenya where the major sources of forage are shrubs, bushes and small trees. Goats are also generally more prolific than sheep and probably less troublesome to manage (Wilson, 1982).

Small stock production has played a major role in the economy of range areas of Kenya in the past ten years. Sheep and goats have contributed significantly more than cattle, in terms of livestock products, from these areas (Semenye, 1977).

In the pastoral areas, goats have a crucial role to play both in reducing the vulnerability of pastoralists to drought and in improving standards of living. Goats use available browse efficiently, they can be used for bush clearing and control, they suffer lower death losses than cattle and sheep during drought, and their high rate of reproduction allows a rapid re-establishment of herds after culling has been implemented during years of drought (Sheep and Goat Development Project, 1976).

Keeping of goats therefore remains one of the main methods by which the vast arid and semi-arid areas can contribute to the nations nutrient requirements.

Very little work has been done on the small East African goat in spite of it being able to withstand the hottest and the driest conditions likely to be found in the tropics (Schoen, 1968). Some work has been done in the northern part of Kenya where fertility and mortality have been studied to a small extent by Carles and Schwartz (1982) and in Uganda where water balance in this goat has been studied (Schoen 1968). Field (1978) and Carles (1980) have also done some work on the milk production potential of the Small East African goat. Work done in Kenya, using the Small East African goat, has shown great potential for crossbreeds especially with the Boer goat (Haas, 1978).

Survival is an important component of performance in any livestock production system, therefore mortality should be minimised. The aim of this study was to make a detailed study of the factors affecting mortality in free ranging Small East African goats in a typical range area in Kenya.

On recognising the factors affecting mortality, attempts can be made to suppress the adverse ones and maximise the beneficial ones.

2. LITERATURE REVIEW

2.1 Goat production in Kenya

2.1.1 Adaptation and numbers

The goat occupies a particularly remarkable position among domestic animals, firstly, because it is one of the oldest domesticated ruminants (Zeuner, 1967), and secondly, because it is endowed with an almost unique adaptability to varying local conditions (Horst, 1973 : Devendra and Burns, 1970). Epstein (1966) describes the goat as the domestic animal with the widest range of adaptability.

This wide range of adaptability could partly be due to the goat's feeding behaviour. Depending on vegetation, considerable variations arise in feeding habits in different locations. Observations in Northern arid areas of Kenya by Wilson (1957), showed that goats spend more than 50% of their feeding time eating from shrubs and trees. In comparison with cattle and even sheep, goats consume a considerably wider spectrum of plant species. Glover, Stewart and Gwynne (1966), working in Maasai and Kipsigis areas in Kenya observed that besides numerous species consumed by all ruminants, 17 additional plants species were preferred by cattle, 20 by sheep but more than 90 by goats.

The predominantly positive aspects of the goat are masked by its connection with environmental deterioration. This connection is primarily due to the goats feeding habits. The cattle and sheep disappear earlier from these areas since there is nothing to graze but the goat persists since there is still some browse. Accordingly, the goat is the last to leave the area and is unfairly blamed for the damage (Haas and Horst, 1979).

The population of goats has been growing at a rather slow rate in Kenya. In 1968 there were about 5,086,000 goats. With a growth rate of 1.75% p.a. the population of goats was estimated at 7,065,600 in 1979 (Sheep and Goat Development project,1979). More recent estimates in 1983 put the number at 7.7 million with 40% of these being kept by pastoralists (Stotz,1983).

In 1979 it was estimated that there were 300 goats per 1000 inhabitants and the ratio of goat to sheep was 1.13 (Haas and Horst, 1979).

2.1.2 Socio-economic importance

Goats are multipurpose animals, producing meat, milk, skins and hair . Mention must also be made of the varied and numerous miscellaneous functions that goats serve in Kenya. These include their value as a source of income, investment against failure of cash crops, the prestige inherent in their ownership and their place in custom, religion and festive occasions

(Devendra, 1966).

In Kenya like many African countries, preferences have developed for goat meat rather than mutton (Fischer, 1975). However, some tribes in Western Kenya do not allow women to eat goat products, meat or milk, probably as measure to protect them from Brucellosis (Haas *et al.*, 1979).

Field (1985) working in Northern Kenya concluded that small stock supply 22-26% of energy and 55% of protein requirements of a household under traditional management systems. The contribution of small stock was greater than that of cattle, their contribution of protein being exceeded only by the camel. He also noted that sales from male animals are used to purchase cereals which help increase the energy in the human diet.

Local sheep and goats are meat producers for various functions ranging from dowry to funeral rites in various communities (Lowe, 1943; Devendra and Burns, 1970; Devendra, 1978). Of late, goat meat has become an invaluable constituent of the barbecue for local parties among elite groups (Nasibu,1980).

2.1.3 Rangeland goat productivity in Kenya

The goat is a well suited animal for the Kenyan rangelands. Goats unlike other domestic animals can graze on short grass and also browse and are thus able to survive in harsh conditions (Orago and Njoroge, 1984). They also relish eating aromatic herbs in areas of sparse food supply and hence can penetrate deep into the desert (Devendra and Burns, 1970). Goats have a high digestive efficiency for cellulose, a factor responsible for their ability to survive in areas unsuited for cattle and sheep (Peters and Horst, 1981).

Recent estimates by Stotz (1983) show that only 40% of the goats in Kenya are kept in pastoral areas despite these areas covering 80% of the country. This is due to constraints in range areas. FAO/UNDP (1976) identified constraints to goat husbandry in these areas as poor pasture management, infertility, neonatal mortality, abortion and poor growth rates. Little information is available as to the exact percentage contribution of the range goats to the national economy.

2.2. Relevance of mortality to production

Mortality has been cited by several workers as a limiting factor to production. Some preliminary analyses by Upton (1984), have shown that productivity is more sensitive to survival of young than any other factor. Mortality has also been given as the most important factor in a goat breeding programme (Sarmah, Thakuria, Sarma, Borah, Mohan and Pant, 1981).

Wilson (1982) recorded preweaning losses of upto 40% while Gall and Huhn (1981) reported losses of 30-40% of the goat stock, with the young animals being the most strongly affected.

2.3 Causes of mortality

Few workers have classified the causes of mortality in goats. Wilson (1982) pointed out that despite the availability of a voluminous and rapidly growing literature on small ruminant disease, real causes of most mortalities are only suspected rather than known.

However, several workers have reported causes of death but most of the available literature is on kids. Reports have indicated that pneumonia and enteritis are the major causes - Mazumdar *et al.* (1980) and Srisvastva, Patil and More (1986) from India, Ndamukong (1985) from Cameroon, Traore (1985) from Mali and Carles (1986) working in arid areas in northern Kenya. Starvation has been reported as a major cause of death in the arid areas of Kenya (Carles *et al.*, 1982).

2.4. Factors affecting mortality

Many workers have studied the factors affecting mortality in goats. Most of this work has been done in developing countries where mortality is a limiting factor to production. In India these studies have been quite extensive but elsewhere, especially Africa, little literature is available.

2.4.1 Age

The relationship between age and mortality has been studied by several workers in different breeds of goats and across different environments.

Some of the earlier studies were done in India by Lall and Singh (1949) working with Beetal, Jamnapari, Barbari, Toggenberg and cross breed goats. They reported that kids always had a higher mortality than adults, with disease contributing 29.5% compared to 10.7% in adults.

In Kenya very little information is available on mortality in goats. Wilson, Peacock and Sayers (1981) observed 22.3% preweaning mortality in a Maasai group ranch. Studies in a pastoral system in north-eastern Kenya, with Small East African goats, have shown a mortality rate of 6-12% for breeding females rising up to 66% during the first year of life (Carles and Schwartz, 1982).

Other reports from studies in different breeds and environments have supported the above observation. For instance, Minnet (1950), Chawla, Bhatnagar and Mishra (1982) and Srivastava *et al.* (1986) in India ; Figuerado, Simplicio, Lima and Riera (1980) in their studies of traditionally managed goats in Brazil.

Reports from the Africa (Ndamukong 1985, Vohradsky and Sada 1973, Adu, Buvanendran and Lakpini 1979 and Gonzalez 1973) have agreed with the above observation.

Khan, Vihan and Sahni (1978) using Jamnapari goats observed an increase in mortality with age. This observation though contrasting with others is supported by Sarmah *et al.* (1981) who observed that mortality increased with age, most deaths occurring after 30 days. No explanation has been given for these two contrasting reports both observed in Indian goats.

2.4.2. Birthweight

Most workers have reported a significant effect of birthweight of kids on survival in different breeds of goats.

Seth, Saraswat, Chorey, Naithani and Roy (1966) and Prasad (1983) working with Barbari goats; Khan *et al* (1978) working with Jamnapari goats and Mittal (1976) working with Barbari and Jamnapari ; Gupta and Sengar (1985) working with Beetal, Barbari and Black Bengal all reported higher mortality in light kids. Also Sarmah *et al.* (1981) working with Assam local breed, Ali, Hoque and Hasnath (1975) working with Black Bengal, Mazumdar, Mazumdar and Goswami (1980) with pashmina, all reported significantly lower mortality rate for kids with high birth weight.

Ahmed and Tantawy (1960) working with Egyptian Baladi goats, Osugwuh and Akpokodje (1981) working with West African Dwarf goat and Adu *et al.* (1979) working with Red Sokoto goats also observed higher survival for kids of high birthweight.

