REPRODUCTIVE PERFORMANCE AND WASTAGE IN GOATS IN ARID AND SEMI-ARID AREAS OF KENYA WITH SPECIAL EMPHASIS ON PRE-WEANING MORTALITY.

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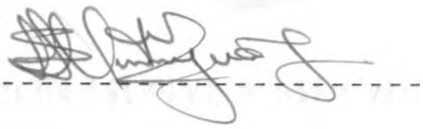
THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN VETERINARY REPRODUCTION AND OBSTETRICS (THERIOGENOLOGY) IN THE DEPARTMENT OF CLINICAL STUDIES, UNIVERSITY OF NAIROBI.

1997, Nairobi, Kenya.

DECLARATION.

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



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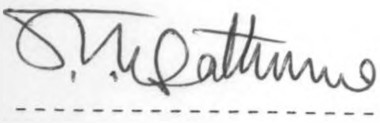

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DEDICATION

THIS THESIS IS DEDICATED TO:

My Wife - **HILDA MANTEMA MUCHINA MUNYUA**

Sons - SOLOMON MUNYUA MUCHINA

And

FRED "RICO" MUCHINA MUNYUA

And daughter - FELISTER "LISTA" HURO MUCHINA MUNYUA

TABLE OF CONTENT

Chapter 3

General materials and methods.

CHAPTER 4

Reproductive efficiency indicators in indigenous goats, under commercial (ranch), State owned Sheep and Goat Multiplication Centres and traditional (pastoral and semi-sedentary) livestock production systems.

CHAPTER 5

Reproductive efficiency on selected farms with emphasis on management of preweaning mortality and economics of veterinary intervention: An on-farm study.

CHAPTER 6

Haematological profiles, total protein and immunoglobulin levels and E. coli antibody titre in sera obtained from goat kids and their dams in the first week postpartum: An on-station study.

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ACKNOWLEDGEMENTS.

I wish to express my gratitude and appreciation to my supervisors, **Professors J. M. Gathuma** and B. N. Mitaru for their guidance, assistance, moral support, insights, patience, continued encouragement, understanding and constructive criticism during the course of this project.

As in any undertaking of this magnitude the efforts of many persons other than those of the supervisors and the PhD candidate make it possible for the task to be completed in time. To them all, I express my sincere and grateful appreciation.

I wish to express my gratitude and appreciation to my colleagues and friends, and especially Dr. C. O Bwanga and J. Katita, who assisted in the challenge trial, Drs K.M. Mbai, D.I. Karioki and M.D. Chibeu, who assisted in some aspects of data collection, Dr. R. Wahome who assisted in data entry and Prof. E. K. Kangethe and Drs. J. N. Kuria and C. K. Gachuiri who diligently and patiently read this thesis and gave constructive criticisms.

I wish to acknowledge the technical/material assistance received from the Director, Department heads and technical staff in: Ministry of Agriculture, Livestock Development and Marketing district and divisional offices, Veterinary Investigation Laboratories (Vetlabs), Kabete, Kenya Medical Research Institute (KEMRI), Kenya Agricultural Research Institute (KARI), Kenya Trypanosomosis Research Institute (KETRI) and Faculty of Veterinary Medicine (FVM), Kabete. I particularly wish to acknowledge the technical assistance of Muchiri and Sang (Microbiology, KEMRI), Muchene and Ndirangu (Diagnostic laboratory, VETLABS), Kaburia, Wimbia and Nduhiu (Public Health Pharmacology and Toxicology Department (PHPT), Kabete), Gitau and Wainaina (Animal Production, Kabete), Kibe and Njoroge (Pathology and Microbiology Department, Kabete), Moses Mbugua, Mzee Onyango, Martin Onyango, Ndungu, Nduhiu, Oduor, Nyongesa, Gitahi, Thuo, Kamukwa, Wamboi, Kiarie and Muraguri (Clinical Studies Department, Kabete).

I wish to record special thanks to the Director of Livestock Development for allowing me to use the data from Sheep and Goat Multiplication Centres country wide. The response and assistance of the station directors and technical personnel is also appreciated.

I wish to express very special thanks to Prof. P. Mbugua, the Chairman Animal Production Department, for taking me in as "a member of staff" and for allowing me to use departmental computer facilities extensively during this study. I wish to record my appreciation of technical assistance in computing given by Elizabeth Wainaina, John Gitau (of Animal Production Department) and Matere of PHPT.

I wish to express my deep-felt appreciation for the **understanding, encouragement and moral support provided by my wife Hilda Mantema Muchina Munyua, Sons Solomon Munyua Muchina and Fred Rico Onyari Munyua and daughter Felister Lista Huro Munyua**, and many family members and friends, throughout the study period.

And lastly, I wish to record my sincere thanks to **the German People and Government, who through DAAD Nairobi office** availed the fellowship.

ABSTRACT.

This thesis records the results of a study on the reproductive performance and wastage (reproductive efficiency) in indigenous goats in arid and semi-arid areas of Kenya, with special emphasis on pre-weaning mortality.

The study can be broadly divided into 3, including an initial slaughterhouse and field survey and an on-farm and on-station study. In the slaughterhouse survey reproductive tracts from both pregnant and non-pregnant does were collected over a 12 month period from a local slaughterhouse in Dagoretti, Nairobi and data on pregnancy, ovarian activity and genital tract pathologies recorded.

The field survey was undertaken in 14 purposefully selected goat producing districts over a 4 year period. During each field visit appropriate samples were obtained, the flocks scored and a questionnaire seeking information on salient features of biophysical characteristics of the study areas and goat production was administered.

The on-farm study, which was undertaken in 4 districts over a three year period, was aimed at establishing reproductive efficiency in goat flocks, with emphasis on economics of veterinary intervention and elucidating the factors determining the development of gastroenteritis. To complement the on-farm study and better understand the events of the early and delayed postnatal period that influence the viability of the kids born of vaccinated and non-vaccinated does were studied more closely.

From the slaughterhouse study, a clear pattern of ovarian cyclicity was observed with peak ovarian activity being between February (25%) and May (27%). This pattern was reflected in the two kidding peaks observed during the field and on-farm studies.

Of the 461 organs examined loss of conceptus, (maceration and mummification), made up less than 1% of the organs, whereas early embryonic death (EED), ranged between 4-25%, being highest in August (25%). Chronic purulent endometritis (pyometra), congenital malformations, structural abnormalities and functional infertility (cystic ovaries) were only occasionally encountered (<2%).

Uterine and vaginal swabs prepared from the slaughterhouse organs or parturient does showed that the does' genital tract postpartum may be contaminated with a wide range of bacteria including E. coli, Proteus sp. Pseudomonas sp., Streptococcus sp., Bacillus sp. and S. aureus. In comparison to cytology, however, positive bacteriology was considered to be a poor indicator of genital infection.

Producers and Departments of Animal Production and Veterinary Services personnel listed trypanosomosis, brucellosis, contagious caprine pleuropneumonia (ccpp)/pneumonia and a co-infection of streptothricosis and mange to be the main causes of abortion and infertility in does. They also listed hyperkeratinization of the scrotum with generalized alopecia due to either streptothricosis, mange, or trichophyton infection, physical testicular injuries, brucellosis, lameness and weakness after drought or trypanosomosis and orchitis of unknown etiology as the major causes of buck

infertility. The results of the clinical examination and serological screening, on the other hand, indicated that rift valley fever, leptospirosis, besnoitiosis and trypanosomosis, mainly due to T. vivax and T. congolese, in that order, though not listed by most respondents, were widespread.

The causes of postnatal losses identified during the field, on-farm and on-station studies and those reported by the Sheep and Goat Multiplication centres were similar differing only in the ranking. The causes included kids born weak and are unable to suckle (secondary starvation), gastroenteritis, pneumonia, helminthosis, flea, mange and lice infestation and fungal infections, heartwater and trypanosomosis. Parity and season of birth were the most important variables influencing the rate of postnatal deaths. The veterinary intervention package instituted during the on-farm study, at cost of between Ksh. 14.10-35.80 and Ksh. 24.55-439.90 /kid/season, reduced preweaning kid mortality to ≤5% (range 5-10%). Based on these results the intervention was considered to have been cost effective, practical and adaptable.

Of the kids confirmed, during the on-farm study, to have gastroenteritis characterized by diarrhoea, enteropathogenic E. coli, Streptococcus sp. and Staphylococcus sp. were the most frequent isolates. In comparison several bacteria species, including E. coli , Pasteurella sp., beta haemolytic Streptococcus, S. aureus and Proteus sp. were isolated from 15 lung samples from kids that had died of pneumonia during the on-farm and on-station studies.

Similar isolates, mainly S. aureus, A. pyogenes and beta haemolytic Streptococci, were isolated from udder secretions, (milk/pus), obtained from does with mastitis during the field and on-farm studies. Stress and external parasitic infestations were considered to be the most important determinants of postnatal respiratory and gastrointestinal infections.

In the present study no virus(es) or mycoplasma were isolated or observed on negative stained preparations from cases of gastroenteritis or pneumonia.

In the first three days postpartum serum IgG levels in vaccinated does ranged between 18,000 and 19,000mg/l, while the levels in colostrum, which were significantly higher, ($P<0.05$), ranged between 5,320 and 53,000mg/l. The levels in sera from non vaccinated does ranged between 6,000 and 19,000mg/l, while the levels in colostrum, which were significantly higher, ($P<0.05$), ranged between 4,000 and 45,000mg/l. The levels of IgG in colostrum of both groups fell to less than 25% by the third day postpartum.

Only traces of IgA were detectable in serum, colostrum and milk obtained from does during the on-farm and on-station studies.

Blood parameters of kids born of both vaccinated and non vaccinated dams before suckling were: a total protein (TP) of 36-9.0g/l, a packed cell volume (PCV) of 29-41%, a haemoglobin (HB) concentration of 10-13 mmol/l, a white cell count (WBC) of 2,500-800, while IgA, IgG and E. coli antibodies were not detectable. 12 hours postpartum kids born of vaccinated and non-vaccinated

dams had 19,460± 7,479.72mg IgG/l and E. coli antibody titre of 1/160-1/640, and 22,346.67± 7,885.70mg IgG/l and E. coli antibody of about 1/160 respectively. Blood parameters of kids in categories 3 and 4 righting reflex remained at the pre-suckling stage and they died in early postnatal period. At 2 weeks of age kids had an average TP level of 60.03± 6.9g/l (range 50.0-73.0g/l), IgG level of 41,460±10,061mg/l (range 26,000-56,000mg/l) and an E. coli antibody titre of 1:640 to 1:5,160. Only traces of IgA were observed in the same sera samples. At four weeks of age the TP and IgG levels in sera fell by about 10% while E. coli antibodies were undetectable. There were no significant differences ($P > 0.05$) in the TP and IgG levels in sera obtained from male and female kids. The levels of TP and IgG and E. coli antibody titre attained in serum after the eighth week of age were similar to those found in a pooled serum sample obtained from 5 pregnant dams.

Blood glucose levels at birth in under weight twins (800 and 900gm), were <2.0mmol/l while those of surviving twins and single kids were 4.9 and 5.3mmol/l. The levels of glucose in the underweight kids remained low till death and were closely related to the righting reflex.

In the present study the righting reflex, weight at birth, rectal temperature and blood parameters including TP, WBC and blood glucose levels at birth were found to be good prognostic indicators of kid viability. These prognostic indicators and the producer's production objectives and resource allocation priorities need to be assessed before an intervention package is instituted.

CHAPTER I

Introduction.

1.1.0 General introduction.

Reproductive efficiency in goats, which is a function of reproductive performance and wastage, is determined by many different processes which result from interactions between genetic and environmental factors (Shelton, 1977, Wilson, 1991). These processes, which may act singly or in concert, include the length of breeding season, ovulation and fertilization rate, placentation, embryo and fetal development and survival, viability and growth of the newborn (Shelton, 1977; Khatter and Mishra, 1977; McDowell and Bove, 1977; Sands and McDowell, 1978; Smith, 1978; Shelton, 1978, Sahni, 1979; Bliss, 1980, Karua, 1989, Wilson, 1991, Mwandotto et al. 1992). The net effect of these influences determines the level and efficiency of reproduction, and thus annual reproductive rate, at least in theory, may be improved by proper manipulation of these factors (Wilson, 1981; 1989, Carles 1986; Njanja 1991; Mwandoto et al. 1992, Munyua et al., 1995a; 1996a). Of critical importance while measuring the annual reproductive rate, however, is the actual number of kids weaned and reared to market weight/size as this is a true measure of reproductive efficiency and an indicator of the economics of production. The economics of an intervention package designed for use in goat producing areas in the arid and semi-arid areas of Kenya to reduce reproductive wastage and more so preweaning mortality, is yet to be established.

From the available literature conception rates are highest in does that are in good body condition at service and are bred 1-12 hours of standing heat (Rao and Bhattacharyya, 1980; Bliss, 1980; Wilson, 1991). In the event of a successful conception the length of the ensuing gestation, which lasts for between 144-151 days, can be, at least potentially, affected by the diseases, season, parity, age of the dam, sex of the conceptus and number of offsprings (Wilson, 1976; 1989; 1991; Peaker, 1978; Mishra et al., 1979; Bliss, 1980; Njanja, 1991; Suba et al.1991; Karua and Banda, 1992; Mwandotto et al. 1992; Karua et al. 1992a,b; Ndlovu, 1993).

The kidding interval, which is composed of the service period (kidding to conception) and gestation period (conception to parturition), is an important production trait in goats because of its effect on efficiency of production and reproduction. The interval also influences genetic improvement as it affects population turnover and selection pressure (Devendra and Burns, 1970; 1983; Haumesser, 1975; Quartermain, 1975; Carles, 1986; Blackburn and Field, 1986; Wilson 1989, 1991, Karua and Banda, 1992; Karua et al. 1992a,b; Ndlovu, 1993).

The service period, which varies between 4 and 210 days, is greatly influenced by fate of the newborn, breed, lactation and postpartum nutritional status (Sahni and Roy, 1967; Quartermain, 1975; Prasad and Bhattacharya, 1979a,b). Quartermain (1975) observed that does that lost their kids during the neonatal period had shorter inter-kidding intervals (180 days) than those that raised kids to at least one month of age (>223 days).

There is a wide variation in weights of kids at birth (2.0-3.9kg) depending on level of crossbreeding, breed, age of doe, parity, litter size, season of birth, level of nutrition and veterinary intervention (Blackburn and Field, 1986; Kimenye and Karimi, 1987; Njanja, 1991). The lack of sex differences and seasonal effects on birth weight reported in arid and semi arid areas of Kenya including Marsabit (Blackburn and Field, 1986) and Turkana (Njanja, 1991), contrasts sharply with reports of males being heavier than females at birth in high rainfall areas (Sidwell et al. 1964, Karua, 1989; Lebbie and Manzini, 1989).

Newborns of all domestic species are born without significant levels of gammaglobulins (agammaglobinaemia), and have to attain a minimum concentration of immunoglobulins in circulation to minimize the occurrence of perinatal diseases/conditions and mortality (Newby et al., 1979; Blood and Radostits, 1989; Vihan, 1993; Brenner, 1995). Failure to attain the necessary levels of immunoglobulins predisposes the newborns to severe infections and possibly death (Newby et al., 1979; Blood and Radostits, 1989; Satapathy et al., 1992; Vihan, 1993). Perinatal resistance of lambs and calves is further compromised by the fact that the high levels of corticosteroids, produced 8-10 days before parturition, results in lymphopaenia and a decrease in the phagocytic defense capability which depresses the cellular immune mechanisms (Cabello, 1979; Newby et al. 1979; Banks, 1982). Blood and Radostits (1989) proposed that the closure of the epithelium may have clinical importance in protecting the gut epithelium against pathogens. In

similar studies Vihan (1993) concluded that colostral anti-E. coli antibodies provided sufficient immunity for preventing collibacilosis in new born kids.

There is, however, a controversy as to the actual relationship between the levels of serum immunoglobulin in newborn farm animals at 24-48 hours of age and subsequent morbidity and mortality (Blood and Radostits, 1989; Vihan, 1993). This controversy is based on observations in some beef herds which indicate that levels of serum immunoglobulins in calves at 48 hours of age are of no value in predicting the incidence or severity of acute undifferentiated diarrhoea.

Working with cows, sows and does respectively Acres (1985), Nagy et al. (1985) and Vihan (1993) observed that it was possible to enhance the specific resistance of newborn to infectious diseases by vaccinating the dam during pregnancy. These workers showed that vaccinating dams with E. coli vaccine stimulated the production of specific colostral antibodies which provided specific protection against enteric pathogens.

Reproductive losses, from conception to weaning, are usually divided into early embryonic deaths, abortions, maceration, mummification, stillbirths, parturient deaths, pre-weaning and post weaning losses (Devendra and Burns, 1970; Ali et al., 1975; Emady, 1976, Blood and Radostits, 1989; Munyua et al. 1995a; 1996a; Karioki et al. 1996, Chibeu et al. 1996). The highest perinatal mortality rates have been recorded in the first 7-30 days postpartum (Mittal, 1976; Wilson, 1976; Rajan et al., 1976; Molokwu

and Igono, 1978; 1980; Adu et al., 1979; Figueiredo et al., 1980; Mazumdar et al., 1980; Riera et al., 1980; Riera, 1982; Karua, 1989; Morand-Fehr, 1991; Belay et al. 1994; Munyua et al. 1995a; 1996a; Karioki et al. 1996). Among the factors shown to influence the losses are nutrition of the dam, breed, litter size and birth weight (Amble et al., 1964; Quartermain, 1973; Vohradsky and Sada, 1973; Mittal, 1975; Munyua et al. 1995a; 1996a), age at first kidding and season (Ahmed and Tantawy, 1960; Devendra and Burns, 1970; 1983; Karua et al. 1992a,b), level of veterinary intervention (Omeke, 1988a,b; Karua, 1989; Munyua et al. 1996a) and diseases (Minet, 1950; Vohradsky and Sada, 1973; Kapur et al., 1974; Rajan et al., 1976; Mittal, 1975; Mazumdar et al., 1980; Maiga, 1992; Belay et al., 1994; Munyua et al., 1995a; 1996a,b; Karioki et al. 1996).

In the first section of this thesis (chapter 1), a review of the various production systems and biophysical characteristics of the goat producing areas are briefly described. And as the immune and nutritional status of the kid and the environmental conditions within the first weeks of birth determine the ability of the kid to survive, the defence mechanisms, predisposing factors and causes of preweaning mortality are dealt with in great details. In the last section of the literature review, the principles of on-farm studies, which were the basis on which the study was designed and undertaken, and the economics of livestock production are dealt with.

1.2.0. Objectives of the study.

The objectives of this study were to:-

1. Establish the reproductive performance and wastage in local goats, in arid and semi-arid areas with emphasis on prevalence, predisposing factors and causes of reproductive wastage, with emphasis on preweaning mortality.
2. Study closely the events of the early and delayed postnatal period to determine the survival of goat kids, with a view of suggesting appropriate prognostic indicators of kid viability.
3. Establish the costs and economics of possible veterinary interventions based on selected farms.
4. Suggest an economically feasible, easily adaptable and applicable flock health package for use by goat producers in arid and semi-arid areas, using results from objectives 1-3 above.

CHAPTER 2

Literature review.

2.3.0 Literature review.

2.3.1 Goat production in Africa.

2.3.1.1. Livestock production systems.

In Africa, it is possible to distinguish two major types of production systems - the traditional and "modern/commercial" systems. The two groups differ essentially in their use of the main factors of production, with traditional systems using mainly land and labour while modern systems also have large capital inputs (FAO 1989; 1991; 1993; Woie and Mavia, 1988; Woie and Kariuki, 1992).

2.3.1.1.1. Traditional production systems.

The two principal criteria that serve to define traditional production systems are; a) the degree of dependence of the household or the production unit on livestock or livestock products either for household income or for food supply and b) the type of agriculture practised in association with livestock production. The distance and duration of movement (transhumance, migration) might also be used to define systems and it is recognised that this is an essential aspect of management within some systems (Woie and Mavia, 1988; Wilson, 1991; Woie and Kariuki, 1992; FAO, 1989; 1991; 1993). Using these criteria a pastoral system is one in which more than 50 per cent of gross household revenue or more than 20 per cent of total household food energy is derived directly from livestock (Wilson, et al., 1983). The term "derived from livestock" in relation to revenue would also include the value of any draught

power or transport, sales or exchange of manure and direct or indirect income from any other functions (Wilson, et al., 1983, Oxyby, 1994). Using the same criteria an agro-pastoral (semi sedentary) system, is one in which between 10 and 50 per cent of household revenue is derived from livestock or livestock products. A third, production system - agricultural (crop production) which includes peri-urban livestock production, is the one in which revenue from livestock amounts to less than 10 per cent of the total (FAO, 1989; 1991; 1993; Wilson, 1991; Woie and Kariuki, 1992, Oxyby, 1994).

Within the pastoral production system, three major sub-systems can be identified including:- i) a pure pastoral system characterized by little or no agriculture and high mobility; ii) one associated with dryland or rainfed agriculture; iii) one that is associated with oases or with large irrigated areas (Woie and Mavia, 1988; FAO, 1989; 1991; 1993; Wilson, 1991; Woie and Kariuki, 1992, Oxyby, 1994).

1.3.1.1.2. Modern or commercial production in ranches.

The two principal criteria that serve to define commercial production system are; a) land ownership, and b) the level of resource input and allocation. Using these criteria two sub-systems are recognized, commercial and semi-commercial systems. A commercial system is one in which the land is owned/leased by an individual, company or co-operative. Ranches, which are market-orientated in their operations, rank high in terms of livestock sales, and especially beef cattle (Woie and Mavia, 1988; Woie and

Kariuki, 1992). Majority of company owned ranches are located in semi-arid areas (eco-zones 4 and 5) of Machakos, Laikipia, Taita-Taveta, Kwale and Kilifi districts, while most of the co-operative ranches exist today mainly in Machakos, Kitui, Taita-Taveta, Tana River, Kilifi, Lamu and Kwale districts (Woie and Mavia, 1988; Woie and Kariuki, 1992).

Group ranches are composed of sedentary or semi-sedentary pastoralists and some mixed farmers who own land as a group, under Group Ranch Representatives Act, loosely form the semi-commercial sub-system. Although initially designed for pastoralists in the Kajiado, Narok, Transmara and Samburu districts, group ranches have also evolved in some mixed farming rangelands of Kwale, Kilifi, Tana River, Lamu, Koibatek and Baringo districts (Woie and Mavia, 1988; Woie and Kariuki, 1992).

2.3.1.2. Goat population, products and by-products.

It has been estimated that tropical Africa contains one-third of all the world's goats, giving a density of one goat on every 10 ha or 1.1 head of goats per person employed in the agricultural sector (FAO 1989; 1991; 1993; ILCA, 1993). Goats and sheep are equivalent, in weight terms, to about 17 per cent of the total uminant biomass (TRB) of tropical Africa (FAO 1989, 1991; 1993; ilson 1991; ILCA, 1993).

Africa produces an estimated 1.5 million tonnes of meat and 99 million tonnes of milk, 228,000 tonnes of wool and 258,000 nnes of skins from both goats and sheep, the proportion of skins om goats being about 25% higher than that from sheep (FAO 1989,

1991; 1993; ILCA, 1993).

2.3.1.3. Rationale of adopting a particular production system and the associated economic importance of goats.

The reasons for livestock producers adopting a specific production system are often related to their particular short or long term needs. This hypothesis can be supported in regard to the age and sex structure of flocks, for irrespective of the objectives of the keeping of goats, there is always a preponderance of females in the flocks while minor differences in sex and age structure are maintained (FAO 1988; 1989; 1991; Wilson, 1991). In addition all animals in the flock are "productive" whether that production consists of breeding, providing wool or hair, producing milk and manure, or simply undergoing the process of growth to a size at which another product becomes the principal one. The observation that most tropical African goat flocks have 70-75% of the total as females and about 55% of the flock are does of breeding age and the fact that there are very few old females in the flocks (5%-10%) is an indication of rationality of their production decisions (Wilson, 1991).

The major management practice used to obtain this stability of structure is non-stratification of the flock and early culling, for sale or slaughter of males not required for other productive functions. Under certain circumstances the numbers of breeding bucks are occasionally in "excess" of those required but this may be an "insurance policy" against sterile and temporarily infertile males (FAO 1989, 1991; 1993; Wilson, 1991). Where breeding control

is required it is achieved by a variety of means including the 'kunan' (a piece of rope tied to the preputial sheath to prevent penile protrusion) in northern and western Africa and an apron placed just in front of the prepuce in eastern Africa.

In a modified traditional system among the Rendille in Kenya, in which veterinary medicines were provided, goats contributed 18% of the minimum calorific requirements (in meat and milk combined) of the human population, being surpassed only by camels (27%). Cereals and other sources made up 27% of the remainder of the diet. In this same Rendille system, goats provided 33 per cent of the maximum protein requirements even though protein availability was in excess of that required. In other regions of Kenya, goats accounted for about 75 per cent of the total meat consumption in pastoralist households (Schwartz et al., 1983). The supplies of milk, though minor in volume per doe, are often available during the most difficult periods of the year, the dry season, for pastoral producers. In addition the resumption of breeding in sheep and goats following drought guarantees food in the form of milk even before cereals can be harvested (FAO, 1989; 1991; 1993; Wilson, 1991). Thus it is important that the value of milk and manure, irrespective of whether the latter is deposited in the fields or at the night enclosure, be included in any calculations to establish the economics of goat production.

2.4.0. General biophysical characteristics common to most major goat producing areas.

2.4.1. Ecological types.

The type of livestock production system adopted in a given area is influenced by the annual rainfall and its effect on the main vegetational characteristics.

The arid zone, associated with pastoral production, includes all areas receiving less than 600 mm of rainfall per year. The zone has two major sub-zones. The first which has less than 200 mm of rain per year and no agriculture at all is possible outside a few oases or other irrigable areas, has Saharan type of vegetation. The second sub-zone has rainfall of 200-600 mm per year and is often called the Sahel zone in northern and western Africa. Some agriculture is possible but crop failures are frequent and yields are generally low as the coefficient of variation of rainfall is in the range 25-35 per cent (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992; FAO, 1993).

In the semi-arid zones, where the rainfall is between 600 and 1000mm per year, livestock raising is usually intimately associated with crop production. Vegetation is of the south-Sahelian or north-Sudanian type in northern and western Africa. In eastern and southern Africa the lightly forested 'Miombo' areas are part of this ecological zone. Rainfed millet (Pennisetum eleusine, Digitaria sp.) are the principal cereal crops but these are replaced by sorghum and maize where rainfall is better and where year to year variation is less. Some cash crops such as cotton and

groundnuts may be grown in the more favoured areas. The coefficient of rainfall variation is generally in the region of 20-25% (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992; FAO, 1993).

In Kenya arid and semi-arid areas comprise of three major agro-ecological zones, namely zones 4, 5 and 6. Zones 4 and 5 are considered to be the semi-arid areas while zone 6 is the arid region. The semi-arid areas have 500-800 mm of rainfall while the arid zone receives less than 500 mm of rainfall per year (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992, FAO, 1993).

In general, zone 4 is characterized by low to medium altitude of between 1300 to 1800 metres above sea level and a mean annual temperature of between 18-21°C. In comparison Zone 5 falls between altitude 800-1300 metres above sea level, with mean annual temperatures of between 21-24°C; while zone 6 falls between 0-800 metres above sea level with temperatures above 24°C. Zones 4 and 5 cover only about 75% and zone 6 about 25% of the arid and semi-arid areas of Kenya, respectively (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992, FAO, 1993).

The semi-arid areas (zones 4 and 5) in Eastern, North Eastern, Central and Coast Provinces, experience two modes of rainfall patterns during the year. Each rainfall season, which is not more than three months, receives between 250-400 mm which determines the effective season for which crops can be grown. Only drought-resistant or tolerant or early maturing crops can survive in these

areas. The other rainfall pattern, commonly found in some parts of the Rift Valley and Coast province, is the unimodal type which lasts for about 4-6 months. In these areas medium maturing crops can be grown (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992, FAO, 1993).

2.4.2. Natural vegetation of Kenya's arid and semi arid areas.

Two characteristic vegetation types found in the arid and semi arid areas of Kenya are the dry thorn-bushland, with acacia predominating in the Rift Valley and Western areas, and the commiphora woodlands in the eastern areas. The commiphora woodland occurs on red basement soils, and small areas of acacia woodland on deep alluvial soils, with tall Acacia tortilis, A. ethaica, A. albida and Balanities aegyptica. The baobab (Adansonia digitata) is important locally and several species of Acacia may occur, especially A. bussei and A. tortilis. The ground cover include several useful grasses and may be dominated by Panicums (P. deustrum, P. infestum and P. maximum) or by Chloris roxburghiana. Other grasses are Cenchrus celiaris, Digitaria spp., Enteropogon macrostachyus and Aristida spp. (Woie and Mavia, 1988; Woie and Kariuki, 1992)

Bushland and scrubland are very extensive in zone 5 and take many different forms. Bush grassland, shrub grassland and wooded grassland occur mostly as intermediates between bushland, scrubland, woodland and grassland, especially where grassland formerly maintained by fire is now under encroachment by woody species. Themeda-Acacia drepanolobbium wooded grassland is a more

stable type which occurs on black clay (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992).

Grasslands, though limited in extent, are varied and are often associated with soils of impeded drainage and flood plains, such as the Sporobolus helvolus seasonally flooded grassland restricted mainly to northern and eastern Kenya (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992).

The characteristic vegetation of the semi-desert area is annual grassland with or without dwarf shrubs. There may be an open scatter of large woody species such as Acacia reficiens, but dense stands develop only in depressions in the landscape or elsewhere on soils of impeded drainage. More widespread is dwarf shrub grassland, which is the characteristic vegetation type of the semi-desert zones, especially on basement soils. The commonest dwarf shrub is Indigofera spinosa, but Indigofera cliffordiana and species of Barleria, Duosperma, Heliotropium and Sericocomopsis also occur (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992).

2.4.3. Soils of arid and semi-arid areas of Kenya.

The soils in these arid and semi-arid areas vary from district to district and within the districts. Topography, a factor influencing the nature of the soils, includes large flat to lightly rolling areas. Additionally there are many hilly areas where slope ranges from mild, 3% to 7% up to steep slopes of 20% to 30%. Soil texture in the drylands cover the range from coastal sands to loamy sands in the hinterlands to stony loamy sands and red loams, clay

loams and even black cotton soils. The soils are relatively shallow with limited capacity to store water extractable by crops. Internal drainage structure of the soil is not well developed resulting in waterlogging and excessive water run-off losses during rainy periods. Lack of a well structured soil also means that soil particles are more easily dislodged and eroded. Altering the husbandry of the drylands from pastoral grazing to cultivation of annual crops greatly increases the exposure of the soil to this erosive process (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992; FAO,1993).