2.4.3 Type of birth

Survival rates of kids from different types of births have been studied with contrasting results. Most workers have found significantly higher survival rates for kids from single births than multiple births across many breeds (Sarmah *et al.*, 1981, Osugwuh *et al.*,1981, Ahmed *et al.*, 1960, Seth *et al.*, 1966, Prasad, 1983, Wilson, Peacock and Sayers, 1985, Ndamukong, 1985 and Mackinnon *et al.*, 1985).

However, Mittal (1976) working with Barbari and Jamnapari kids did not find any significant difference. Ali *et al.* (1975), working with Black Bengal, reported slightly higher mortality in singles than multiples.

2.4.4 Sex

Observations as to whether there is any significant difference between the death rates of male and female kids and adults are not conclusive.

Osugwuh *et al.* (1981) working with the West

African Dwarf goat found significant differences with more deaths in females (32.8%) than males (20.6%). A similar observation was reported by Adu *et al.* (1979) working with Red Sokoto goats. Minett (1950) and Khan *et al.* (1978) observed higher mortality in males.

However, Samar *et al.* (1981), Seth *et al.* (1966), Mittal (1976) and Ahmed *et al.* (1960) did not observe any significant difference in mortality due to sex.

2.4.5 Forage

Most studies on mortality have not specifically considered the effect of forage supply. Carles *et al.* (1982), working with the Small East African goat in northern Kenya reported that starvation was a major cause of death. Westhuysen (1980), working with Angora goats reported birth of weak kids with high mortality rates if does did not receive adequate forage during pregnancy.

2.4.6 Age and weight of dam at kidding

Mazumdar *et al.* (1978) reported that neither age nor weight of dam at kidding had any significant effect on kid survival in their studies on the factors affecting mortality in Pashmina kids. This observation was supported by Vihan, Saini, Singh and Prakash (1986) who reported that dam weight did not affect kid survival in Jumnapari goats in semi-arid conditions.

3. MATERIALS AND METHODS

3.1 THE STUDY AREA

The study was carried out at a research station situated on a holding ground of the Livestock Marketing Division, Ministry of Agriculture and Livestock Development near Isiolo, 300 km. north of Nairobi, longitude 37.6 East and latitude 0.4 North (see Fig.3.1). The altitude is 1100 m. above mean sealevel and the mean annual rainfall is 510 mm. in two rainy seasons (long rains in March to May and short rains in October to November). The area is in ecological zone 5(Pratt and Gwynne, 1977). Shade temperatures taken at 0900 and 1500hrs, range from a minimum of 13 to a maximum of 36 C. .

The soils are volcanic in origin with some alluvial floodplains along seasonal water courses. The main vegetation type is a thorn bush savannah dominated by various *Acacia* species with sparse ground cover of annual grasses, herbs and dwarf shrubs. Along the seasonal watercourses *Acacia* woodland and dense bush dominated by *Grewia* species occur and perennial grassland is found on the floodplains.

For most of the year the holding ground is

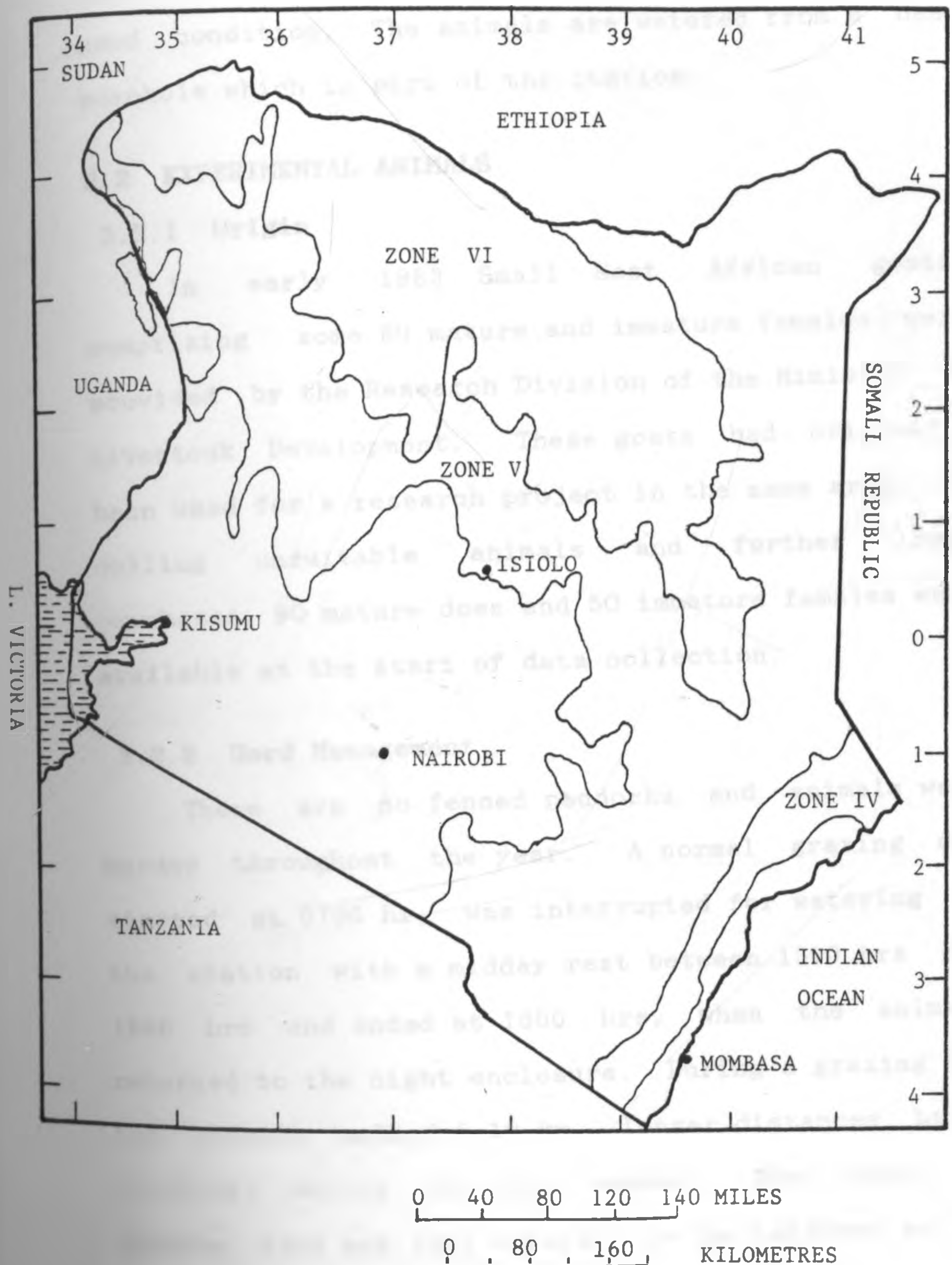

Figure 3.1 Location of study area

understocked and consequently most of the range is in good condition. The animals are watered from a deep borehole which is part of the station.

3.2 EXPERIMENTAL ANIMALS

3.2.1 Origin

In early 1983 Small East African goats, comprising some 60 mature and immature females were provided by the Research Division of the Ministry of Livestock Development. These goats had originally been used for a research project in the same area. By culling unsuitable animals and further local purchases, 90 mature does and 50 immature females were available at the start of data collection.

3.2.2 Herd Management

There are no fenced paddocks and animals were herded throughout the year. A normal grazing day started at 0700 hr, was interrupted for watering at the station with a midday rest between 1300 hrs and 1500 hrs and ended at 1800 hrs, when the animals returned to the night enclosure. During a grazing day the animals walked 5-10 km., longer distances being travelled during the dry season. The choice of grazing area was left entirely to the herdsmen so as to imitate a normal pastoral grazing method.

The animals were drenched twice a year with an anthelmintic prior to each rainy season and were vaccinated once a year against contagious caprine pleuropneumonia. Injuries were treated as they occured. Grease containing pyrethroids (Coopers Pye grease) was applied to animals infested with ticks. Rock salt was supplied in the night enclosure. Miscellaneous conditions (e.g. fevers of unknown cause, pneumonia, mastitis) were treated with available antibiotics.

3.3 RECORDS AND DATA COLLECTION

All events such as abortion, births and deaths were recorded continuously. Liveweights and milk yields were measured regularly every two weeks and dentition recorded monthly. Whenever possible dead animals were subjected to post-mortem examination to establish the cause of death.

The data were recorded on a computer coding sheet in the field every two weeks. These were subsequently entered into an IBM personal computer for analysis.

3.3.1 Rainfall

Rainfall data was obtained from Isiolo town, which is about 25 km. from the station. The monthly rainfall over the two year study period is shown in Fig. 3.2.