2.5.0. Breeding and reproductive performance in the doe.

2.5.1. Onset of puberty and age at first kidding.

The onset of puberty is often related to body weight, which depends on the level of nutrition, age, type of birth and the season of year the kids are born (Epstein and Herz, 1964; Singh and Singh, 1974; Sahni, 1979; Devendra and Burns, 1970; 1973; Vohradsky and Sada, 1973; Haumesser, 1975; Shelton, 1978; Sibanda, 1988; Karua, 1989; Ndlovu, 1993; Karua et al., 1992a,b). These authors showed that there was a relationship between body weight and age of the doe to the first standing oestrus or age at first kidding. But while these reports indicate that most breeds are pubertal between 5 and 10 months of age, they do not relate weight and age of the pubertal does to follicular activity and ovulation. It is important to recognize that the climatic environment, production objectives, nutrition and management conditions, including the presence of the buck, under which the measurements (onset of puberty) were made

could also have a significant influence on the results (Shelton, 1977; Sahni, 1979; Karua, 1989; Ndlovu, 1993; Mwandotto et al., 1992). It has been said that the tropical goat is non-seasonal in sexual activity and the doe kids also have this reproduction pattern and may present their first pubertal oestrus at any time of the year (Wilson, 1976). This worker observed that many goats were known to have kidded well before the eruption of their first pair of permanent incisors, though only a few gave birth to live and / or viable kids.

Age at first kidding, which is a response to age at puberty and post puberty fertility, is an important economic trait in goats and excellent reviews are available (Sacker and Trail, 1966a,b; Devendra and Burns, 1970; 1983; Gill and Dev, 1972; Raja and Mukundan, 1973; Vohradsky and Sada, 1973; Singh and Singh, 1974; Ali et al., 1975; Khatter and Mishra, 1977; McDowell and Bove, 1977; Sands and McDowell, 1978; Adu, et al., 1979; Bliss, 1980; Karua, 1989; Mwandoto et al. 1992; Ndlovu, 1993). These authors recorded age at first kidding to vary from 12 to 24 months, which indicated that the does were 7 and 19 months of age at conception. These authors re-affirmed the relationship between the age and body weight and the age at first kidding and their variation within breed(s).

Though the potential for improved reproductive efficiency increases as age at first kidding decreases, management practices are often introduced to delay mating in order to guarantee full body development of the female to increase conception rate,

frequency of multiple births and survivability of the offspring (Singh and Sengar, 1970). Shelton (1960a,b; 1977) and Wilson (1976) among others have suggested that breeding be delayed until the doe kids approached at least 75% of the adult body weight.

The age at first kidding within a breed could be shortened by imposing certain management practices in terms of kidding season, nutrition and disease control (Epstein and Herz, 1964; Devendra and Burns, 1970; 1983; Sands and McDowell, 1978, Morand-Fehr, 1991; Bosman and Ayeni, 1993; Ndlovu, 1993).

The mean age at first parturition quoted for the Turkana area is 18.3 ± 4.3 (n=7) months (Njanja, 1991), while that for Maasai goats was 18.5 months (Wilson, 1981). In these areas this age is just after the eruption of the first pair of permanent teeth. From the available data, it is apparent that fertile ovulation and conception among the Turkana and Maasai goats occurs at the age of 11-13 months. Similar findings have been reported in Uganda (Sacker and Trail 1966a,b), Mali (Wilson, 1981), Ghana (Molokwu and Igono, 1980), Malawi (Karua and Banda, 1992), Zimbabwe (Ndlovu, 1993) and Tanzania (Belay *et al*., 1994).

While the influence of type of birth on age at first kidding is yet to be completely elucidated, Ali *et al*. (1973) and Singh and Singh (1974) observed that does born as singles kidded earlier than those born as twins.

.5.2. Breeding season, oestrous cycle and oestrus period.

The onset and length of the breeding season is primarily the result of genetics and environmental interactions with nutrition

and climatic factors such as rainfall and temperature playing a major role in influencing parturition intervals and onset of puberty (Devendra and Burns, 1970; 1983).

Reduced variation in photoperiod and perhaps other climatic factors in the equatorial, tropical and sub-tropical regions results in extended periods of breeding including continuous, year round sexual activity in both goats and sheep (Devendra, 1962, Amble et al., 1964; Hofmeyer, et al., 1965; Vohradsky and Sada, 1973; Haumesser, 1975; Khatter and Mishra, 1977 and Simplicio et al., 1982a,b). According to these authors, even under these environmental conditions, there are variations in frequency of kidding, resulting in one or more peaks within the year.

In temperate zones, the goat behaves as a seasonal breeder showing a definite anestrous period due to the influential changes in photoperiod (Phillips et al., 1943; Gill and Dev, 1972; Corteel, 1968; 1975; 1977; Shelton and Spiller, 1977; Shelton, 1978). Under these conditions, proper management of the introduction of the male can be used to slightly hasten the initiation of the breeding season and also synchronize oestrus among the does involved (Shelton, 1960b; 1978; Ott, 1980; Bliss, 1980). Sands and McDowell (1978) and Rajkonwar and Borgohain (1978) observed that if a breed is translocated from temperate to tropical zones it becomes a continuous breeder.

The duration of the oestrous cycle and oestrus are well documented and indicate an extreme variation from cycles as short as three days to cycles as long as 62 days (Shelton, 1961a; Mutiga

and Ogaa, 1977; Sands and McDowell, 1978; Bhattacharyya et al., 1981; Simplicio et al., 1982a,b). Some of these variations have been thought to be related to seasons of kidding and periods postpartum while some appear to be due to ovulation with oestrus. The majority of the oestrous cycles, however, are 19-21 days in length (Prasad and Bhattacharyya, 1979a,b). These workers, among others, also observed that the length of the oestrous cycles in multiparous females is shorter than those of primipara or biparous and that oestrous cycles were significantly shorter in extremes of weather.

The oestrus period, which varies between 22-36 hours, also appears to be variable in length and the literature has abundant information on oestrus by breed type country, season, months and age (Shelton, 1961a,b; Mishra and Biswas, 1966; Devendra and Burns, 1970; Salama, 1972; Pretorius, 1973; Shelton and Groff, 1974; Grobler, 1974; McDowell and Bove, 1977; Simplicio et al., 1982a,b).

Great care should, however, be exercised in evaluating data reporting the length of the oestrus period because of the varied nature of techniques (and frequency) used to detect oestrus.

2.5.3. Ovulation rate and timing of insemination or service.

Ovulation rate refers to the number of ova released from the ovary(ies) at a given oestrus period. Estimates of ovulation rate vary greatly particularly with the genotype (Epstein and Herz, 1964; Moulick et al. 1966; Sudarsanan and Raja, 1974; Singh and Singh, 1974; Haumesser, 1975; Mani et al., 1992). Ovulation rates of between 1.03-1.63 in ovaries collected from pregnant goats in

slaughterhouses have been reported by Shelton (1960a) and Lyngset (1968), while Rao and Bhattacharyya (1980) found an ovulation rate of 4.0 using laparoscopy. Ovulation rate appears to be higher from the right than from the left ovary (Lyngest, 1968; Gonzales, 1977; Mani et al. 1992). These authors reported that the right ovary was more functional than the left one (55 and 45%, respectively) while the right horn accommodated 63% of the embryos compared to 37% in the left, indicating migration of fertilized eggs to the opposite horn.

It has been reported that ovulation occurs 24-103 hours after the onset of oestrus and that does should be inseminated 1-12 hours after she allows mounting by gomer buck as ovulation occurs a few hours after the termination of standing oestrus (Harrison, 1948; Gonzales, 1977; Corteel, 1977; Sahni, 1979; Rao and Bhattacharyya, 1980; Bliss, 1980) after the onset of oestrus (Devendra and Burns, 1970; 1983; Steele, 1996).

2.5.4. Services per conception and the gestation period.

Detailed information on the number of service(s) per pregnancy in does is scanty. Sahni and Roy (1967) reported higher conception rates in goats bred during the middle and last stages of oestrus compared to the early stage. Though based on a relatively small number of observations, their findings on the timing of artificial insemination were in agreement with those by other workers (Jardim et al., 1965; Sahni and Roy, 1967; Ali et al., 1975, Rahman et al., 1977; Corteel, 1977; Riera et al. 1980; Devendra and Burns, 1983). The workers reported that services per conception varied between

1.2 and 2.3. It is important, however, that the potential differences due to methods used, management and environmental conditions among studies reported be recognized when comparing these and similar reports.

The gestation period, which may be defined as the period from conception to parturition, can be, at least potentially, affected by the season, parity, age of the dam, sex of the conceptus and number of offsprings. A large body of data is available in the literature indicating that the length of the gestation period varies from 144 -151 days (Asdell, 1929; Arriola, 1936; Shelton, 1960b; Gupta et al., 1964; Jardim et al., 1965; Gill and Dev, 1972; Wilson, 1976; Peaker, 1978; Mishra et al., 1979; Bliss, 1980; Karua and Banda, 1992; Suba et al. 1991).

Several workers have shown that there were no significant differences in the length of the gestation period between breeds, post kidding weight of dam, the type of birth (including the number of fetuses) or weight of the kids at birth (Asdell, 1929; Mishra et al., 1979; Karua and Banda, 1992; Suba et al. 1991). However, the correlation of gestation length with weight of the kid at birth and weight of the does at service were highly significant (Arriola, 1936; Mishra et al., 1979).

There is contradicting information on the effect of season and age of the dam on the gestation length. Mishra et al. (1979), in contradiction with earlier findings by Asdell (1929), concluded that the season of kidding did not affect length of gestation. Other reports by Wilson et al., (1983) and Ngowo (1989) also

contradicted findings by Asdell (1929) who had observed that the age of the dam, but not the order of the parities, influenced gestation length, with young female goats having shorter pregnancies than older ones.

2.5.5. Kidding rate (litter size).

Several workers have, over the past years, established that differences in litter size, (kidding rate or prolificacy), occur within and between breeds (Amble et al., 1964; Sands and McDowell, 1978; Riera et al., 1980) and between seasons (Amble et al., 1964; Vohradsky and Sada, 1973). In contrast, however, reports on the effects of season on multiple births have, however, not been consistent. Amble et al. (1964), working with Beetal goats, and Prasad and Bhattacharya (1979a,b), working with Barbari goats, observed a higher incidence of multiple births in winter (59.03%) than in summer (45.60%).

The mean litter sizes in arid and semi-arid areas of Kenya have been observed as being 1.01 ± 0.1 (Wilson, 1981; Carles, 1986; Blackburn and Field, 1986). Similar studies in traditionally managed farms in arid areas of Malawi (Reynolds, 1979; Karua, 1989) and Swaziland (Lebbie and Manzini, 1989) recorded litter sizes of 1.38 and 1.18 respectively. Wilson (1989) observed that does in the more arid regions appeared to produce smaller litters than those in humid zones. The author, (Wilson, 1989), argued that in these environments, single births had an advantage over twins since the milk produced did not have to be shared. The author implied that it was possible that natural selection against this trait has taken

place.

In the present climate of economic liberalization, it is important to observe that although prolificacy or kidding rate is a useful indicator of reproductive performance, the actual number of kids weaned and reared to market weight/size is of greater practical importance in measuring productive or reproductive efficiency in all the small ruminants.

2.5.6. Service period and the kidding interval.

The service period, the interval between two consecutive parturitions and the first postpartum oestrus, is an important trait which contributes greatly to the reproductive and productive efficiency in goats. The shorter the service period the earlier she can be bred and conception can occur, the shorter is the kidding interval and the more efficient the reproductive performance. The service period varies between 4-6 days to 41-210 days or more depending on the breed, lactation and nutritional status (Sahni and Roy, 1967; Prasad and Bhattacharya, 1979a,b; Devendra and Burns, 1983; Suba et al. 1991; KARI/ODA, 1996; Munyua et al. 1995a; 1996a).

On the other hand the kidding interval (inter-kidding interval), which can be defined as the period between two consecutive kiddings, is composed of the service period (period from kidding to conception) and gestation period from conception to parturition (Devendra and Burns, 1970; 1983). The kidding interval is an important production trait in goats because of its effect on efficiency of production and reproduction. The kidding interval

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also affects genetic improvement as it affects population turnover and selection pressure. This interval varies between and within breed, age of doe, parity, level of lactation, kidding rate, season of year and the level of nutrition (Devendra and Burns, 1970; 1983; Raja and Mukundan, 1973; Haumesser, 1975; Quartermain, 1975; Wilson, 1989; Maiga, 1992).

In Kenya the mean inter-kidding interval has been reported to be 344.2 ± 117 days for Turkana (Njanja, 1991), 230-406 days for Kajiado (Wilson, 1989), 442 days for Kor, Marsabit (Carles, 1986) and 350 days for Marsabit (Blackburn and Field, 1986). While undertaking similar studies Quartermain (1975) observed that does that lose their kids during the neonatal period had shorter interkidding intervals (180 days) than those that raised kids to at least one month of age (> 223 days).

There are conflicting reports on the effect of cross breeding of European and tropical types of goats on the kidding interval (Raja and Mukundan, 1973; National Dairy Research Institute, 1976). Reports from India indicated that kidding intervals of 382, 304 and 368 days for the Alpine, Beetal and Alpine X Beetal does respectively (Raja and Mukundan, 1973; National Dairy Research Institute, 1976). It is possible that the variations observed were due to the differences in ages of the dams, parity and treatment at the time of study and/or nutritional status (Riera, 1982; Devendra and Burns, 1970, 1983; Njanja, 1991; Suba et al., 1991; Karua and Banda; 1992).

2.5.7. Weight at birth and the sex ratio.

In Kenya the mean kid birth weights reported for Turkana were higher (2.0 ± 0.3kg) for anthelmintic treated dams than for non treated dams (1.8 ± 0.4) (Njanja, 1991). The recorded birthweights for Turkana goat kids were lower than those reported for Marsabit (2-2.4 kg) (Blackburn and Field, 1986) and Mbirikani, Kajiado (2.5 kg) (Kimenye and Karimi, 1987), this probably being a reflection of the breed, level of cross breeding, nutritional status of the dams, average age and parity of the sampled does. The lack of sex differences and seasonal effects on birth weight reported under arid and semi-arid conditions in Marsabit (Blackburn and Field, 1986), Mbirikani, Kajiado (Kimenye and Karimi, 1987) and Turkana (Njanja, 1991) contrast sharply with reports of males being heavier than females at birth from more favourable environments (Sidwell et al., 1964, Karua, 1989; Lebbie and Manzini, 1989).

When assessing reproductive efficiency and breeding in populations, increased frequency of the desirable sex helps in maximizing the reproduction index for genetic gain by enhancing the intensity of selection. Despite attempts by many workers to separate sperms to modify sex ratio, the sex ratio did not deviate significantly from 50 percent (Moulick et al., 1966; Mukundan and Rajagopalan, 1971; Prasad and Bhattacharya, 1979a,b; Mishra et al., 1980; Devedra and Burn, 1983). These workers also showed that breed and season had no significant effect on the sex ratio.

2.5.8. Milk Production.

The importance of goat in a pastoral livestock production system is through does that have a "secondary lactation" comprising of does with kids or weaners which have completed a primary lactation in the previous dry season, returning to milk secretion in the wet season, presumably in response to ample forage and the stimulation through milking to meet human requirements for milk.

Marginal increases in milk yields were observed during the dry season following deworming (Carles, 1986; Carles and Schwartz, 1991). These workers, however, implied that the observed increment was not significant due to either the small sample sizes, lack of adjustments on parity, previous lactations and/or precise durations of measurements.

The mean daily milk yields reported by Njanja (1991) and KARI/ODA (1996) differed between years in wet and dry season lactations, with maximum mean peak yields of 298.6 ± 46.3 ml (n=14) and 326.8 ± 143.3 ml (n=12) being observed in non-treated and anthelmintic treated does, respectively during the dry season lactations, and a maximum mean peak yields of 865.0 ± 21.2 ml (n=2) and 624.0 ± 481.4 ml (n=5) being observed in non-treated does, respectively during wet season lactations. The peak yields were followed by a gradual decline during dry season (Njanja, 1991).

2.5.9. Annual reproductive rates.

The annual reproductive rate, which can be improved by manipulating reproductive traits contributing to it, including the age at first kidding, litter size, kidding interval, level of

abortion and numbers of barren does, is greatly influenced by the local climate, environmental conditions and the existing production system. The rates observed in most studies, however, would have been much lower if adjustments for abortions and barren females were made (Wilson, 1981; Carles 1986; Wilson, 1989; Njanja, 1991).

2.6.0. Reproductive wastage - Perinatal and preweaning diseases and preweaning kid mortality.

2.6.1. Perinatal and preweaning diseases and conditions.

To reduce the confusion in the classification of diseases and conditions of the neonatal and pre-weaned kids, Blood and Radostits (1989) suggested that they be divided into fetal, parturient and postnatal diseases. These workers suggested that postnatal diseases be subdivided into early (within 48 hours), delayed (2-7 days) and late post natal disease (1-4 weeks of age). These authors described: **fetal diseases** as those that affect the fetus during intrauterine life, for example, prolonged gestation, congenital defects, abortions, fetal death with resorption, mummification or maceration and goitre; **parturient diseases** as those associated with dystocia causing cerebral anoxia, injury to the skeleton or soft tissues; and **postnatal diseases** as those that occur within 48 hours (early-parturient), or within 2-7 days (delayed) or within 1-4 weeks (late). These authors ascribed the diseases/conditions that occur within 48 hours of birth (early) to poor mothering, hypothermia due to exposure to cold, low vigour in neonates due to malnutrition and specific diseases such as navel-ill or collibacillosis. They ascribed the diseases/conditions classified

under delayed postnatal diseases including kids that die due to starvation and increased susceptibility to collibacillosis, pneumonia and septicemia, to hypogammaglobulinemia. Blood and Radostits (1989) suggested that enterotoxeamia which occurs at 1-4 weeks be considered to be a late postnatal disease.

2.6.2. General epidemiology of neonatal diseases/conditions.

Diseases of the newborn and neonatal mortality are a major cause of economic loss in livestock production and every practical and economically viable effort should be made to minimize disease and mortality (Blood and Radostits, 1989, Munyua *et al*., 1995a,b; 1996a,b).

Considerable interest centres on the question of whether some infections of the newborn occur before, during or after birth (Beaver, 1980; Blood and Radostits, 1989). It has been argued that if the disease or condition is contracted intrauterine then infection must gain entrance via the placenta (transplacental), while if the disease or condition is postnatal the portal of entry may be through the navel or ingestion - *per os*. The presence of lesions in the fetus at birth, as in leptospiral abortion in pigs, *Actinomyces equi* and *E. coli* infections in foals and streptococcal gastroenteritis in kittens, is additional evidence that the infection in newborns most likely gained entrance during intrauterine life or parturition (Beaver, 1980; Blood and Radostits, 1989).

The sequel of events after intrauterine infection is dependent on the age of the conceptus, the virulence of the infecting agent,

immune status of the dam and conceptus. While intrauterine infections are commonly associated with death of the dam or fetus, or with abortion, infection of a bovine fetus aged 45-125 days with bovine viral diarrhoea (BVD) virus can result in immunotolerance and birth of a clinically normal calf, which may develop fetal mucosal disease at 6-8 months of age or older (Blood and Radostits, 1989).

2.6.3. Resistance to infection.

2.6.3.1. The role of maternal antibodies.

Newborns of most domestic animals including calves, lambs, piglets and foals are born without significant levels of gammaglobulins (Blood and Radostits, 1989). The age at which the fetus becomes immunocompetent varies from species to species (Acres; 1985; Blood and Radostits, 1989).

It has been shown that lambs can respond to some antigens as early as 41 days (Acres, 1985). This worker also established that some lambs were not capable of responding to the same antigens until day 120. Piglets (Bourne et al., 1974; 1978, Newsby et al., 1979) and foals (Perryman et al., 1977), on the other hand, were shown to respond to antigens at 55 days. In addition Perryman et al. (1977) demonstrated that normal foals are immunocompetent at birth but have little or no immunoglobulin G (IgG). Davidson et al. (1981), Blom (1982), and Corbeil et al. (1984), demonstrated that morbidity and mortality rates due to infectious diseases of the intestines and respiratory tract are significantly higher in calves with low levels of serum immunoglobulin than in those with adequate

levels. Similar observations have since been made in goat kids (O'Brien and Sherman, 1983a,b; Rowan et al. 1994; Constant et al. 1994; Brenner, 1995). Hauser (1986) observed that the high levels of corticosteroids, produced by lambs and calves 8-10 days before parturition, resulted in lymphopaenia and a decrease in the phagocytic defense capability in the newborn which may affect the cellular immune mechanisms thereby decreasing perinatal resistance.

2.6.3.2. Transfer of passive immunity.

The transplacental transfer of immunoglobulins does not occur in calves, lambs, piglets and foals except for rare occasions in the mare which results in a foal with isoimmune haemolytic anaemia in foals. Immunoglobulins are rapidly absorbed over a wide area between the duodenum and the small intestines within the first 24 hours of birth with peak absorption being at 6-8 hours (Newby et al. 1979; Blood and Radostits, 1989). The rate of absorption of immunoglobulin depends on the amount of colostrum fed, how soon it is fed, the ambient temperature (Jeffcott, 1974; 1975) and whether the newborn was single or twins (Blood and Radostits, 1989; Rabbani et al., 1990; Sherman et al., 1990). The role of the type of birth (single or multiple) may be based more on physical properties such as the righting reflex and the ability to suckle rather than an inherent advantage possessed by single kids.

Jeffcott (1974; 1975) and Blood and Radostits (1989) reported that goat kids continue to absorb immunoglobulins for upto 4 days postpartum, piglets for upto 12 days and lambs for 24-48 hours. These workers showed that absorption in lambs is diminished by 15

hours, while in pigs it is markedly reduced between 12-27 hours but may occur upto 3 days. In comparison absorption terminates in about 24 hours in the foal (Jeffcott 1975; Blood and Radostits, 1989). Blood and Radostits (1989) theorized that the closure of the epithelium may have clinical importance in protecting the gut epithelium against pathogens.

Working with the mare and sow, McGuire and Crawford (1973) and Snodgrass, (1986) respectively established that immunoglobulins are absorbed to produce similar concentrations in the offspring(s') serum as that in the dam's within 24 hours. In comparison serum immunoglobulin levels in goat kids produced similar concentrations in 48 hours (Rabbani et al. 1990; Sherman et al., 1990; Constant et al. 1994). While working with the sow Bourne et al. (1974; 1978) and Snodgrass (1986) observed that colostral IgG fell rapidly in the first few days of birth, while those of IgA fall only slightly to become the major immunoglobulin in the sows milk. Thus IgA, which is synthesized locally in the mammary gland tissue in the sow, is the most important mucosal defence mechanism in pigs. This contrasts sharply with he situation in kids, calves and lambs, where there is little IgA and its role is taken over by colostral and milk IgG derived from serum and antigen stimulus in the intestines (Bourne et al., 1974; 1978; Rabbani et al., 1990; Sherman et al., 1990; Vihan, 1993; Rowan et al., 1994; Constant et al., 1994; Munyua et al., 1996a).

It has been observed that colostral immunoglobulins present in the intestine prevent the establishment of enteric diseases, while

circulating immunoglobulins are necessary for the protection against septicaemia. The latter do not prevent diarrhoea as they do not reach the lumen of the intestine in protective amounts (Blood and Radostits, 1989). In comparison colostral antibodies were observed to exert a protective effect on newborn kids against the establishment of collibacillosis (Vihan, 1993). Villouta et al. (1980) concluded that high serum levels of IgG and IgA, while not preventing the establishment of diarrhoea, reduced the severity of such infections by preventing massive outpouring of fluids and electrolytes into the intestinal lumen.

2.6.3.3. Decline of passive immunity.

Passive antibody levels fell rapidly (to <50%) 6-8 weeks after birth, and had disappeared in most domestic animals by 6 months of age (Jeffcott, 1975; McGuire et al., 1976; Snodgrass, 1986; Constant et al., 1994; Munyua et al., 1996a). From these studies, it was apparent that while immunological competence is present in most domestic animals at birth the endogenous antibody production does not usually reach protective levels until one month (and maximum levels until 2-3 months) of age.

Kids with failure of passive transfer of immunity have been shown to have a total protein level of ≤54.0g/l and IgG concentration of <12,000mg/l) (Satapathy et al., 1992, O'Brien and Sherman, 1993a;b). In comparison foals with failure of passive transfer of immunity have been shown to have a total protein level of 40.0-86.0g/l (cf normal foals 84.0-130.0g/l) while calves which have not ingested and absorbed sufficient immunoglobulin are

hypogammaglobulinaemic and have a total protein level of <40.0g/l of serum (Blood and Radostits, 1989). Such hypogammaglobulinaemic newborns have been observed to be highly susceptible to infectious diarrhoea and pneumonia and secondary starvation. In addition it has been established, at least in calves and kids, that immunoglobulin deficiency cannot be easily or economically corrected (Sawyer et al., 1977, Blood and Radostits, 1989; Munyua et al., 1996a,b).

A post-suckling kid serum IgG levels of less than 7,500mg/l is indicative of failure of passive transfer; those levels of 12,000mg/l as being indicative of partial failure and levels of >16,000mg/l representing adequate transfer (Satapathy et al., 1992; O'Brien and Sherman, 1993a;b). In comparison post-suckling foal serum IgG levels <2,000mg/l is indicative of failure of passive transfer; those levels between 2-4,000mg/l as being indicative of partial failure and levels of >8,000mg/l representing adequate transfer (Sawyer, et al. 1977; Blood and Radostits, 1989). These authors defined partial failure of passive immunity as being one standard deviation (SD) below the normal mean and failure as two SD below the normal mean at 24 hours after birth.

There is, however, controversy as to the actual relationship between the levels of serum immunoglobulins in newborn farm animals at 24-48 hours of age and subsequent morbidity and mortality (Bradley et al., 1979; Blood and Radostits, 1989; Satapathy et al., 1992; Vihan, 1993; O'Brien and Sherman, 1993a;b). This controversy is based on observations in some beef herds which indicate that

levels of serum immunoglobulins in calves at 48 hours of age are of no value in predicting the incidence or severity of the acute undifferentiated diarrhoea (Bradley et al., 1979).

2.6.4. Increasing specific resistance to infection in the newborn.

It has been observed that it was possible to enhance the specific resistance of newborn to infectious diseases by vaccinating the dam during pregnancy (Acres, 1985; Nagy et al., 1985, Vihan; 1993). These workers showed that vaccinating cows and sows, respectively, with E. coli vaccine stimulates the production of specific colostral antibodies which provide specific protection against enteric pathogens. In similar studies Snodgrass (1986) showed that combined vaccines containing E. coli and rotavirus given to pregnant cattle provided protection against diarrhoea in calves caused by the two enteropathogens.

2.6.5. Perinatal and preweaning kid mortality.

Perinatal kid losses, which can be divided into early embryonic, fetal and pre-weaning losses, is one of the major factors of impairment of productivity in goat raising areas around the world (Datta et al., 1963; McDowell and Bove, 1977; Adu et al., 1979; Karua, 1989, Morand-Fehr, 1991, Mani et al., 1992; Munyua et al., 1995a; 1996a,b; Karioki, et al., 1996).

2.6.5.1. Early embryonic death.

There is considerable evidence that fetal losses in the form of resorption or atrophy occurs in females of all species (Emady, 1976). The diagnosis of early embryonic death or failure of fertilization is usually based on the discrepancy in the number(s)

of ova shed (number of corpora lutea) and the number of fetuses found in utero (Emady, 1976; Morand-Fehr, 1991, Mani et al., 1992; Munyua et al., 1995a; 1996a,b). Based on this criteria Munyua et al. (1995a; 1996a,b) recorded a 2-25% early embryonic death while Emady (1976) reported that out of 26 specimens examined there were two ovulations in three, and triplet ovulations in one, but in each case only one fetus was present.

2.6.5.2. Preweaning kid mortality.

Preweaning kid losses are usually divided into parturient and early and late postnatal losses (Devendra and Burns, 1970; 1983; Blood and Radostits, 1989). Workers from various parts of the world have shown that mortality rate is highest in the first 30 days postpartum (Ali et al., 1975; Mittal, 1976; Adu et al., 1979; Figueiredo et al., 1980; Mazumdar et al., 1980; Gachuiri et al., 1986; 1988; Karua, 1989).

Preweaning mortality rate in goats varies greatly in pastoral societies; Sacker and Trail (1966a,b) reported 45.3%, Wilson (1981), 22% and Dahl and Hjort (1983), 30%. The differences in the observed preweaned mortalities, are most likely due to qualification of preweaned mortalities, which under certain definitions e.g. deaths immediately after birth (before suckling) tend to result in reduction of reproduction potential of goats (Njanja, 1991; Munyua et al., 1996a, Karioki et al., 1996). The other source of difference is due to the fact that percent preweaning mortality can be expressed as crude mortality rate (a fraction of the total number of goats in the flock - % kids dead in

a flock) or age-specific mortality (number of kids born in that season - % kids dead among kids born). Irrespective of the expression used, however, preweaning mortality is highest in first seven days of birth (Ali et al., 1975; Riera et al., 1980, Devendra and Burns, 1983; Belay et al., 1994; Karioki et al., 1996; Munyua et al., 1995a; 1996a,b)

2.6.6. Factors affecting preweaning mortality.

2.6.6.1. Effect of weight at birth, dam's age at first kidding and type of birth.

Birth weight has been reported to be one of the most important factors affecting viability of kids (Amble et al., 1964; Vohradsky and Sada, 1973; Mittal, 1976, Karua, 1989; Ngowo, 1989, Morand-Fehr, 1991; Belay et al., 1994; Munyua et al., 1995a; 1996a,b). These workers showed that as birth weight decreases, the mortality rate increases. Mittal (1976) reported that the average birth weights of Barbari and Jamnapari kids were 2.0 and 3.50 kgs, respectively, while the mortality rates for kids that were lighter than the breed average, were 24 and 38% respectively. On the other hand, the kids that were heavier than the breed average had mortality rates of 6.6 and 9 percent for Barbari and Jamnapari, respectively. These, and results from similar studies, re-emphasize the practical application of selecting for birthweight as a means of reducing kid mortality (Ahmed and Tantawy, 1960; Amble et al., 1964; Ali et al., 1975; Riera et al., 1980; Gachuiri et al., 1986; 1988; Kimenye and Karimi, 1987; Karua, 1989; Ngowo, 1989, Morand-Fehr, 1991; Belay et al., 1994; Munyua et al., 1995a; 1996a,b).

The age at first kidding was an important factor in determining kid mortality (Ahmed and Tantawy, 1960; Devendra and Burns, 1970; Riera et al., 1980; Wilson et al., 1983; Karua, 1989; Ngowo, 1989, Morand-Fehr, 1991, Karua and Banda, 1991; Suba et al., 1991). These workers observed that does at first kidding usually produced kids with lower birth weight than at subsequent kidding and that the inexperience of the does to rear kids also contributed to higher mortality rates.

When litter size was considered, ignoring the other limiting factors, the single kids (with heavier weight) had a higher survival rate than lighter weight twins or triplets (Amble et al., 1964; Ali et al., 1975; Riera et al., 1980; Wilson et al., 1983; Karua, 1989; Ngowo, 1989, Morand-Fehr, 1991, Karua and Banda, 1991; Suba et al., 1991). Their observations have not been contradicted to date.

2.6.6.2. Effect of year, season and breed.

Variation in kid mortality exists among and within years and seasons (Ahmed and Tantawy, 1960; Amble et al., 1964; Rajan et al., 1976; Adu et al., 1979; Mazumdar et al., 1980; Devendra and Burns, 1983; Ngowo, 1989; Karua, 1989). Many causes of the seasonal variations in kid mortality are mainly environmental, although other factors such as breed, may play a role and must be taken into account (Ali et al., 1975; Mittal, 1976; Ngowo, 1989; Ndlovu, 1993).