3.3.2 Forage

Pasture condition was judged every two weeks using a

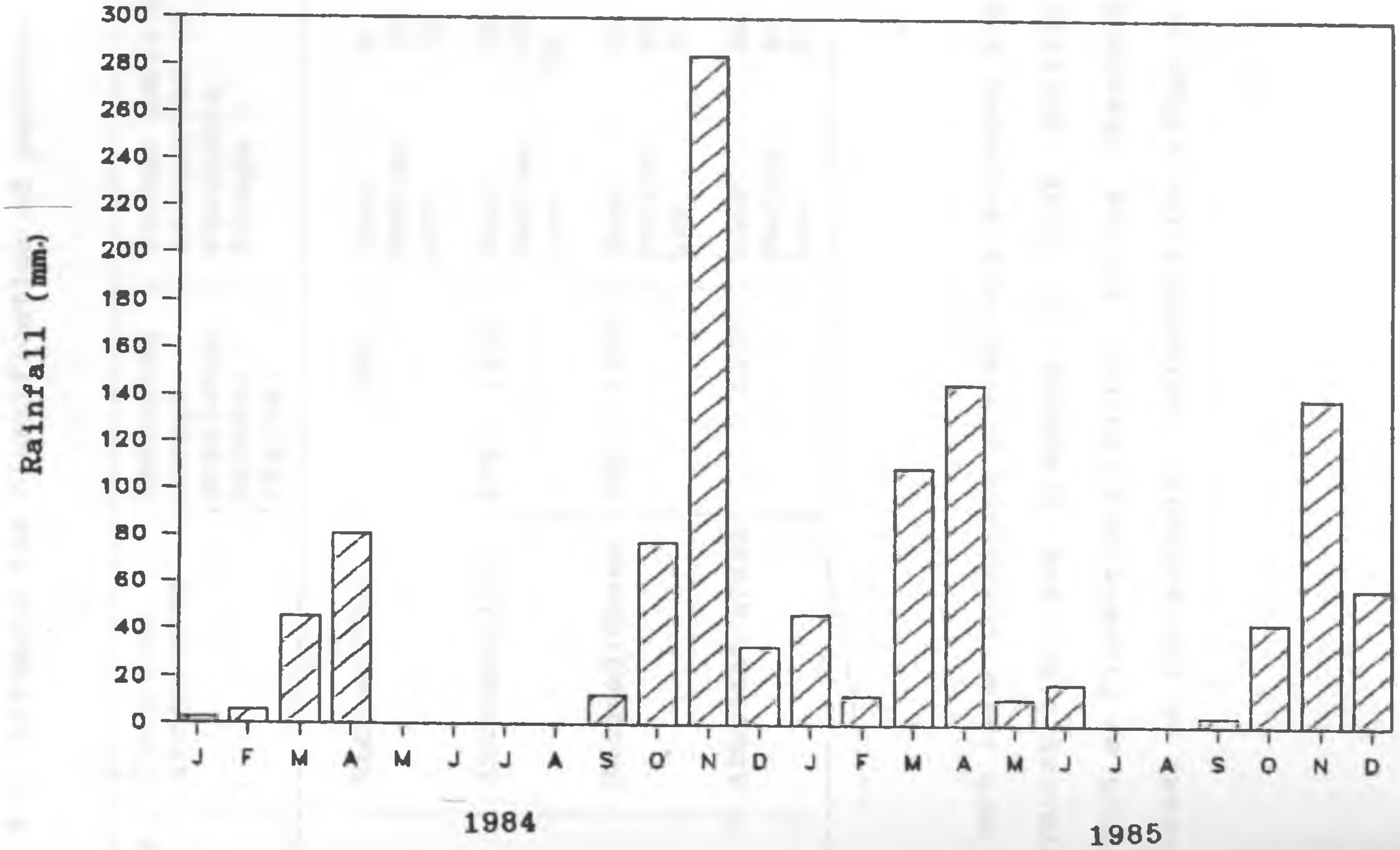

Figure 3.2. Monthly rainfall distribution

Table 3.1: Criteria for classification of pasture

Condition Score	Condition groundcover	Estimated forage available biomass (Kg/ha)	Forage quality categories (% available forage)	
1	Reduced/Dry	< 500	Good Medium Low	0 50 50
2	Abundant/Dry	500 - 1200	Good Medium Low	10 40 50
3	Reduced/Green	700 - 1200	Good Medium Low	30 40 30
4	Abundant/Green	> 1200	Good Medium Low	40 40 20

Note:

The herb layer condition scores were adjusted for browse availability and presence of high quality litter, such as flowers and fruits, in the observed forage intake of the animals, extending the range to 5.

simple classification with five grades (Table 3.1) incorporating forage availability and quality (Rutagwenda, Schwartz, Carles and Said, 1985).

3.3.3 Body weights

These were recorded every fortnight. The weighing was done early in the morning before the animals went out to graze and by the same people every time to minimise error.

The kids were weighed immediately they were born to the nearest 0.25 kg using a spring balance, by first restraining them using a piece of cloth and then hooking them to the balance, until they were 6-8 kg. Thereafter all animals were weighed using a weighing crate with accuracy to the nearest 0.5 kg.

3.3.4 Deaths

Standard post mortem forms were designed to be filled by trained field assistants who were at the station all the time. The use of these ensured a systematic description of carcass at post mortem when still fresh. The forms were then used to make a tentative diagnosis of the cause of death.

3.3.5 Births

Birth weight, sex, type of birth (single or multiple) and the birth date were recorded. Any abortions noticed were also recorded.

The old does whose dates of birth were not known had their ages estimated by dentition.

3.3.6 Milk records

Milk yields were measured every fortnight when all lactating animals were milked four times to determine their daily yield. On the first day the left half of the udder was milked for measurement in the morning and in the evening. On the second day the same procedure was repeated for the right half. All the four recordings were added together to give the average daily yield for that fortnight. This procedure ensured that the kid had one half to suckle. A doe was assumed dry if the average daily yield fell below 5 ml.

3.4: DATA PREPARATION

Three age groups were chosen for analysis based upon their age and distribution of the deaths.

1. Group 1 kids (1-13 days old)

2. Group 2 kids (14-160 days old)
3. Immatures and adults (> 160 days old)

3.4.1: Immatures and adults

Two analyses were done to determine which factors affected the cause of death and those which affected mortality. Five causes of death were identified for the first analysis.

3.4.1.1 Factors affecting cause of death

The cause of death was diagonised, with a reasonable degree of confidence, from the post mortem sheets. The original classification of causes of death which included; pneumonia, cestodes, strongyles, emaciation, doubtful diagnosis, predation, unexplained losses and miscellaneous causes was modified for analysis due to the small numbers involved in some classes. These were then summarised into five main categories (Table 3.2).

The following factors were analysed to determine whether they affected the cause of death :

Period

Year 1984 was particularly adverse with a very severe drought while 1985 experienced average rainfall.

Table 3.2 Classification of the causes of death

Code	Cause of death	Definition
1	Unexplained loss	Animal was sick but for some reason post mortem was not done.
2	Emaciation	
3	Miscellaneous	Post mortem was done but causes of death too diverse for individual classification
4	Predation	
5	Pneumonia	

Sex

Males and females.

Lactation group

The animals were divided into two groups, lactating and non-lactating.

Forage condition

The forage condition prior to death was analysed. This was divided into four periods : At time of death, two weeks before death, four weeks before death and an average over the four weeks. Forage condition was based on the pasture classification shown in Table 3.1.

Age

Age in days was used for the analysis.

Weight before death

This was taken as the last recorded weight (in kg.) before death.

Weight change

This was calculated as the change in weight (in kg.) over 6 weeks prior to death.

Proportionate weight change

This was calculated as a proportion of change in weight in six weeks compared with the weight of the animal six weeks prior to death.

Milk yield

The total milk produced over the six weeks prior to death was analysed for its effect on the cause of death.

3.4.1.2 Factors affecting levels of mortality in immatures and adults

About 75% of the adult deaths occured over a relatively short period of time. This period was associated with the drought and therefore some characteristics were analysed to evaluate factors affecting survival during this drought. For the analysis this was defined as the time when the forage score dropped to 1 until it rose to 2. Since the studies were carried out in a dry area, survival during the dry period was considered to be very important . Due to the flock structure, males were very few, therefore only females were considered in this analysis.

The factors analysed were ;

Age

At the start of the dry period.

Weight

At the start of the dry period.

Weight change

For the survivors it was calculated as the difference in weight at the start and end of the dry period. For non-survivors this was calculated as the change between the start of the dry period and time of death.

Reproductive status

This was a scale to represent the stress during the dry period due to reproduction, either lactation or pregnancy.

The scale took values from 0-40 in weeks. The value 0 was equivalent to sixteen weeks before the start of the dry season. All animals that kidded between point 0 and 40 were assigned a value on the scale equal to the number of weeks they kidded after the origin of the scale. All other animals not kidding over that period of 40 weeks were assigned 0 on the scale. Stress due to lactation was assumed to be minimal at 16 weeks since the highest stress is normally during the first sixteen weeks when most does are dry while others are drying off. The higher the number the more stress the animal had since it had kidded just before the dry season or during the dry season or immediately after.

3.4.2 Kids

Causes of death were not analysed as the gross pathological findings on the carcass were inadequate for specific diagnosis to be made. Analysis was confined to factors affecting the incidence of death.

3.4.2.1 Group 1 (1-13 days)

Kids dying from 1-13 days were compared with the survivors. The following factors were analysed for their effect on survival -

Sex

Type of birth

Singles or multiples (only one set of triplets was observed).

Forage

This was the quantity and quality of forage available to the dam at the time of kidding. The five categories of forage classification shown in Table 3.1 were used.

Birth weight

Dam weight at kidding

Dam age at kidding

Average daily milk consumption

The average daily milk consumption (in mls.) during the first fourteen days of life or until time of death for both survivors and non-survivors was used for this analysis.

3.4.2.2 Group 2 (14-160 days)

The following were analysed as for group 1 -

Period group

Type of birth

Birth weight

Dam weight at kidding

Dam age at kidding

Two additional factors were analysed -

Daily weight gain - during the first 42 days of life.

Average daily milk consumption - during the first 42 days of life.