In most goat producing areas the maximum kid mortality was recorded during the rainy period and the minimum during the dry

season (Vohradsky and Sada, 1973; Wilson, 1976; Mazumdar et al., 1980, Karua, 1989; Njanja, 1991). Vohradsky and Sada (1973), Ali et al. (1975) and Wilson (1976) argued that since humidity is highest during the rain season, it is possible that there is some relationship between these factors (rainfall, temperature and humidity) and mortality rate.

In India, Gill and Dev (1972) observed that mortality of kids from imported French Alpine and Anglo Nubian females was high (45-53%). In comparison Karua and Banda (1992) did not observe any significant differences in mortality rates of Saanen x local crosses and local Malawi goats, which were 22% and 21% respectively. On the other hand, Vohradsky and Sada (1973), and Quartermain (1975) reported that neonatal mortality in goats averaged 24% and 21% prior to three months of age in West African Dwarf and Zambian goats respectively. In Kenya neonatal mortality of between 20-70% has be recorded for both Small East African and Galla goats (Carles, 1986; Gachuiri et al., 1986; 1988; Njanja 1991; Karioki, et al., 1996; Munyua et al., 1995a; 1996a,b). Rajan et al. (1976) reported kid mortality of 44% from birth to the third month, 13% from three to six months and 43% in kids older than six months of age based on total deaths registered. It is important that data on the effect of breed on mortality be translated with caution as it is difficult to clearly differentiate the effects purely due to climate, management, nutrition and/or diseases and those inherent to the breed.

2.6.6.3. Effect of disease and the influence of veterinary intervention.

Disease is a very important factor in kid mortality and 18 diseases have been diagnosed and incriminated as having caused kid mortality (Minet, 1950; Vohradsky and Sada, 1973; Kapur et al., 1974; Rajan et al., 1976; Mittal, 1976; Mazumdar et al., 1980). From a list of diseases, gastroenteritis, pneumonia and coccidiosis were considered to be the major ones by the authors.

Many suggestions have been given on the management of does during pregnancy, the management of kids at birth and from birth to weaning in an attempt to lower kid mortality (Datta et al., 1963; Sacker and Trail, 1966a,b; Riera et al., 1980; Morard-Fehr, 1991; Maiga, 1992; Carles, 1986; Gachuiri et al., 1986; 1988; Njanja 1991; Karioki, et al., 1996; Munyua et al., 1995a; 1996a,b).

The impact of veterinary intervention packages including vaccinations against common goat diseases such as pasteurellosis, anthrax and pestes des petits ruminant (PPR), and external and internal parasite control have had some mixed results (Traore and Wilson, 1988; Njanja, 1991; Mwandoto et al., 1992; Bosman and Ayeni, 1993 and Ba and Udo, 1995; Munyua et al., 1996b). Traore and Wilson (1988) showed that mortality can be reduced by upto 30% in small ruminants by the use of an autogenous Pasteurella sp. vaccine while Omeke (1988a,b) showed that supplementary feeding and veterinary care increased annual weight gain, multiple litter, kid weight at birth and weight at weaning. The higher weights at birth was associated with low preweaning mortality. In addition Omeke

(1988a,b) showed that kidding intervals were shortened by between 10 and 20 days through supplementation and veterinary care. In a similar study Karua (1989) observed that kid mortality varied among seasons in villages but not so on ranches. This, Karua (1989) took to be an indication of the influence of management and resources, including veterinary care, on kid mortality. In contrast Bosman and Ayeni (1993) and Ba and Udo (1995) observed that veterinary intervention packages, including vaccinations and external and internal parasite control, did not have a significant effect on kid mortality. This conclusion was arrived at despite the fact that 50% of the reported deaths were due to infectious diseases. These workers argued that since 40% of the pre-weaning losses were due to malnutrition, trauma and loss (straying), the first priority in reducing pre-weaning mortality in kids should be given to improving management practices. It is important to note that in the studies described by Bosman and Ayeni (1993) and Ba and Udo (1995) the kids used in the trials were born just before or at the starting of the survey and therefore were not vaccinated until they were 4-5 months of age. It is therefore possible that the vaccination did not have an effect on kid mortality as the kids were already exposed to the pathogens before they were vaccinated.

2.7.0. Concepts of on-farm research.

2.7.1. Animal Research (AR) within farming systems research (FSR).

To improve technology that is pertinent to animal production on small farms requires a systematic analysis of farm problems, household goals and aspirations, existing crop-livestock

enterprises, market potential and government policy (Devendra, 1987; Amir and Knipscheer, 1987; 1989; Tripp and Wolley; 1989). Although several approaches are available to carry out this analysis, including the traditional farm management approach and agricultural extension methods, farming system research (FSR) has now been accepted for design of new technology (Devendra, 1987; Amir and Knipscheer, 1987; 1989; Tripp and Wolley; 1989; Spore 1995). Farming systems research (FSR) is currently being used to describe, diagnose, design and test new technologies at farm level (Amir and Knipscheer 1989, Spore 1995).

2.7.2. Farming Systems research.

A farming system is a unique and reasonably stable arrangement of farming enterprise that a household manages according to well defined practices in response to physical, biological and socio-economic factors and in accordance with household goals, needs, preferences and resources (Van Der Veen, 1986). All these factors influence the production method used by the household and the output achieved (Van Der Veen, 1986; Amir and Knipscheer, 1987; 1989; Tripp and Wolley, 1989;).

In the context of farming system research, a system is defined as a conceptual artifice that includes a collection of interdependent and interactive elements that act together to accomplish a given task (Amir and Knipscheer, 1987; 1989). The interactions with, and influence upon, elements outside the system may be either weakly or strongly connected to any intrinsic feedback mechanisms of the system.

Within each farming system, are household, crop, animal, soil, urea and insect and other subsystems that are integrated and interdependent (Amir and Knipscheer, 1989; Munyua and Onyari, 1996). The household provides labour and management, crops provide feed and animals provide milk, meat, manure and capital (Amir and Knipscheer, 1989). Thus FSR is an approach to agricultural research and development that views the whole farm as a system, focuses on the interdependencies of components under the control of members of farm household and on interaction of these components with physical, biological and socio-economic factors not under the household's control and aims at enhancing the efficiency of farming systems by improving the focus of agricultural research in order to generate and test better technology (Sharner et al., 1982, Van Der Veen, 1986).

2.7.2.1. On-farm Research (OFR).

On-farm research (OFR) in FSR involves five basic activities including:-

1. Selection of target areas and farmers,
2. Identification of problems and opportunities and development of a research base,
3. The design of an on-farm research plan,
4. Execution of on-farm research and analysis,
5. Implementations, evaluation and extension of the research (Devendra, 1987; Amir and Knipscheer, 1987 Tripp and Wolley, 1989).

Activities carried under on-farm research rely on the collaboration of the farmer(s) with extension worker(s) and the

research scientist(s). In the context of its application the FSR has some principle elements that distinguish it from traditional agricultural research including:-

i. FSR aims to understand the farm, the farmer and farm environment holistically - that is; as a complex system of interdependent parts.

ii. Priorities for FSR are determined by analyzing farming systems that represent target groups since the purpose of FSR is to use technology to solve farming system problems.

iii. The FSR process, including the analysis of the farming system, technology development and testing, and verification of test results, is carried out by inter-disciplinary teams of social and biological scientists with the cooperation of local farmers (Devendra, 1987; Amir and Knipscheer, 1987; 1989; Tripp and Wolley; 1989).

2.7.2.2. Upstream and downstream FSR programmes.

In FSR there are two programmes that can be adopted, an upstream and a downstream FSR programme. These two levels of FSR are differentiated by the type of research and implementation that is involved (Simmonds, 1985). The upstream FSR programmes generate prototype solutions which lead to major shifts in potential productivity of farming systems in general. Upstream programmes involve several years of research on and off station (Simmonds, 1985).

The downstream FSR programmes, on the other hand, identify and test possible innovations that can be easily integrated into

existing farming systems by focusing on close interaction with farmers via on-farm trials - that it is a site-specific FSR programme (Simmonds, 1985).

2.7.2.3. Categories of FSR.

According to Simmonds' (1985) classification three categories of FSR can be identified (i) Sensu stricto, defined as a farming systems research which attempts to simply understand the system as it exists. The analysis, in this type of farming system, is usually technically and socio-economically in depth and the orientation is academic or scholarly rather than practical; ii) Site specific - which is on-farm research with a farming systems perspective and ii) New farming systems development - which is the introduction of ew concepts and ideas. These categories are in agreement with hers proposed earlier (De Boer, 1977; Rohrbach, 1981; Fitzhugh, 78; 1982).

'.2.4. Stages in farming systems research for the design of new hnologies.

The commonly recognized stages of FSR for the development of technologies (De Boer, 1977; Rohrbach 1981; Fitzhugh, 1978;) include:-

Description - which involves the examination of the cteristics of a series of representative farming systems. often the analysis of the farming system targeted for ance requires an initial review of existing secondary ation, such as baseline surveys on resources and climate, and es formal and /or informal farm surveys. During this stage,

production systems can be studied and classified for the purpose of introducing appropriate modifications that lead to higher productivity.

ii) Design - which involves the evaluation of the specific technological needs of the farming system and identification of technologies that might be developed and adapted to increase farm system productivity.

iii) Testing - This involves trials of the chosen technologies on farmers' field.

iv) Verification - Final evaluation of whether the technology is acceptable to the farmer and provision of information about the technology to extension service for dissemination.

2.7.3. Approaches of on-farm animal research.

There are two approaches to on-farm research namely the traditional and innovative approaches (Devendra 1987).

2.7.3.1. The traditional approach

Steps in the traditional approach described by Devendra (1987) include:- i. Farm surveys - these are used to examine the nature of the system and prevailing patterns of management, livestock production and / or feed and water resources. The survey results provide firm understanding of the prevailing situation, and enable specific interventions to be formulated and introduced within the on-farm research (OFR), the survey is more restricted to examining farmers receptivity, suitability to project objective, nearness to the institutions undertaking the experiments, ease of transportation and costs in relation to the scale of operations.

ii) On-station research - this step is used to examine major constraints or problems from all angles in an institution to arrive at a solution that is beneficial and has great potential value, including economic benefits. iii) Implementation - after the on-station research the research team identifies farmers who are willing, have resources (animals, land, family labour and some capital) and have high potential to be successful for implementation of the programme (Devendra 1987). The implementation of the chosen intervention could be with the farmer as an "on-looker" benefiting from rental of resources and fringe advantages or with farmer participation - participatory approach. In the participatory approach the farmers assist with animal treatments, day to day management, measurement of animal's response to treatment and discussions on the project. The latter approach has several advantages, including the fact that the farmer learns new technology first hand, is encouraged to consider taking up the innovation and it encourages neighbours to adopt the same.

iv) Extension - extension utilizes the results of on-farm implementation by introducing and demonstrating new technologies to the farming community and extension personnel.

v) Interpretation of the results - data is analyzed to determine the responses of animals and possible economic benefits of the interventions (Devendra 1987).

2.7.3.2. Innovative approach.

Innovative approach is based on the belief that farmer participation is critical in OFR as it increases the farmers'

willingness to commit resources and ensures that insurance against risks is discussed and agreements reached.

Many of the innovative approaches to OFR are complementary to the traditional ones (Devendra, 1987; Chambers, 1987; 1992; Amir and Knipscheer, 1989), including enhanced dialogue between farmers, researchers and extension workers while discussing the research project development of field recommendations for farmers and contribution to knowledge.

2.7.4. Goals of on-farm animal research.

On-farm research generally has four main objectives, namely:-

i) Description of animal components at farm-level.

ii) Systematic screening of on-station technologies that help alleviate production constraints at the farm level

iii) Testing the screened technologies at the farm level for their partial and whole farm implications, including expected gains.

iv) Support of implications of animal/crop interventions.

2.7.5. Farm economics: Identifying costs and benefits.

Identifying applicable costs and benefits of a given treatment or innovation are among the factors that determine whether a project can be implemented or not (Devendra, 1987; Amir and Knipscheer, 1989; Tripp and Wolley; 1989). Local input costs include labour, transportation, veterinary chemicals and drugs and marketing costs, while outputs include meat, milk, hides and skins and manure (Price, 1982; Amir and Knipscheer, 1987; Amir and Knipscheer, 1989). The value of animals can either be per kilogram live weight (Kg/bwt) or per head based on physical inspection,

depending on the market (Amir and Knipscheer, 1989).

Labour costs are often difficult to arrive at, and especially under traditional management systems, due to the fact that the marginal costs of additional animal is negligible in terms of care and management (Price, 1982). Thus if the new technology, innovation or treatment requires that animals are handled individually labour input should be valued at its opportunity cost (Price, 1982; Amir and Knipscheer, 1987). The difficulties of calculating labour costs under traditional livestock production systems are compounded by discrimination on the basis of age and sex and their being two classes of labour namely - leisure and hard labour. Leisure labour activities include watering, giving medication, organizing mating and feeding while hard labour includes ploughing and transporting materials (Amir and Knipscheer, 1987).

In raising small ruminants, the production characteristics that producers consider most important include the animals reproductive capacity, mortality, ability to gain weight and milk production. According to Amir and Knipscheer (1987, 1989) these variables must be valued since farmers would like to know how the new technology might influence them. If market prices for manure are not available, manure can be given a value equal to the reduced cost of artificial fertilizer (including delivery costs). Amir and Knipscheer (1987) conceded that it is generally easier and more relevant to develop budgets for flocks or herds than estimate the cost per animal.

CHAPTER 3

3.0. General material and methods.

This chapter is devoted to describing techniques used throughout the survey, on-farm and on-station experimental work in the present study. Sample collection, including bleeding, separation of serum, lung and intestine flushing, swabbing, taking of tissue sections, serology and culture and identification of bacteria and virus(es) were all performed using standard laboratory procedures described.

3.1.0. Routine bacteriology.

Two rectal swabs, one for bacteriological and the other for viral isolation, were obtained from at least 10% of kids with diarrhoea during each farm visit. In each case 1-5 kids without any evidence of diarrhoea were also sampled. Whenever the number of kids affected did not exceed 10 then all kids were sampled. When fresh carcasses were available a postmortem was performed and intestinal swabs obtained for bacteriology. The swabs, rectal or intestinal, were transported to the laboratory in Stuart's or thioglycolate media and processed as described by Cruickshank et al. (1969) and Williamson et al., (1983).

Vaginal and uterine swabs for bacteriology obtained during the survey, slaughterhouse and on-farm studies were processed as described above (Cruickshank et al., 1969 and Williamson et al., 1983). The results of the bacterial isolation were, however,

interpreted using criteria suggested by Shin et al. (1979).

3.2.0. Typing of E. coli isolates.

3.2.1. Serotyping of E. coli isolates using Hoechst and Wellcome test kits.

All E. coli isolates from kids, with or without diarrhoea, were subcultured in cooked meat media and typed using commercial serotyping kits (Hoechst Kenya. LTD and Wellcome Kenya. LTD), as per manufacturers recommendations (Appendices 2.1a and b). The isolates were then categorized as either enteropathogenic (EPEC), enterotoxigenic (ETEC), enterohaemorrhagic (EHEC), enteroadherent (EAEC) or as being out of range of the test kit used.

3.2.2. Guinea-pig eye (Sereny) test for invasiveness.

The guinea pig eye test adopted was that in use at the Kenya Medical Research Institute (KEMRI) (Sang, 1994). In this test E. coli cultures grown on nutrient agar slopes were washed off in physiological saline to give a suspension of approximately 10^{10} colony forming units (CFU)/ml. A single drop was allowed to fall into the eye while the eyelids were held apart. The eye was examined 24 hours post inoculation for signs of conjunctivitis. Those that had not reacted were re-examined at 48 hours post challenge.