Only two kids did not attain 42 days and were excluded from this analysis.

3.5 ANALYTICAL METHODS

3.5.1 Descriptive statistics

The means, standard deviations, frequency distributions and time series charts were all obtained using the PANACEA computer programme (PAN Livestock Services,1986).

3.5.2 Sources of variation

Several sources of variation were identified for both the kids and adults. These consisted of both classified and continuous variables.

3.5.2.1 Adults

Classified sources of variation were , period (2 levels),sex (2 levels),lactation (2 levels) and forage condition (5 levels). The covariates were ; age, weight at death, weight changes, proportionate weight change and reproductive status.

3.5.2.2. Kids

Classified sources of variation were ; period (2 levels), sex (2 levels), type of birth (2 levels) and forage condition (5 levels). The covariates were ; birth weight, dam weight at kidding, dam age at kidding, average daily milk yield , average daily weight gain.

3.5.3 Analytical procedure

The analysis of variance and covariance for factors affecting cause of death and those affecting mortality, and estimates of the respective coefficients were made using the least squares methods for multiple classifications of non orthogonal data, as described by Harvey (1966) and applied by Seebeck (1975) in his computer programme SYSNOVA (Version 7.1) - Appendix 1.

A stepwise elimination procedure was used, omitting variables that contributed very little to the variation, to obtain the best model for analysis.

The following general model was used for the analysis of factors affecting cause of death in adults and immatures and factors affecting mortality for both the younger and older kids.

$$Y_{ij} = u + a_i + b_1X_{1j} + b_2X_{2j} + e_{ij}$$

where;

Y_{ij} = the response due to the ith discrete variable and jth covariate .

u = general level

a_i = effect of discrete variable

X_{1j} = effect of covariate X_1

X_{2j} = effect of covariate X_1

b_1 = partial regression coefficient on X_1

b_2 = partial regression coefficient on X_{2k}

e_{ij} = error term

The variables below were used to obtain the results and are described in the results.

Model	Discrete variable	Covariate
1	Forage score (five levels)	Weight at death. Weight change before death.
2	Sex (two levels)	Birth weight. Milk intake.
3	Type of birth (two levels)	Birth weight. Weight gain.

Mortality was coded as death or survival. This binomial coding of the dependent variable created the problem of unequal error variances and therefore weighted least square analysis was used to overcome this problem. This involved a two stage least squares procedure where the regression model was fitted using the ordinary least squares in stage one ; for a weighted least square analysis weights were estimated using these results in stage two (Neter and Wasserman, 1974).

4. RESULTS

4.1 Levels of mortality

Mortality levels for different age groups are shown in Table 4.1.

Young animals before weaning had the highest level followed by the adults with the weaners having the least. The difference between the very young kids and older kids was very small and non-significant and could be attributed to chance.

Most of the adult deaths occured during the dry season with most animals either pregnant or lactating.

4.2 Causes of death for adults and immatures

4.2.1 General levels

Causes of death for adults and immatures are summarised in Table 4.2 .

Emaciation was the major cause of death followed by miscellaneous causes. Pneumonia and unexplained losses had equal losses while predation contributed the least.

The incidence of emaciation was largely confined to the prolonged drought during the first year. The deaths attributed to pneumonia all had lesions typical of contagious caprine pleuropneumonia.

Table 4.1. Age specific mortality levels

Class	Age (days)	Number	Mortality level
Young kids	1-13	156	16%
Older kids	14-160	104	18%
Weaners	161-365	300	4%
Adults	> 365	233	12%

Table 4.2. Causes of death for 40 adults and immatures

Causes	Number	Proportion(%)
Predation	6	15
Pneumonia	7	17.5
Unexplained loss	7	17.5
Miscellaneous	8	20
Emaciation	12	30

4.2.2 Factors affecting cause of death in immatures and adults

The normal statistics for the continuous variables are shown in Table 4.3 and the distribution of discrete variables in Table 4.4 .

After elimination of the non-significant variables during model building the final model chosen was model 1 (ref. page 30).

The results of the analysis of variance are shown in Table 4.5 .

These results indicate that cause of death in adult animals is significantly influenced by forage condition four weeks prior to death ($P<0.01$), the weight of the animal ($P<0.001$) and the weight changes ($P<0.05$) of the animal (Table 4.5). Sex, lactation (analysed as a heirachical effect within sex thus confining this to females), period and age were not statistically significant ($P > 0.05$). Proportionate weight change though statistically significant was dropped from the model due to collinearity with weight.

It is interesting to note that forage score four weeks prior to death significantly affected cause of death while that at two weeks prior to death and at the time of death did not.

There were no significant interactions between

Table 4.3. Normal distribution statistics for 40 adults

Variable	Mean	Std. dev.
Age at death(days)	1016.28	605.486
Weight at death(Kg)	26.29	10.169
Weight change(Kg)	2.16	4.057
Proportionate weight change	0.08	0.155

Table 4.4. Distribution of discrete variables

Forage score at 4 weeks prior to death	Sex	Lactation	Period 1984	Period 1985
1	female	lactating	2	-
		non-lactating	7	-
	male	.	6	-
2	female	lactating	1	-
		non-lactating	2	-
	male		3	-
3	female	lactating	-	-
		non-lactating	2	5
	male		-	-
4	female	lactating	1	1
		non-lactating	-	3
	male		2	-
5	female	lactating	2	-
		non-lactating	1	-
	male		1	1
		Total	30	10

Table 4.5. The analysis of variance for factors affecting cause of death (of adults and immatures).

Source of variation	DF	Mean square	
Forage 4 weeks prior to death	4	5.546	**
Weight before death	1	14.636	***
Weight change	1	8.104	*
Residual	33	1.227	

* P < 0.05, ** P < 0.01, *** P < 0.001

the factors.

As the weight of the animal increased, causes of death were more of a specific nature like pneumonia and predation. This was observed both from the statistical analysis and the raw data (Table 4.6). It was observed that of the animals dying from the unexplained losses or emaciation, 84% were below 30 kg. while for predation and pneumonia only 43% were below 30 kg. others being above. The miscellaneous deaths were evenly distributed over the weight range.

Forage score 1, 3 and 4 were associated with death due to emaciation and unexplained loss while score 2 and 5 were associated with predation and pneumonia.

The six weeks change in weight shows that the more weight the animal lost the causes of death tended to be emaciation or non specific while the animals with smaller weight loss or gaining weight tended to die from predation and pneumonia. This observation was supported by the raw data (Table 4.7) and also the statistical analysis. From the raw data it was observed that though the distribution of causes of death for animals with little or no weight changes was even over all the causes, 52% of deaths from emaciation and unexplained loss were among animals loosing over 4 kg. weight and only one death occurred from pneumonia in this category.

Table 4.6. Effect of weight upon cause of death in adults and immatures.

WEIGHT (Kg.)	DEATH CODE 1	2	3	4	5	Total
10-19	1	9	2	1	1	13
20-29	4	2	2	1	2	11
30-39	2	1	2	2	4	12
40-49	0	0	2	1	0	3
>50	0	0	0	1	0	1
Total	7	12	8	6	7	40

Table 4.7. Effect of weight change upon cause of death in adults and immatures

WEIGHT CHANGE (Kg.)	DEATH CODE 1	2	3	4	5	Total
-10_-7.1	2	1	2	0	0	5
-7_-4.1	1	6	0	0	1	8
-4_-1.1	0	3	2	1	3	9
[illegible]9	3	2	3	3	3	14
[illegible].9	1	0	1	1	0	3
5_7.9	0	0	0	0	0	0
8_11	0	0	0	1	0	1
Total	7	12	8	6	7	40

Note : Negative values refer to weight loss

4.3 Factors affecting mortality of kids from birth to 13 days

The normal statistics for continuous variables are shown in Table 4.8 and the distribution of discrete variables is shown in Table 4.9.

After elimination of the non-significant variables during model building the final model choosen was model 2 (ref. page 30).

The results of the analysis of variance and covariance are shown in Table 4.10. The results from this analysis indicate that birth weight (P<0.05), sex (P<0.05) and milk intake (P<0.001) significantly affected survival.

Forage score, type of birth, dam weight and dam age at kidding were not statistically significant (P > 0.05).

The effect of birth weight on survival is illustrated by the fitted line using coefficients from the complete model in Fig. 4.1. For every extra 100g. in birth weight the probability of survival increased by 2.6%. Thus, there was a 36% difference in probability of survival between the kids born with the lowest birth weight and those with the highest birth weight over the expected range covering 90% of the observations. The 90% range for the significant continuous variables was 1.4 - 2.8 kg for birth weight

Table 4.8. Normal distribution statistics for 156 kids from birth to 13 days

Variable	Mean	Std. dev.
Birth weight (kg)	2.11	0.424
Dam weight at kidding (kg)	34.85	5.750
Age of dam at kidding (days)	1220.33	428.828
Daily milk intake (ml)	355.06	12.909

Table 4.9. Distribution of discrete variables for kids from birth to 13 days

		Sex	
		Female	Male
Forage score	Type of birth		
1	Single	2	4
	Multiple	5	8
2	Single	2	3
	Multiple	2	2
3	Single	9	9
	Multiple	18	10
4	Single	10	9
	Multiple	4	3
5	Single	11	17
	Multiple	19	9
	Total	82	74

Table 4.10. The analysis of variance for weighted values of factors affecting mortality of kids from birth to 13 days old.