3.2.3. Tissue culture test for invasiveness.

The method adopted at the Kenya Medical Research Institute (KEMRI) to detect the penetration of HEp-2 cells by enteroinvasive E. coli was used in the present study.

3.2.4. Tissue culture test for adhesion.

The method used to test for adhesion was the one adopted by the KEMRI, which tests the ability of bacteria to adhere to a monolayer of HEp-2 cells (Sang, 1994). In the present study D-mannose (1% w/v) was used during the test to prevent attachment to the tissue culture cells to other surfaces due to type 1 fimbriae, which may be expressed by the bacteria (Sang, 1994).

3.2.5. Test for vero cytotoxin (VT).

The method adopted was that in use at KEMRI, in which the E. coli strain to be tested is grown in trypticase soy broth (Sang, 1994).

3.3.0. Viral isolation.

The swabs, rectal and intestinal, obtained for viral isolation and negative staining electron microscopy were transported to the laboratory in minimum essential media containing antibiotics (MEM - Flow laboratories LTD - UK). The swabs were incubated at 37°overnight in the transport media before the filtrates were inoculated into goat fetal renal and lung tissue cultures in 5ml tissue culture bottles (Costar, Cambridge, Mass. USA) as described by Merchant and Packer (1971). The tissue culture bottles contained minimum essential media (Flow Laboratories, UK), antibiotics and fetal calf serum (Flow Laboratories LTD - UK). Only samples that showed evidence of cytopathology after 4-6 days incubation were reinoculated into 25ml flasks. The infected cells were subsequently pelleted and processed for transmission electron microscopy as described by Ricketts et al., 1978; Samuel et al. (1979) and Leeson

et al. (1985).

3.3.1. Negative Staining (negative contrasting).

A method in use at the Department of Pathology and Microbiology, Kabete, of the University of Nairobi, was adopted for use in negative staining. Briefly a grid was placed for one minute in a drop of a sample suspected to contain virus particles (the same material that was used to inoculate the cell cultures in section 2.3 a). The grid was then introduced into a drop of 1.25% phosphotungstic acid in 0.4% sucrose, previously stored at 4°C. The grid was then allowed to dry before being examined in a transmission electron microscope.

3.4.0. Vaginal and uterine cytology.

The second vaginal swab obtained from does during the field, on-farm and on station studies and uterine swabs obtained during the slaughterhouse study were rolled on to 1% gelatin coated slides. The slides were then processed and the results interpreted as for equine uterine cytology (Munyua, 1985).

3.5.0. Histopathology.

The technique of collection, processing and assessment of uterine, cervical, intestinal, lung, hepatic, renal and brain tissues obtained at postmortem was as described by Leeson et al. (1985).

Briefly the procured tissue sections were placed in bouin's solution while another was fixed in 10% formal saline. All biopsies were routinely processed by the paraffin wax method and stained with haematoxylin-eosin for histological examination (Leeson et al,

1985).

3.6.0. Examination for external and internal parasites

3.6.1. Internal parasites.

The technique of collection, processing and assessment of gastrointestinal parasites was as described in detail by Hensen and Perry (1990). Briefly faecal material from kids of various ages, with and without diarrhoea, was obtained in plastic short sleeves or plastic cuvettes and transported in a cool box to the laboratory. Examination of the samples and interpretation of the results was done according descriptions by Hensen and Perry (1990).

3.6.2. External parasites.

All external parasites were collected in ethanol and 10% formal saline and identified in the Parasitology Laboratory at the University of Nairobi, Faculty of Veterinary Medicine, Kabete, following the method described by Soulsby (1966).

3.7.0. Quantitative serum protein assays.

Serum and uterine fluid protein levels were determined by spectrophotometry (Bradford 1976; Spector, 1978). The uterine fluid was obtained from uteri with severe acute or chronic suppurative endometritis. Bovine albumin served as the standard.

3.8.0. Immunoglobulin A and G assay.

3.8.1. Screening for immunoglobulin A (IgA) and G (IgG) using radial immunodiffusion.

Single radial immunodiffusion (RID) procedure as described by Mancini et al. (1965) was used in pre-screening IgA and IgG in sera obtained from kids and serum, colostrum and milk from does.

To determine the presence of immunoglobulin G (IgG) in colostrum and milk the Ouchterlony immunodiffusion test was used (Hudson and Hay, 1989). The central well was filled with the rabbit anti-goat IgG or IgA (Bethyl Laboratories, Inc. USA) and the others filled with four serial dilutions of the sample (serum, milk or colostrum). The loaded slides were incubated overnight in a humid chamber at room temperature before being read.

3.8.2. Isolation and purification of goat IgA and IgG.

About 200ml of fresh colostrum obtained from does within 12 hours of kidding was used. A similar volume of colostrum and milk was collected from does in the first seven days postpartum. The colostrum or milk was collected in 100ml plastic containers containing 500-100μg of sodium azide and stored at 4°C until required.

Samples confirmed to contain high levels of IgG and traces of IgA using RID were then processed for isolation, purification and characterization of IgG and IgA using a modification (Kaburia and Wimbia - Personal communication, 1993) of the method described in detail by Hudson and Hay (1989).

Briefly, the modification involved a stepwise elution with a continuous gradient using 300 ml of 0.02m, 0.03m, 0.04m, 0.05m, 0.06, 0.07, 0.08 and 0.09m of phosphate buffers each in a column packed with DEAE. The effluent was collected in 5ml fractions in an automatic fraction collector (LKB, Broomar, Sweden) and its protein content estimated using a Model 25 spectrophotometer (Beckman, USA) set at 280nm. An elusion profile was plotted. The peaks obtained

were pooled and concentrated by ultrafiltration using an Amicon model, 402 ultrafiltrator (Amicon, MA, USA).

To purify the concentrated peaks the pooled fractions were applied to the column packed with Sephacryl and eluted with a continuous gradient 0.01m, 0.02m, 0.03m, 0.04m, 0.05m, 0.06m, 0.07m, 0.08m to 0.09m phosphate buffer pH 7.5. The effluent was monitored, collected and peaks concentrated as for the DEAE. The purity of the concentrated peaks was confirmed using immunoelectrophoresis.

3.8.3. Production of rabbit anti-goat IgG.

Four rabbits were used for the production of antisera. The rabbits were tagged II-2, IC3, 1B3 and III-3 and housed individually in cages. The rabbits were fed on rabbit pellets, greens and water. After 2 weeks of acclimatization the rabbits were bled and the pre-immune sera harvested.

3.8.3.1. Production of rabbit anti-goat sera.

Rabbit antisera was produced following the method described by Hudson and Hay (1989). Briefly, the purified goat IgG, diluted in saline, was emulsified in Freud's complete adjuvant (Sigma Chemical Co. Mo. USA) in the ratio of 1:1. Approximately 1ml of the emulsion was injected deep intramuscularly into gluteal muscles of each rabbit. The first, second and the third boosters, which were prepared in Freud's incomplete adjuvant, were given after two and three weeks and after 2 months respectively. Blood for harvesting serum were collected from each of the rabbits every two weeks. The harvested sera was stored at -20°C

To determine the titre in serum samples, a serial dilution of the antisera, ranging from 1/2 to 1/128 were made. Slides for Ouchterlony immunodiffusion were prepared as described by Hudson and Hay (1989). A 1/2 dilution of the antigen (goat IgG) was prepared and filled into the central well of each slide, while dilutions of antisera were loaded into the surrounding wells respectively starting with neat in well 1 down to 1/128 in well eight. Slides were incubated in a humid chamber overnight before being read, pressed, dried and stained with coomasie blue for preservation.

3.8.3.2. Isolation of rabbit anti-goat IgG from the whole rabbit serum.

The tenth and eleventh bleeding of rabbits II-2 and Ic3 were pooled and the potency of the pooled antisera confirmed. The subsequent precipitation of gammaglobulins with 40% Ammonium Sulphate, dialysis, concentration, equilibration and running of the DEAE cellulose and the sephacryl columns was as previously described (See section 2.8.2).

3.8.3.3. Production of glucose oxidase conjugated rabbit anti-goat IgG.

The concentrates (from 2.8.3.2 above) in the two pools of 10ml of each were further concentrated to 10ml by ultrafiltration. Sodium chloride (0.85%) was added to the final concentrate before being stored at 4°C, awaiting conjugation. Conjugation of the rabbit anti-goat IgG with glucose oxidase was done following, the method described by Hudson and Hay (1989).

3.8.3.4. Quality control of the conjugate.

To determine the conjugate dilution to use, a checkerboard titration of the conjugate and goat serum was performed. A working dilution of the conjugate (1/500) was established (Hudson and Hay, 1989).

3.8.3.5. Confirming the working dilution of the antigen and antisera in indirect ELISA.

The working dilution of the antigen and antisera was also established using the checkerboard titration (Hudson and Hay, 1989). Briefly in the checkerboard ELISA titration of inactivated E. coli, the immune sera of does vaccinated with crude E. coli vaccine and pre-immune sera was carried out using the conjugate dilution established in 2.8.3.4 above. Following the checkboard titration the working dilutions for the antigen and test sera were confirmed to be 1/500.

3.9.0. Screening for diseases affecting reproduction.

Screening of brucellosis, leptospirosis and rift valley fever was undertaken at the Central Veterinary Laboratories (Vetlabs), Kabete while Trypanosomosis, antigen and antibody titres, were screened for at the Kenya trypanosomiasis Research Institute (KETRI), Muguga.

3.9.1. Brucellosis.

3.9.1.1. Rosebengal precipitation test (RBPT).

The antigen used in the RBPT system was an 8% concentrate of Brucella abortus strain 99 bacteria stained with Rose Bengal

reagent (Kenya Veterinary Vaccine Production Institute, Kabete - KEVEVAPI). The antigen and test sera were left standing at room temperature for 30 minutes before 30μl drops of the test sera were placed in a row on a white enamel plate. To each drop of test serum, an equal volume of antigen was added and the reactants mixed with a wooden applicator stick. The plates were gently rocked for 4 minutes and the test read against a white background. The reactions were compared to those of controls which included known positive and negative sera (Kindly donated by Vetlabs, Kabete).

3.9.1.2. Complement fixation test (CFT).

All suspect and positive sera on RBPT were selected for included in the CFT and serum agglutination test (SAT). The methods described by Hudson and Hay (1989) and modified at the Vetlabs, Kabete, were adopted for the CFT. The CFT was performed on the microtiter system, with serum dilutions ranging from 1:2.5 to 1:80 and sensitized sheep red blood cells (SRBC). The test sera was ran alongside known positive and negative ovine and caprine controls.

3.9.1.3. Serum agglutination test (SAT).

As for the CFT, the SAT method used was as described by Alton and Jones (1967) and Hudson and Hay (1989) and modified at Vetlabs. In the adopted SAT, the antigen, Brucella abortus strain 99, was grown on serum dextrose agar and standardized against a known reference standard for anti-Brucella abortus serum. The antigen dilution selected for use was that which gave 50% agglutination at 1:500 final dilution.

3.9.2. Screening for Leptospira antibodies and rift valley fever antigens.

Screening sera for leptospira and rift valley fever antigens was undertaken in Veterinary Investigation Laboratories, Kabete, using methods established in their laboratories.

3.9.3. Screening for trypanosome antigens.

The method described by Nantulya (1993) was adopted for screening for trypanosome antigens in sera collected during the field survey, on-farm and on-station research.

3.10.0. Preparation of buffers and media.

All media and buffers used in the study were prepared using double distilled water and following formulae described in detail by Cruickshank et al. (1969), Johnstone and Thorpe (1987) and Hudson and Hay (1989).

3.11.0. Statistical analysis.

The performance characteristics of vaginal cytology and bacterial cultures were described in-terms of sensitivity, specificity, diagnosability and probability of false positive and/or negative (Martin, 1974;1976).

The differences between the mean immunoglobulin levels and antibody titres for the kids born of vaccinated and non-vaccinated dams and the mean blood parameters, including total protein, leucocytes and glucose levels and body weights of kids at birth were compared using Analysis of variance (ANOVA), student t-test, sign test and/or descriptive statistics.

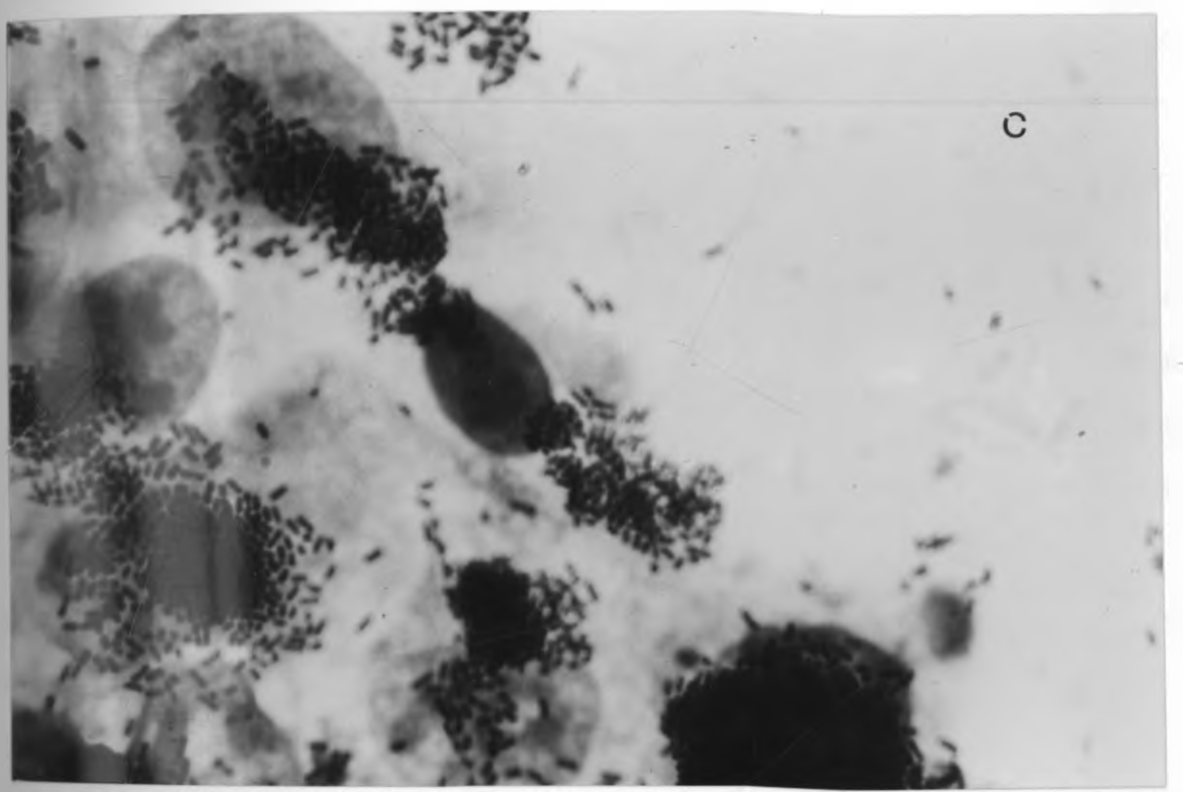
3.12.0. RESULTS AND DISCUSSION.

In the present trial E. coli strains were considered positive for HEP-2 adhesion when at least 40% of the HEp-2 cells had at least 10 attached bacteria. As observed in other laboratories some strains adhered within 3 hours, while others required up to 6 hours attachment period for unequivocal results (Sang, 1994). Strains that were negative for HEp-2 adhesion either showed no attached bacteria or had few (1-5) bacteria attached to less than 5% of the cells. In all positive cases the pattern of attachment was classified as aggregative, localized or diffuse (Figures 2.1 a-c). This classification, which was applied equally to E. coli isolates obtained during the slaughterhouse, field, on-farm and on-station studies, was based on criteria developed at the Kenya Medical Research Institute (KEMRI) from where positive and negative controls were obtained (Sang, 1994).

In the method adopted for testing for cytotoxin production the presence of the cytotoxin resulted in detachment of the entire monolayer with a few cells being visible, while in the absence of the cytotoxin the monolayer remained intact. However, vero cells were also sensitive to labile toxin (LT) and if this toxin was present the cells tended to round up and become partially detached from each other.

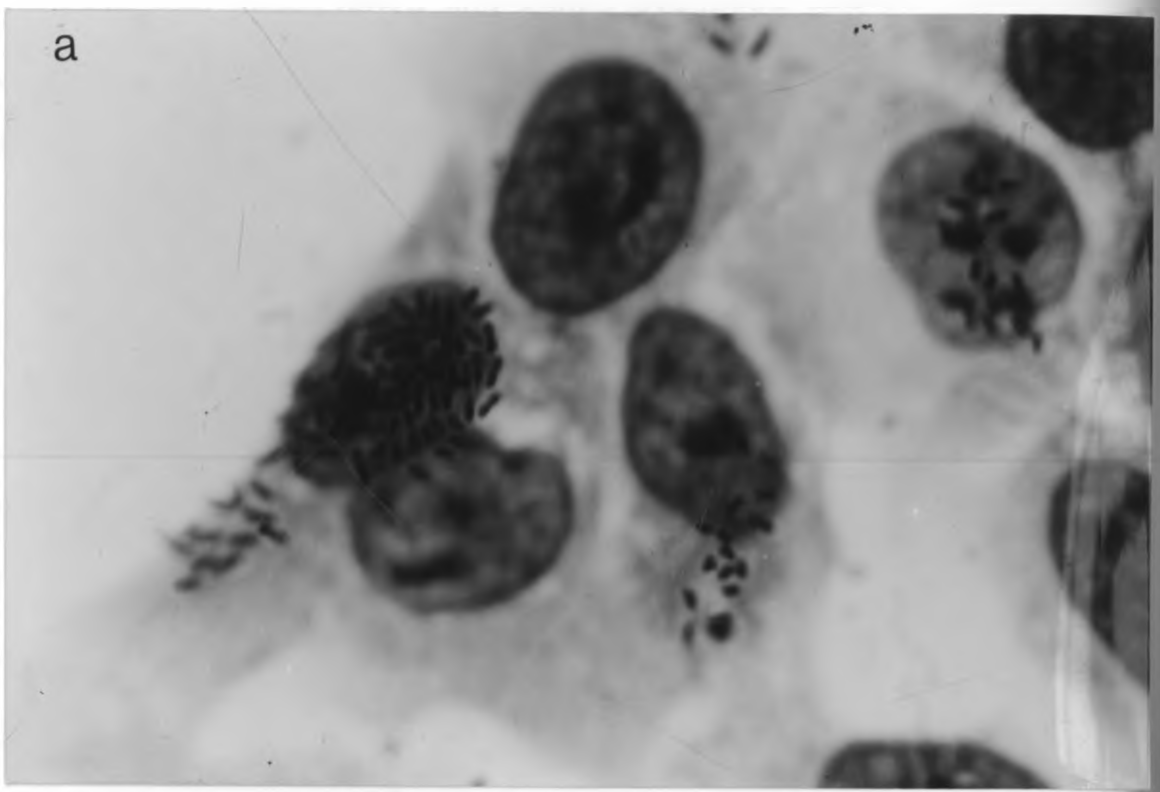
In the tissue invasion test, using guinea pig eyes as the indicator systems, evidence of keratoconjunctivitis was checked at 24 and 48 hours. If the results were positive at 24hrs the experiment was terminated and the guinea pigs treated with

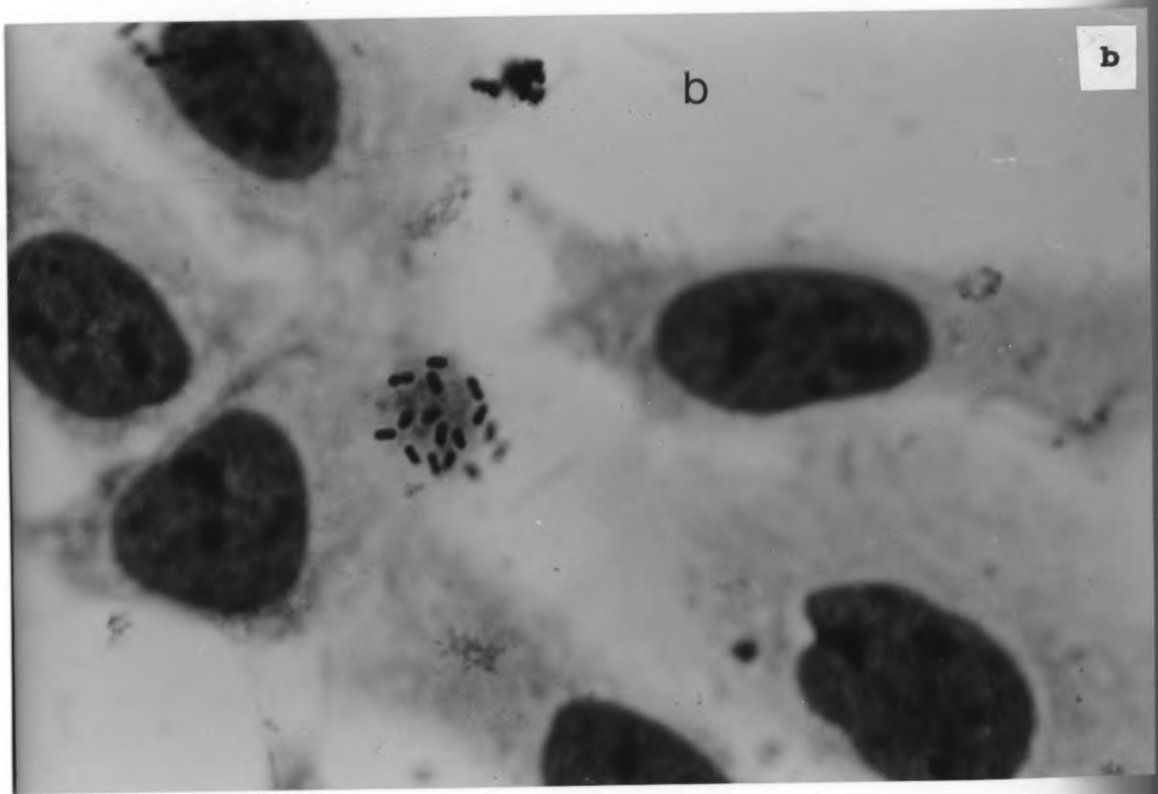
Penstrep^{R} at the dosages indicated by the manufacturers (Norbrook LTD, Britain). In all negative cases the experiment was allowed to run for a further 24 hours before being read. All guinea pigs were treated at the end of the experiment irrespective of whether they reacted or not.

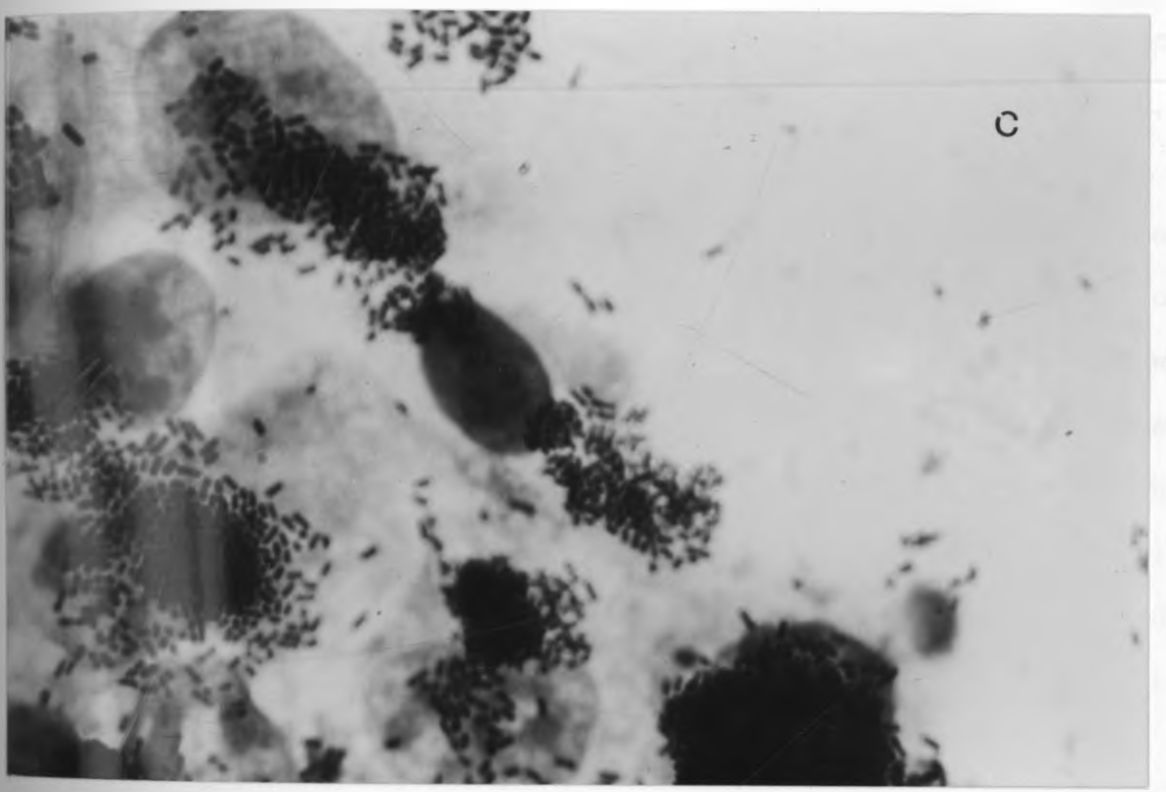


Figures 2.1 a-c

Classification of the pattern of attachment of positive cases of adhesion into aggregative (a), localized (b) or diffuse (c) patterns.


a


b
b



Figures 2.1 a-c

Classification of the pattern of attachment of positive cases of adhesion into aggregative (a), localized (b) or diffuse (c) patterns.

Using RID colostrum obtained from does on days 1-4 postpartum was observed to have had only traces of IgA but high levels of IgG, while milk samples obtained a week after parturition had only traces of IgG. This observation was taken to indicate that the best sample to collect for harvesting and purification of IgG was 1-3 days postpartum colostrum. This sephacryl purified IgG was used for the production of rabbit anti-goat antisera, which was used in the production of local IgG standard. These standards were used to establish IgG levels in serum obtained from kids during the field, on-farm and on-station studies (Figure 2.2a,b).

The four rabbits (II-2, IC3, 1B3 and III-3) selected for the production of anti-goat antibodies, showed similar responses (up to 1/8 antisera titration) between day 14 and 35. After day 35 the New Zealand white (rabbit 1C3) was observed to give a higher titre (1/32). The two California rabbits (II-2 and 1B3) gave peak responses of 1/16 on day 35 but that from California rabbit (II-2) dropped between day 35-60. The antibody titre in the New Zealand white (1C3) increased to reach a titre of 1/64 before evening out for two weeks.

Between day 70 and 112 all rabbits showed a similar decline in antibody titre. This decline was halted by administration of a third booster, which resulted in a similar increase. The New Zealand white was observed to respond earlier and maintain a high titre for a longer time than the California breed throughout the present study. It was thus apparent that the New Zealand White was the breed of choice in the production anti-goat IgG.

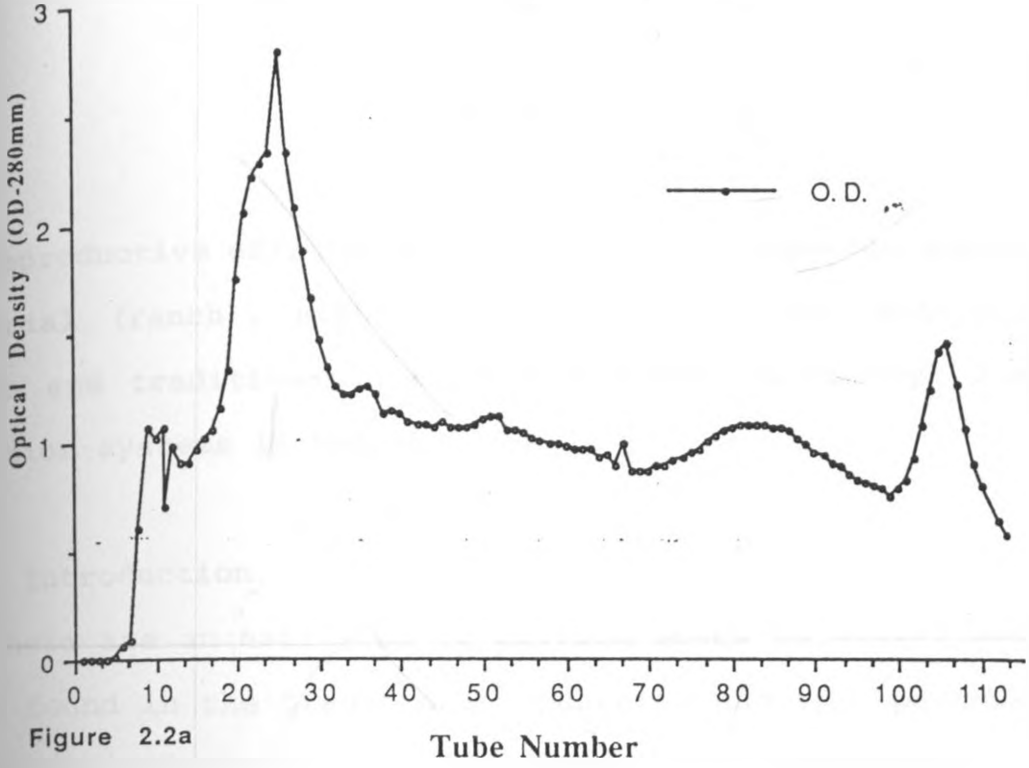


Figure 2.2a

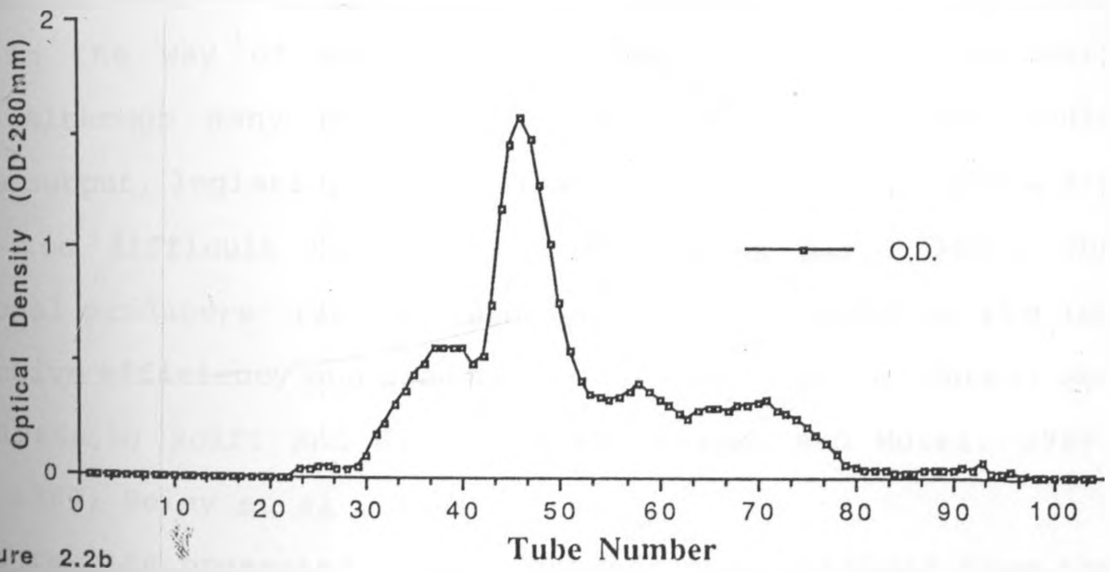


Figure 2.2b

Protein concentration in tubes after DEAE (Fig. 2.2.a) and sephacryl G-200 chromatography (Fig. 2.2b).