Source of variation	DF	Mean square	
Sex	1	0.224	*
Birth weight	1	1.101	***
Milk intake	1	0.245	*
Residual	152	0.054	

* P < 0.05, *** P < 0.001

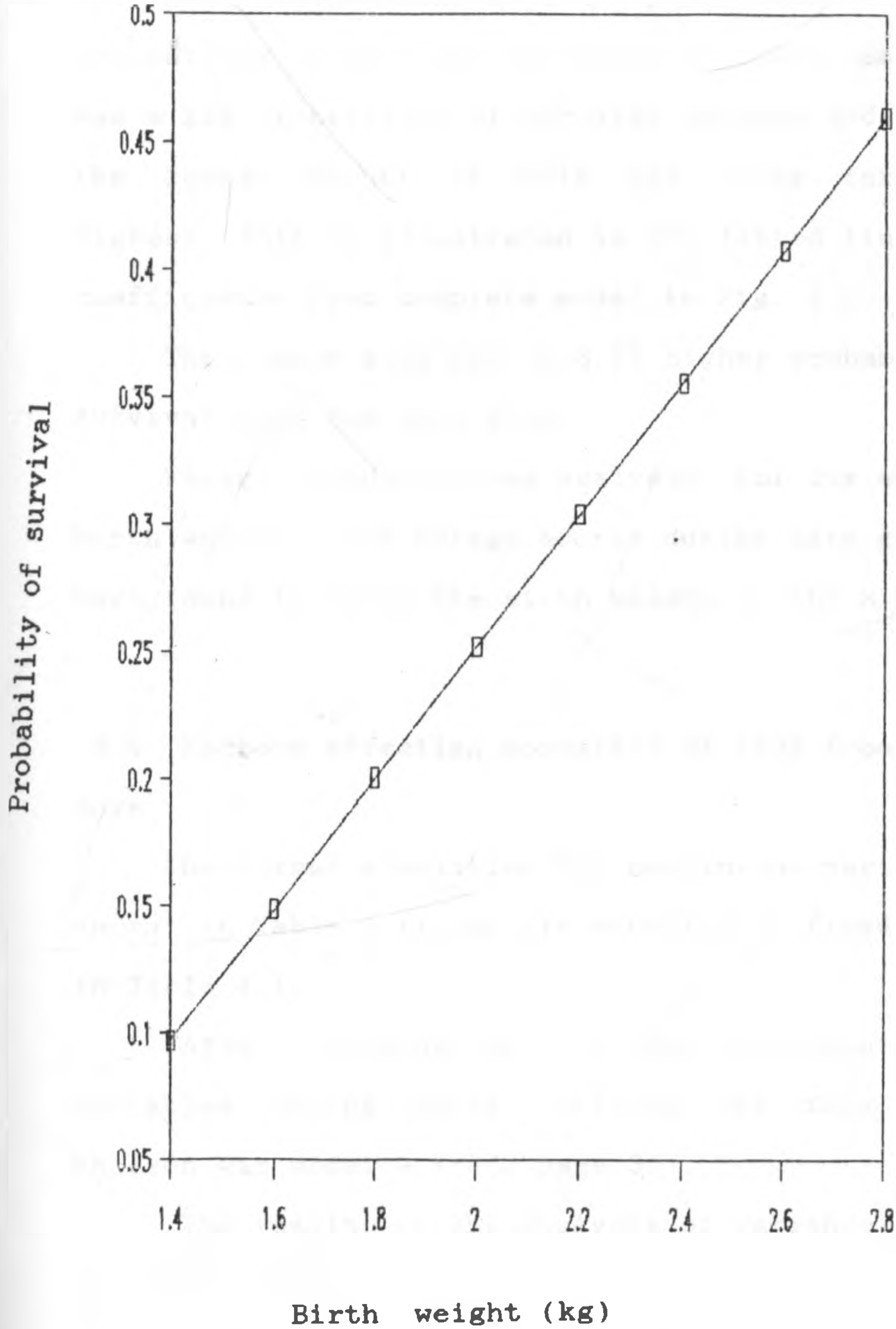

Figure 4.1 Effect of birthweight on the probability of survival

and 4.8 - 705 ml for daily milk intake.

For every extra 100 ml/day of milk taken the probability of survival increased by 0.03%. So, there was a 21% probability of survival between kids taking the lowest amount of milk and those taking the highest. This is illustrated in the fitted line using coefficients from complete model in Fig. 4.2.

The female kids had a 3.7% higher probability of survival than the male kids.

Forage condition was analysed for its effect on birth weight. Low forage scores during late gestation were found to lower the birth weight of the kids.

4.4 Factors affecting mortality of kids from 14 - 160 days

The normal statistics for continuous variables are shown in Table 4.11 and distribution of fixed effects in Table 4.12 .

After elimination of the non-significant variables during model building the final model choosen was model 3 (ref. page 30).

The results of the analysis of variance are shown in Table 4.13.

Type of birth (P<0.05) and weight gain (P<0.001) significantly affected the survival of this group of kids. Birth weight, sex, dam weight and dam age at

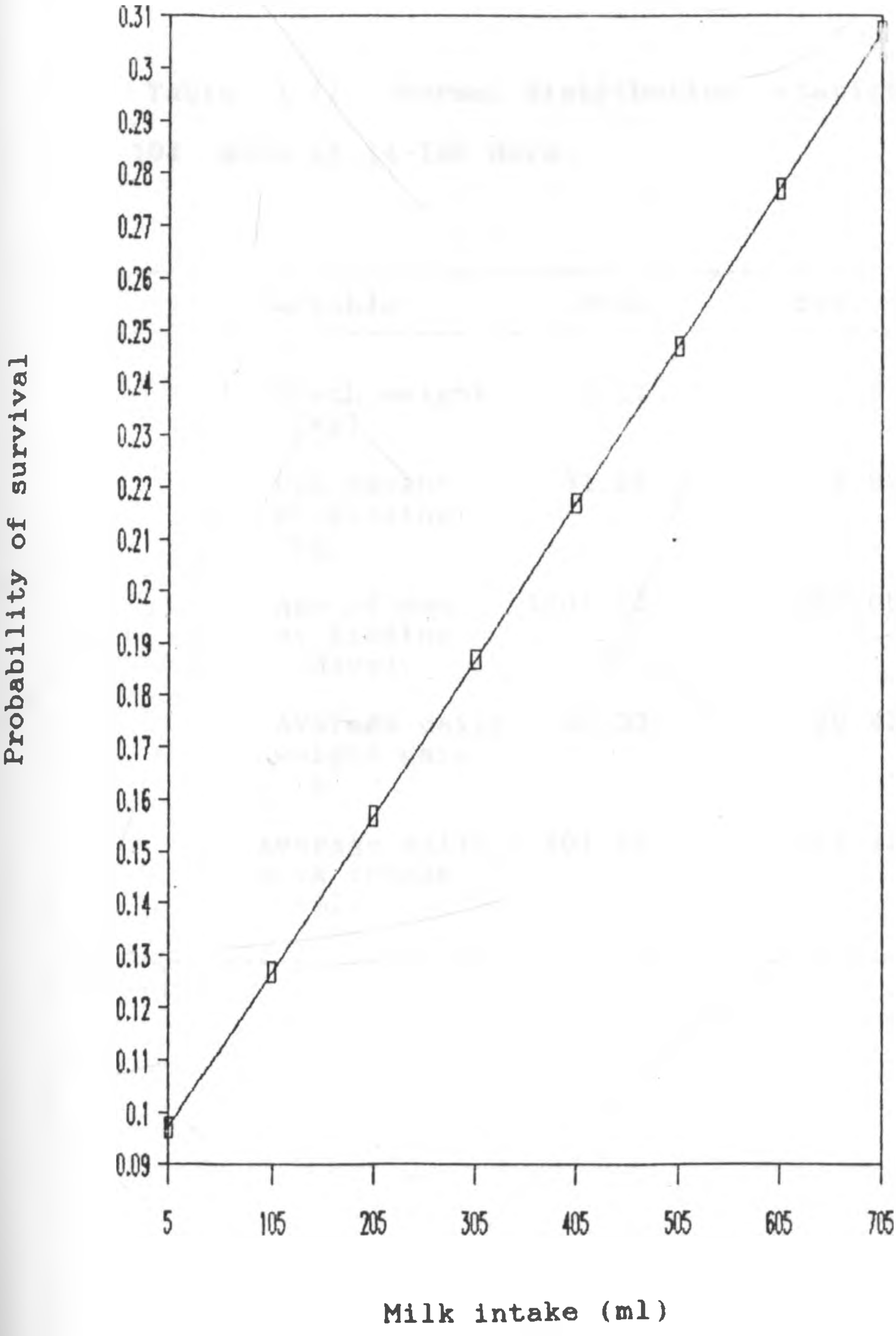

Figure 4.2 Effect of milk intake on the probability of survival

Table 4.11. Normal distribution statistics for 104 kids of 14-160 days

Variable	Mean	Std. dev.
Birth weight (kg)	2.17	0.373
Dam weight at kidding (kg)	34.98	5.929
Age of dam at kidding (days)	1201.23	437.087
Average daily weight gain (g)	63.33	29.432
Average daily milk intake (ml)	401.84	217.127

Table 4.12. Distribution of discrete variables for kids of 14-160 days of age.

		Type of birth.	
		Single	Multiple
Period	Sex		
1984	female	17	18
	male	17	10
1985	female	10	12
	male	10	10
	Total	54	50

Table 4.13. The analysis of variance for weighted values of the factors affecting mortality of kids from 14-160 days.

Source of variation	DF	Mean square	
Type of birth	1	0.132	*
Birth weight	1	0.059	ns
Weight gain	1	1.403	***
Residual	100	0.028	

ns = non-significant, * P < 0.05, *** P < 0.001

kidding were not statistically significant (P>0.05).

The effect of daily milk intake was also examined but because of the very close relationship with daily weight gain, it could not be included in the final model. Its effect, in the absence of weight gain, was highly significant ($P < 0.001$) but was less than that of daily weight gain.

The effect of weight gain on survival is illustrated in Fig. 4.3 which is a fitted line using coefficient from the complete model. For every 1 g. average daily weight gain for the first 42 days the probability of survival increased by 1.05% over the expected range covering 90% of the observations.

The 90% range for daily weight gain was 14.9 - 111.7 g..

The twin kids had a 7.8% higher probability of survival than the single kids. However it should be noted that when type of birth was analysed alone for its effect on survival the results indicated that singles survived marginally better than twins.

4.5 Factors affecting mortality in adults and immatures

The normal statistics of the variables analysed are shown in in Table 4.14 and results of analysis of variance in Table 4.15a . These results indicate that

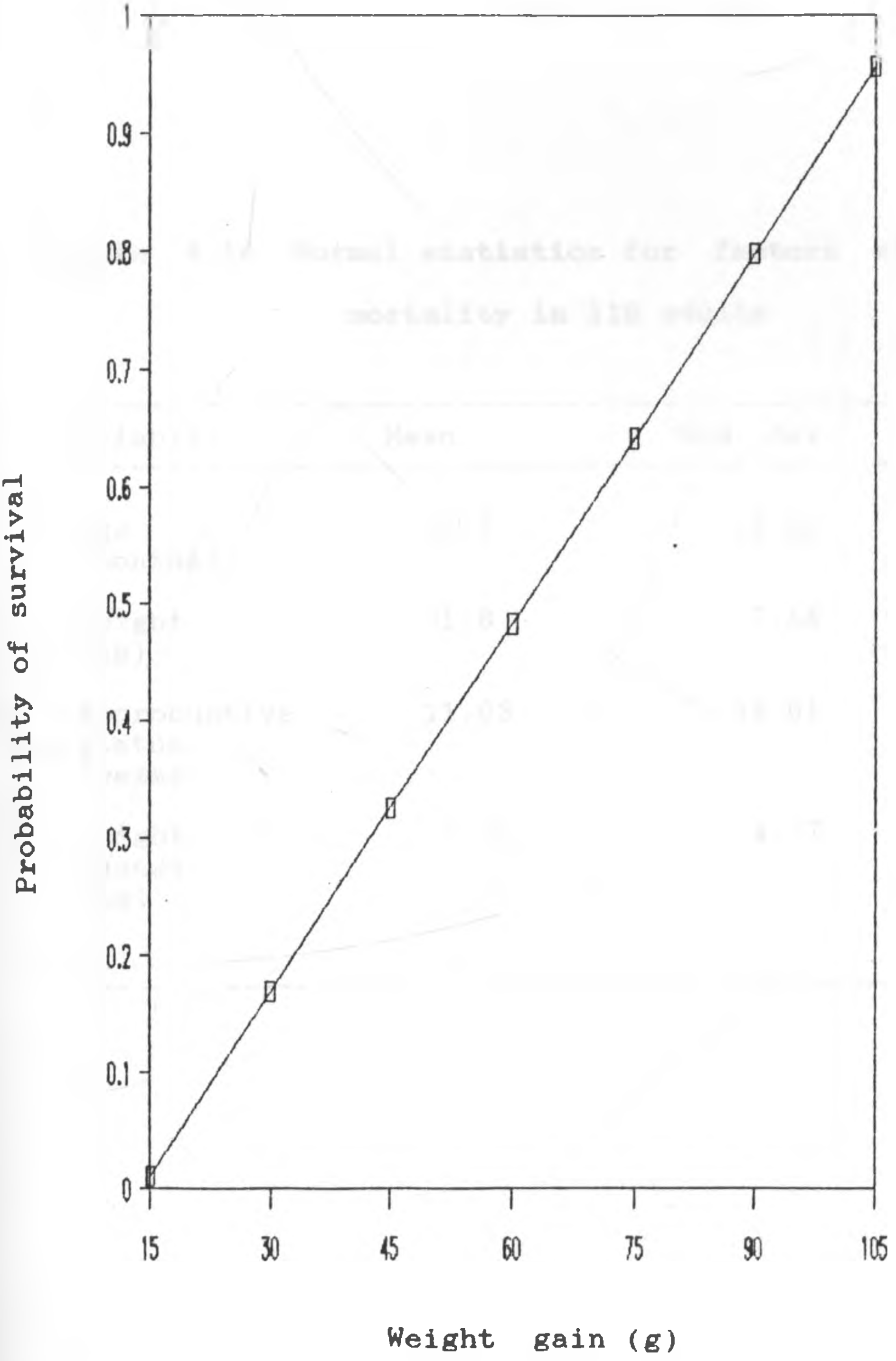

Figure 4.3 **Effect of weight gain on the probability of survival**

Table 4.14. Normal statistics for factors affecting mortality in 116 adults

Variable	Mean	Std. dev.
Age (months)	32.7	15.02
Weight (kg)	31.6	7.55
Reproductive status (weeks)	11.03	14.01
Weight change (kg)	6.30	4.17

Table 4.15a. Weighted analysis of variance for adult mortality.

Source of variation	DF	Mean Square	
Weight			
linear	1	0.2442	*
quadratic	1	0.2194	*
Reproductive status			
linear	1	0.2780	*
quadratic	1	0.2486	*
Error	111	0.0467	

ns = non-significant, * P<0.05, *** P<0.001

Table 4.15b. Correlation matrix for factors affecting mortality in adults.

	Weight	Weight change	Reproductive status
Age	0.74*	0.1	0.07
Weight		0.78*	0.35
Weight change			0.44

* P < 0.001

weight of the animal and the reproductive status were significant both linearly and curvilinearly ($P < 0.05$).

Age and weight change were both highly correlated with the weight of the animal (Table 4.15b). Due to this high correlation they were not included in the final model since the interpretation of the regression coefficients would have been biased.

The fitted lines to illustrate the effect of weight and reproductive status, and to assist in the interpretation of the results, were drawn using the coefficients from the complete model.

The effect of reproductive status on the probability of survival is shown in Fig. 4.4. The probability of survival after the adjustment for other effects became difficult to interpret since it was outside the probability range. This was not surprising because reproductive status was an arbitrary definition. The probability was therefore adjusted by dividing with the highest probability value to obtain values between 0 and 1. The probability of survival falls as kidding approaches the onset of the drought, reaching the lowest value when kidding occurs around the onset of the drought and lactation is confined to the drought period.

With kidding towards the end of the drought (and pregnancy throughout the drought period) the

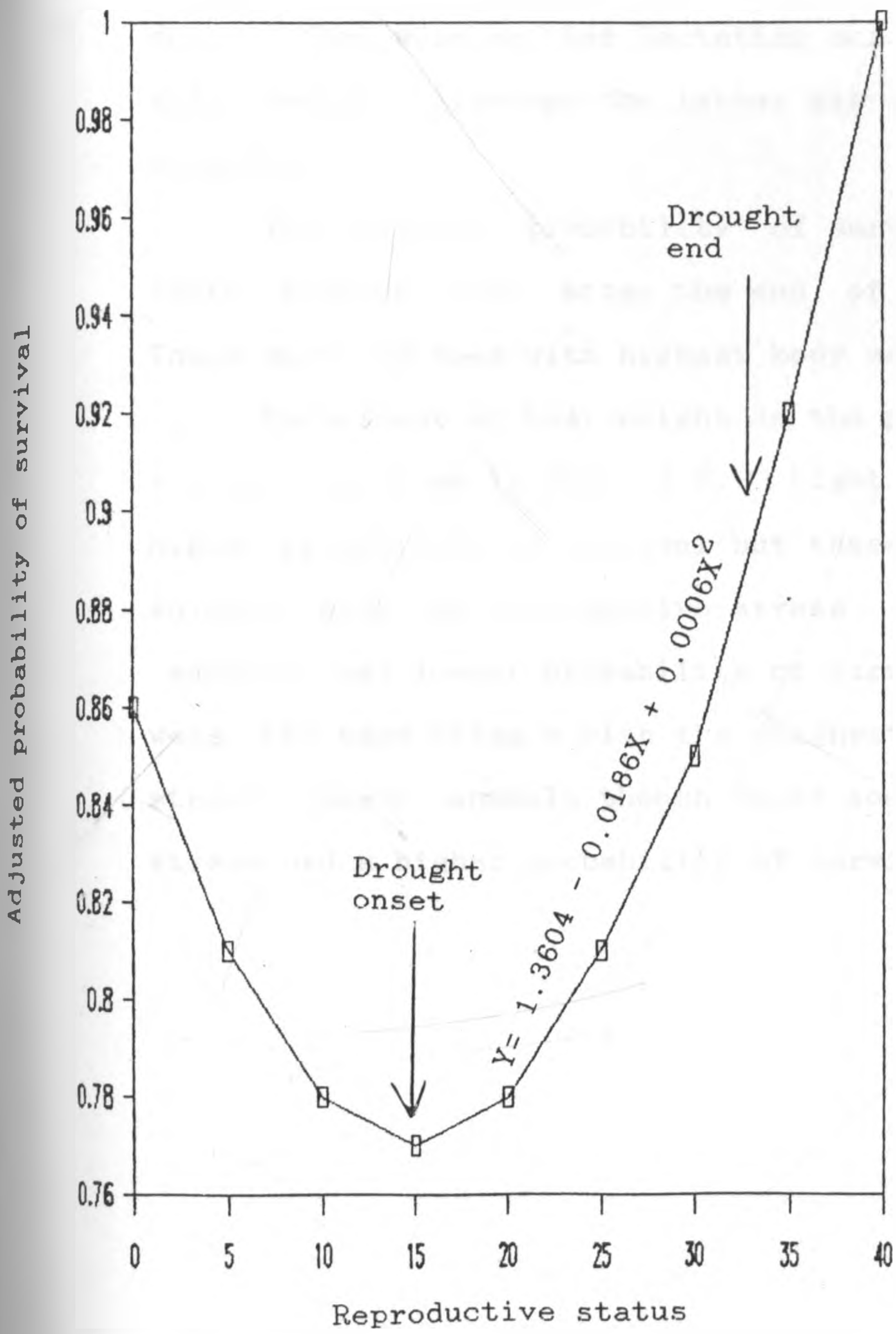

Fig. 4.4. Effect of reproductive status on probability of survival

probability of survival is equivalent to that for does that were neither lactating nor pregnant during this period (although the latter all had low body weights).

The highest probability of survival was for those kidding just after the end of the drought. These were the does with highest body weight.

The effect of body weight on the probability of survival is shown in Fig. 4.5. Light animals had a higher probability of survival but these were also the animals with no reproductive stress. Middle weight animals had lowest probability of survival but these were the same animals with the highest reproductive stress. Heavy animals though under some reproductive stress had a higher probability of survival.

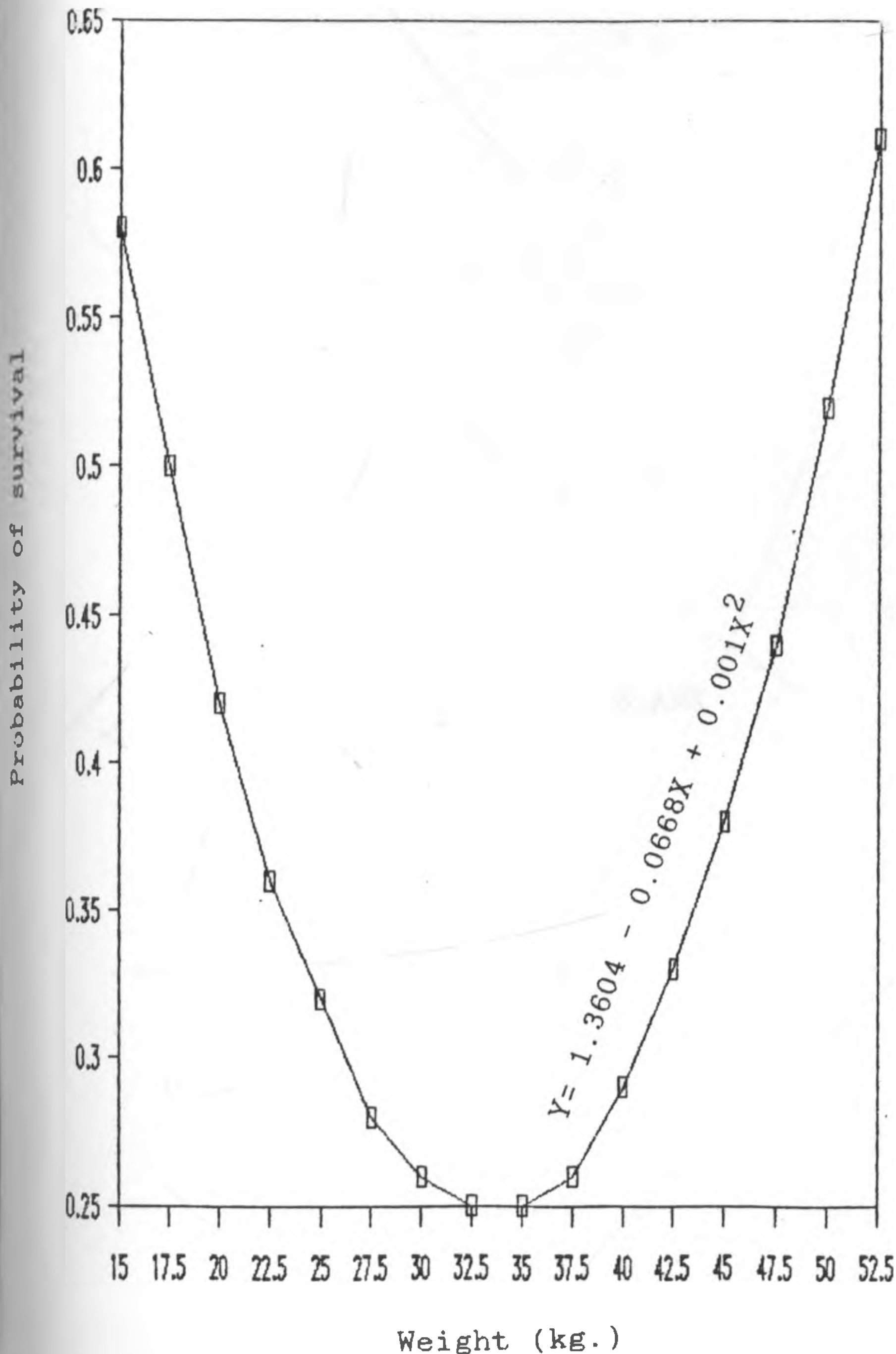

Fig. 4.5. Effect of weight on the probability of survival.

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5. DISCUSSION

Levels of mortality

The higher mortality observed in adults as compared to weaners could be explained by stress due to lactation and pregnancy in the former. Higher mortality rate in the young has been reported by many workers in different breeds and environments. This higher mortality could be attributed to the young being less resistant to adverse environmental factors and infectious diseases. Lall *et al.* (1949) observed that kids always had higher mortality, with infectious disease contributing 29.5% as opposed to 10.7% in adults.

The preweaning mortality of 32% observed in this environment is comparable to observations by other workers in similar and different environments. Carles *et al.* (1982) working with the Small East African goat in a similar semi-arid area in Kenya reported mortalities as high as 66% during the first year of life. However they observed that mortalities dropped to 12% in breeding females which compares with the 12% observed for adults in this study. Wilson *et al.* (1985) also working in a dry area in Kenya observed preweaning mortality of 28.6%. It should be noted that there was a severe drought during the course of this study which may have contributed to increased mortality levels in the different age groups. Similar observations have been reported by Wilson (1986), Adu *et al.* (1979) and Osugwuh (1982). Halpin (1975) (quoted by Ndamukong, 1985) pointed out that the age of the animal has a great effect on it's ability to withstand attack by both physical and biological agents.

Losses of 32% of the kids born will significantly affect productivity. This age group therefore requires greater protection from the harshness of the environment through provision of adequate nutrition, shelter and management.

Causes of mortality in adults and immatures

The main cause of death in this study was emaciation, with the majority of the deaths in this category occuring during a severe drought experienced during the study period. In this arid environment it is expected that inadequate nutrients would play a major role in determining general levels of morbidity and mortality. The high incidences of death in the emaciated and unspecified categories would support this. Working in a similar environment, Carles *et al.* (1982) reported starvation as a major cause of death.

A proportion of the animals died from contagious caprine pleuropneumonia despite the vaccinations. 95% of these animals dying from CCPP were old animals which were present at the start of the study and had been used earlier for CCPP studies. It should be mentioned that pneumonia was not as major a problem as has been reported by many workers elsewhere (Mazumdar *et al.* 1980 ; Ndamukong, 1985 ; Traore', 1985). Carles (1986) reported 9% deaths due to pneumonia in a similar environment and almost all were attributable to an outbreak of CCPP.

Predation is a common occurrence in range areas due to the presence of wild animals. The 15% mortality observed could be due to the animals being protected in a night enclosure. This could be reduced further by leaving behind all the weak and young animals during grazing since some predation occured when animals were left behind during grazing. Carles (1986) working in the Rendille area in Northern Kenya observed 14% deaths due to predation while Wilson (1986) reported 17% deaths due to predation in Mali.

Miscellaneous causes of death ranged from accidents, mastitis, bloat, heavy worm burden to fevers of unknown causes.

The unexplained category accounted for 17.6% of the total deaths . This was more of a reflection of the diagnostic facilities available at the station and taking into consideration the absence of a veterinarian at the station the figure is reasonably low. Reports by other workers, though with different facilities, have been higher. Carles (1986) observed 44% and Wilson (1985) 37% both working in semi-arid areas.

It should be noted that 62.5% of the deaths were attributed to three specific causes, namely emaciation, predation and pneumonia. The incidence of these can be reduced by vaccinations against pleuropneumonia, offering more protection to the animals against predators and in case of starvation, planning a grazing method where some pasture is available for dry season grazing or selling off some animals at the start of the dry season.

Gastroenteritis has been reported as a major cause of death in goats (Ndamukong 1985 ; Srivastava *et al.* 1986). This however does not seem to be a problem in this area.

Factors affecting cause of mortality in adults and immatures

The forage condition 4 weeks prior to death had a close association with the ultimate cause of death. Low forage score was associated with death due to emaciation or unexplained causes. This could be attributed to the animal losing weight continuously for the four weeks before death due to starvation, and as a result, the animal was weak and died from emaciation or became more susceptible to environmental or disease stresses. This trend was also observed for body weight before death, where animals with low body weight died more from emaciation.

High forage scores were associated with deaths from pneumonia. This was not surprising as high forage scores accompany rainfall and cold temperatures which would cause latent pleuropneumonia infections to flare up. Purnomo *et al.* (1987) have reported that pneumonia is associated with climate, the disease being more common in the rainy season. Again, it is the animals with high body weights and not losing weight prior to death, that died of pneumonia.

The intermediate forage levels do not seem to be associated with any particular cause of death. This is expected since some causes of death can occur during any weather. Predation can occur during the wet period (good forage) or during the dry period and so can most of the miscellaneous causes of death. Deaths of animals with average body weights were associated with miscellaneous causes, predation and unexplained loss.

The weight change over a six week period is very indicative of the events prior to death. Animals that lost most weight died of starvation while animals losing little or no weight or gaining weight died of pneumonia.

The absolute weight of the animal at the time of death was more important in determining the ultimate cause of death, than the change in weight over six weeks prior to death.

The time period, sex of animal, forage condition at time of death and two weeks before death, age of animal and milk yield of animal did not affect cause of death. Remarkably, it was the forage condition four weeks prior to death that did affect cause of death than the forage condition immediately preceeding death. It was also noted that the average forage score over four weeks prior to death had no effect on ultimate cause of death. From these results, there seems to be a time lag of about four weeks in the forage effect. Also despite a major drought in the first year of study there was no significant difference between the two. This might be due the Small East African goat being well adapted to the harsh environment and also availability of drinking water at all times.

The absence of the age effect is surprising since no preferential treatment was given to the young adults. These young adults could be expected to succumb faster to environmental stress especially starvation. However, the adult animals had started breeding and though they are more resistant to environmental stress than the young, the breeding stress (lactation or pregnancy) could have contributed to the absence of age difference.

From above observations, causes of death in the range areas seem to depend primarily on the availability of forage and the weight of the animal.

Factors affecting mortality in kids

Kids 1-13 days

Only birthweight, sex and milk intake were of significance for the survival of these very young kids. Ahmed *et al.* (1960), Seth *et al.* (1966), Sarmah *et al.* (1975), Ali *et al.* (1975), Mittal (1976), Osugwuh (1981) and Gupta (1985) all working with different goat breeds and different environments reported that kids with higher birthweight survived better. Similar observations have been reported in sheep (Purser and Young, 1959; Malik and Acharya, 1972; Builov and Khamitsaev, 1972; Raina, Desai and Bhat, 1973; Maund, Duffell and Winkler, 1980).

Birthweight has the most important effect on survival of these kids. This is illustrated by the fact that the difference in survival between the kids with lowest and the highest birthweights (over the expected range) is 36% as compared with 21% difference for the same range milk intake and 3.7% for sex.

This difference could be attributed to heavier kids being more mature at birth, their physiological systems are more developed therefore more resistant to environmental stress. These kids are strong and able to fully suckle their dams. Probably, kids born with very low birth weight die from starvation due to inability to suckle.

Low forage score during late gestation lowered the birth weight of kids thus increasing mortality. Westhuysen (1980) working with Angora goats reported a similar observation.

Female kids under this environment survived better than the male kids. This observation has been reported by Minnet (1950) and Khan *et al.* (1978) both working with Indian goats, Adu *et al.* (1979) working with Red Sokoto goats and Wilson (1986) working with the West African Sahel goat. This is consistent with the findings of Wahome (1987), from the same data, that does with female kids produced more milk than those with male kids.

Kids getting high amounts of milk had significantly higher probability of survival. This is expected since young kids after birth have no other source of nutrients except from milk. It was also observed, from the same data, that dams whose kid(s) died before weaning were generally lower milk yielders (Wahome. 1987).

Type of birth (multiple or single) was not significant. Since after 14 days of age type of birth was not found to affect survival, we can assume that the demand of the twin kids in terms of milk is catered for during this early age. Mittal (1976) working with Barbari and Jamnapari kids also observed no difference in survival between different types of birth.

Age and weight of dam at kidding did not affect kid survival. This observation would lead us to assume that all the dams, irrespective of age or weight, had good mothering ability. Mazumdar *et al.* (1976) and Vihan *et al.* (1986) have reported a similar observation. However, kids from older and heavier does would be expected to survive better than the others since these does have higher milk yield (Alderson and Pollak, 1979). Galal (1982) also reported that weight at kidding did affect milk yield with heavier does giving more. The above results agree with Prakash, Acharya and Dhillon (1971) who argued that when mature weight is attained, age effect on milk yield is no longer significant.

Kids 14-160 days

Weight gain over the first 42 days was the most important factor affecting survival in this group of kids. Milk intake over the same period was also an important factor but was overshadowed by weight gain. It can therefore be argued that though the amount of milk consumed will be reflected in the weight increase, there are other factors contributing to weight gain and hence survival. These would include the genotype of the kid since kids getting the same amount of nutrition will not grow at the same rate due to difference in growth potential.

It seems clear that none of the disease conditions associated with high growth rate (e.g. Clostridial infections) are prevalent in this area.

Factors affecting mortality in adults and immatures

The two most important factors affecting mortality in adults and immatures over the drought, from this study, were the body weight of the animal at start of dry season and the reproductive stress the animal is exposed to during the dry period. However the reproductive stress was of relatively more importance than the weight.

Heavy animals were able to overcome the reproductive stress more than the average weight animals. All the light animals in the study were not under any reproductive stress since they were neither lactating nor pregnant. Heavy animals would be expected to survive better during the dry season since they have body reserves which they can utilise. Middle weight animals had a lower survival than light weight animals and this would be explained by the close relationship between reproductive stress and body weight. The middle weight animals were under reproductive stress while the light animals were not.

Reproductive stress referred to both lactation and pregnancy. The results indicate that animals kidding just before or at the start of the dry season, thus having their lactation over the dry period, had lower probability of survival than animals which were pregnant over the dry season and kidded at the end of the dry season. Since reproductive stress has a highly significant effect on survival we can assume that animals lactating over the dry period were more stressed. This observation would be important when considering seasonal mating. To reduce mortality does should be mated such that they do not kid before the onset of the rains. It must be pointed out that good forage condition during final stages of gestation is important to increase birth weight of the kids which increases their survival.

This conflict is of practical importance and a compromise between the two desirable effects should be attained. This is so because it is important that kids survive since they are the product of the system and also dams have to survive to nurse the kids and produce more kids.

One way of doing this would be to let does kid at the start of the wet season and supplement them during the last days of gestation to increase birth weight of kids. The other alternative is to let the does kid in the middle of the wet season and supplement them at the start of the dry season if they are still lactating heavily. Supplementation in this environment cannot be by commercial feeds (high protein and energy feeds) due to the economics and sometimes unavailability. It is however possible to plan grazing such that a portion near the homestead is preserved for these animals. Also the highly nutritious *Acacia* pods can be harvested and stored to be used as a supplement for these animals.

6. CONCLUSIONS

Within the limits of the experimental conditions and procedures employed, the results of this study lead to the following conclusions :

1. The levels of mortality were comparable to other reports from similar environments.

2. Emaciation, pneumonia and predation were the main identifiable causes of mortality accounting for upto 62.5% of deaths.

3. The forage condition prior to the death of the animal and the weight of the animal at the time of death are the main factors affecting the cause of death in adults and immatures.

4. Birthweight ($P<0.001$), milk intake ($P<0.05$) and sex $P<0.05$) were the main factors identified as affecting mortality of kids from 1-13 days old.

5. Weight gain ($P<0.001$) and type of birth ($P<0.05$) were the main factors affecting mortality of kids from 14-160 days old.

6. Weight of the animal at the start of the dry season and the reproductive stress the animal is exposed to during the dry season were the two factors affecting

mortality of adults and immatures during the dry season.

7. Lactation during the dry season is more stressful than pregnancy. If seasonal mating is practiced then it would be advisable for kidding to occur after the rains when there is forage.

However, the effect of nutrition in the last stages of gestation on birthweight of kid must be taken into account.

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8. APPENDIX

A.1 The general model used by *Sysnova*.

$$y_{ijkl} = u + a_i + b_{ij} + c_k + (ac)_{ik} + (ad)_i + d(D_{ijkl} - D) + e_{ijkl}$$

i =1,2,....p

j =1,2,....q_i

k =1,2,....r,

l =1,2,....,n_{ijk}

where

y_{ijkl} =lth observation in the kth C class and in the jth B class within the ith A class.

u = a general level.

a_i = effect of the ith A class, after removal of u.

b_{ij} = effect of the jth B class within the ith A class, after removal of the ith A class.

c_k = effect of the kth C class, after removal of u.

$(ac)_{ik}$= effect of the ikth AC subclass after the average effects of A and C have been removed.

$(ad)_i$ = interraction between A and the continuous variate D_{ijkl} . This interraction between a treatment and a covariate enables particular slopes to be fitted.

d =partial regression of the y_{ijkl} on the D_{ijk} averaged over the p levels of a.

D_{ijkl}.=an independent continuous variate.

e_{ijkl}=random effects which are assumed to be normally and independently distributed with a mean of zero and a variance of σ_e^2.