CHAPTER 4

Some reproductive efficiency indicators in indigenous goats, under commercial (ranch), state owned Sheep and Goat Multiplication Centres and traditional (pastoral and semi-sedentary) livestock production systems in Kenya.

4.1.0. Introduction.

There are an estimated 11 million goats in Kenya, which are mainly found in the traditional (pastoral and agro-pastoral) and commercial livestock production systems (Gitu and Ngalyuka, 1989). The goats in the traditional production system are provided with little in the way of supplementary nutritional or veterinary inputs. Although many owners are aware that their use would increase output, logistic, financial and institutional problems are usually too difficult to overcome (Wilson et al., 1985). The traditional producers' resource problems are compounded by the low reproductive efficiency and slaughter of pregnant stock (Sacker and Trail, 1966a,b; Kolff and Wilson, 1985; Wilson and Murai, 1988; Wilson, 1989; Belay et al., 1994).

The results presented in this chapter were obtained from the study of genital tracts obtained from a local slaughterhouse and field surveys undertaken in selected goat raising areas in Rift Valley, North Eastern, Eastern, Central and Coast provinces, of Kenya between 1989 and 1994.

4.2.0. Aims.

The aims of the present study were two fold:-

i) to establish the pattern of ovarian cyclicity and the pathologies of does' genital tracts throughout the year,

ii) to establish reproductive efficiency indicators on commercial and traditional production systems; the latter were to be compared to those observed in state owned Sheep and Goat Multiplication Centres.

4.3.0. Material and methods.

4.3.1. Slaughterhouse and field data collection.

The two major elements that provided data for this study were the examination of slaughterhouse material carried out between June 1990 and July 1991 and field surveys in major goat producing areas during the period of 1991 to 1994. Visits to the goat producing areas were organized through the staff of the Livestock Production and Veterinary departments. The staff assisted in introducing the researcher, translating terminologies whenever necessary and in collecting samples. The officers nominated were those that knew and observed the social traditions and were able to explain the purposes of the research programme to producers.

4.3.2. Slaughterhouse study.

Reproductive tracts from pregnant and non-pregnant does slaughtered between June 1990 and July 1991 at a local slaughterhouse in Dagoretti, Nairobi, were collected in plastic bags and taken to the laboratory for further examination.

Data on the pregnancy, ovarian structures and foetal crown-

rump lengths for aging (Osuagwuh and Aire, 1986; Malik et al., 1994) were obtained at each collection. Genital tracts sectioned proximal to the external os of the cervix were considered to be mutilated and were discarded.

4.3.2.1. Collection of samples.

4.3.2.1.1 Uterine swabs from non pregnant and pregnant uteri. Two swabs, for bacteriology and cytology, were obtained from the vagina, cervix and uterus of each reproductive tract after the organs were aseptically opened. Briefly the reproductive system was laid flat on a table, with the greater curvature facing upwards and the area to be incised swabbed with 70% ethanol. A 2-4cm incision was made over each of the areas of interest and the first sterile swab was rolled on to the exposed uterine surface several times before being transported to the laboratory in thioglycolate or Stuart's transport media and processed for bacterial isolation as described in Chapter 2. All bacterial isolates were tested for drug sensitivity using drug sensitivity discs (See chapter 2).

The second swab was collected in a similar manner before being rolled onto a slide coated with 5% gelatin and processed for cytological examination as described earlier (See chapter 2).

Randomly selected pregnant uteri at varying stages of gestation, were wiped as for non-pregnant uteri and incised with a sterile blade along the greater curvature. Samples for bacteriology were collected from the fetal fluids using a sterile needle and processed for bacterial isolation (See chapter 2). All bacterial isolates were tested for drug sensitivity using sensitivity discs

(See chapter 2).

4.3.2.1.2 Uterine fluid. Uterine fluid for protein assays was obtained from infected uteri and stored at -20°C till required.

4.3.2.1.3 Tissues for histopathology. Samples for histopathology were obtained from all uteri, cervices, ovaries and fallopian tubes showing signs of pathology. The collected tissues were handled and processed as previously described (See chapter 2).

4.3.3. The Field Survey.

4.3.3.1. Selection of target study areas.

A three-stage selection programme involving provinces as the primary units, districts as the secondary units, divisions/locations as the tertiary units was used to select the areas to be surveyed. The selection of the areas to be visited was greatly influenced by goat population and distribution contained in the 1989 Economic Survey Report (Gitu and Ngalyuka, 1989; Government of Kenya Economic Survey, 1991).

Using these selection criteria, the field survey was carried out in North-Eastern, Eastern, Central, Coast and Rift Valley provinces. Among the districts selected in these provinces were Narok, Transmara, Kajiado, Koibatek, Baringo and Samburu districts in the Rift Valley province, Lamu, Mombasa and Kilifi districts in the Coast province, Marsabit, Machakos, Kitui and Makueni districts in the Eastern province and Mandera in North Eastern province. Of the selected areas Mandera, Marsabit, Samburu and Kajiado are pastoral areas while Koibatek, Baringo, Transmara are semi-sedentary and Kitui, Machakos, Makueni, Narok, Lamu, Mombasa and

Kilifi are sedentary smallscale subsistence farming areas (Woie and Mavia, 1988; Woie and Kariuki, 1992). With the exception of Narok where wheat is grown, smallscale farmers in these areas cultivate maize and beans as the staple food crops.

The climate in Machakos (Athi), Koibatek (Loboi), Baringo (Marigat), Kajiado (Kilonito-Kangiri) and Kilifi (Ganze and Bamba) is typically semi-arid with a 3-4 months unreliable long rains (500-900mm), a long dry spell and reliable short rains. The climate in Samburu (Siri-olipi, Merille and Laisamis), Marsabit (Logologo) and Mandera (Mandera and Rhamu) is typically arid tropical with a 3-4 months unreliable long rains (500-900mm), a long dry spell, followed by unreliable short rains (Jaetzold and Schmidt, 1983; Woie and Mavia, 1988; Woie and Kariuki, 1992, FAO, 1993). The climate in Lamu (Mpeketoni) and Kilifi (Ganze - Bamba) has in addition long humid spells accompanying both dry and wet seasons.

4.3.3.2. Selection of goats for assessment of distribution of reproductive diseases.

A two-stage purposeful sampling method, involving flocks as the primary units and mature goats of both sexes as secondary units, was used to select a minimum of 200-300 goats in each of the districts nominated for the study. The secondary units represented 10% of the flock size. The selected goats were examined to assess their nutritional and health status during each visit. A flock score (Santucci et al., 1991) was used to rank these two parameters. Any clinically sick or unthrifty animals were examined individually in more detail.

Whole blood for thick and thin smears and clotted blood for serum were collected from at least 10% of the goats presented and analyzed. EDTA Blood was examined by routine haematology while smears were screened for blood parasites (see chapter 2). Serum samples, for serological screening of reproductive diseases, including brucellosis, rift valley fever and leptospirosis were obtained from clotted blood samples. In addition the serum samples were assayed for total proteins and E. coli antibodies, using the methods described in chapter 2. Evidence of besnoitiosis was examined for in all the nominated and serving bucks, and at least 10% of the rest of the flock (does and castrates).

During each field visit milk samples from all does with udder abscesses were collected and materials for bacteriology handled as described (See chapter 2).

Rectal swabs, from kids with diarrhoea and some without, were obtained for bacterial and viral isolation. Faecal samples for the determination of total egg count were obtained from at least 10% of the kids that were over 2 months of age.

All bacterial isolates from rectal swabs were subcultured on either McConkey or blood agar media for subsequent drug sensitivity test. In addition to the sensitivity test serotyping for O and K antigens, using polyvalent serum, was undertaken whenever the isolate was confirmed to be E. coli. The E. coli isolates that agglutinated were tested against corresponding antisera for ETEC, EPEC, EAEC and EHEC group characterisation (See chapter 2 and appendices 2.1a,b).

Vaginal swabs, for bacteriology and cytology, were obtained from all does that had kidded less than 4 weeks before the day of the visit. The swabs were processed and evaluated as described earlier (See chapter 2).

On two establishments where varying degrees of testicular pathology was observed semen was collected from all affected bucks and at least 1 non-affected buck for routine evaluation using a Pulsator II electroejaculator (Lane Manufacturing, Denver, Colorado).

4.3.3.3. Assessment of reproductive performance.

Due to the nature and occupation of the target group, participatory rapid appraisal (PRA) survey rather than knowledge and attitude survey, was preferred for assessing reproductive performance in goat flocks. By opting for this approach flock owners were interviewed on the farm or grazing fields using a pre-prepared questionnaire as a guide (Appendix 3.1). The interview sought information in the broad categories of: salient features of biophysical characteristics of the study area, land ownership pattern and distribution, small ruminant production (including herd structure, age at first heat and kidding, abortions, stillbirths, parturient and pre-weaning mortality), feed and water resources and their availability, and what the producers perceived as the major production constraints (Appendix 3.1). At all points during the interview the interviewees were encouraged to discuss other issues that were peripheral to, but related to goat production.

4.4.0. RESULTS.

4.4.1 Slaughterhouse Survey.

A total of 491 pregnant and non-pregnant genital tracts were collected from the slaughterhouse during the period under study. Out of these 30 were considered as mutilated and were therefore not examined further.

4.4.1.1. Ovarian activity in pregnant and non-pregnant does.

The right ovary in the doe was observed to be more active than the left one, with the right ovary having 64.% versus 36% of the total ovulations recorded between June 1990 and July 1991. Based on observed ovulations the peak of ovarian activity was between February (25%) and May (27%) (Tables 3.1 and 3.2).

Multiple ovulation (maximum of 2 on one or both ovaries) occurred in 7.5% of the organs examined. This was observed during the peak cycling period between February and May. Ovaries without significant structures averaged 13% of the examined organs and were observed to be distributed evenly throughout the year (Tables 3.1 and 3.2).

4.4.1.2. Pregnancy rates, fetal migration and litter sizes.

Of the 461 organs examined between June 1990 and July 1991, seventy (15%) were pregnant, with the highest pregnancy rates being observed in June 1990 (89%) and July, 1991 (92%) (Tables 3.1 and 3.2).

TABLE 3.1 Comparative activity of left and right ovaries in does and the frequency of intrauterine migration in reproductive tracts obtained from slaughterhouses

MONTH	Number of does		Sex ratio	CL	Site		Embryo Migration			NSS
n=Total No. of does	Pregnant	NP	F:M	L	R	Both	L-R	R-L	Multiple	
June 1990 (n=26)	23 (1)(88.5%)	2	3:02	6	6		6	4		
July 1990 (n=12)	11 (91.6%)	1	2:05	* 8	2		4	3		
August 1990 (n=25)	10(40%)	15	3:05	6	5	3	2	2		14
September 1990 (n=49)	23 (46.94)	12	4:09	1	3	4	3	4	3	16
October 1990 (n=55)	8 (14.55%)	47	3:02	6	2					26
Nov 1990 (n=40)	4(10%)	36	1:01	3	1			1	26	**NSS
Dec 1990 (n=12)	2-1/3(11.54)	9	2:01	1	1			1	10 (11/21)	
Jan1991 (n=42)	8 (19.05%)	34	1:02	5	3			2	22	
Feb 1991 (n=35)	4 (11.42%)	43	2:02	9	8		1	1	23	
March 1991 (n=35)	4 (11.42%)	31		1	3			1	20	
April 1991 (n=30)	2 (6.67%)	30	1:01		2				11	
May 1991 (n=50)	5 (10%)	45		2	3		1	2	15	
June 1991 (n=15)	3 (20%)	12	1:01		3				2	

Remarks

Pathologies observed

1 Mummified fetus

1 macerated fetus

1 Kinked cervix

1 paraovarian cyst

* 2 CL on one ovary but 1 fetus, ** Nss- both RO & LO Nss or Foll smaller than 10mm (1cm)

Key

NP= Not pregnant

F:M=Female male ratio

L-R= Left to right migration

L- Left

R= Right

R-L= Right to left migration

LO= Left ovary

RO= Right ovary

NSS- No significant findings

CI = Corpus luteum

TABLE 3.2 Ovarian findings and pregnancy status of genital tracts from Dagoretti slaughterhouse

	PREGNANT SIDE						NON PREGNANT				
n=No of pregnant does	R	L	Feotuses per doe	CL R	Site L	Sex F:M	Right ovary CL	FOLL	Left ovary CL	FOLL	Pathology
June 1990 (n=23)	15	11	26/23 (1.13)	15	12	15:08	1		1		Imummy
July (n=11)	5	6	1(11/11)	2	9	2:05	2				
August (n=10)	5	7	1.2(12/10)	7	8	5:07	7		4		
September (n=23)	11	14	25/23 (1.09)	13**	12	4.09	3				*6(1 fetal resorption
October (n=8)	6	2	8/8 (1)	6	2	2:01	5		2		* macerated feotus 3* kink
											cervix 1 paraovarian cyst
											Two cl or cl both sides
November (n=4)	2	2	4/4 (1)	3	1	1:01	6(1x2 cl		4	2	**1x2 cl (lo)
									1x2 cl	1 ovarian cyst	(1x2 cl) (1)
December (n=2)	2		2/2 (1)	1	1	2:00					
		1	(1/1)		1						
								1 para			1 mucometra
January 1991 (n=8)	5	3	8/8 (1)	5	3	:2	4	ovarian cyst			
February (n=4)	3	1	4/4 (1)	2	2	:2	8				
									4		
March (n=4)	2	2	4/4 (1)	3	1		7				
								1 cyst	1 hypoplasia		1x2 cl (lo)
April (n=2)	2		2/2 (1)	2		1:01	8				
									7	1 cystic ovary	
May (n=5)	3	3	6/5 (1.2)	3	2		11				
								1 cysti	7		
June (n=3)	2	1	3/3 (1)	3		1:01	3				
Remarks											
2** Two ovulations on one ovary											
1x2 cl (lo) 2 cl on 1 ovary (left)											
Key. CL= corpus luteum, R=right, L=left , F:M= Female:male ratio, foll=follicl LO=left ovary, RO=right ovary											

The number of fetuses per pregnant doe ranged from 1.0 to 2.0, giving a twining rate of less than 10%. Of the observed pregnancies 54% were in the right horn while 52.% of corpora lutea of pregnancy were on the left ovary. Left to right migration of the fetus was higher than right to left (65% versus 35%) (Tables 3.1 and 3.2). Based on the crown rump lengths (CRL) of the foetuses recovered from uteri collected from the slaughterhouses, the expected kidding season would have been between November (23%) and December 1990, (16%) and January 1991 (9%). There were small peaks in April and August (9% each), while the rest of the months had between 1 and 7% expected deliveries (Table 3.3).

4.4.1.3. Fetal loss in utero and uterine infections.

Of the 461 organs examined, two cases of fetal maceration were associated with Actinomyces pyogenes (1) and a mixture of A. pyogenes and Staphylococcus aureus (1), while mummification comprised of less than 1% of the organs. Chronic purulent endometritis (pyometra) was observed in two organs, from which S. aureus and A. pyogenes were isolated from one while no isolates were observed in the other despite incubating the material under both aerobic and anaerobic conditions. Fetal loss ranged between (4-25%) and was highest in August (25%) (Tables 3.1, 3.2, 3.4).

4.4.1.4. Uterine bacteriology and cytology.

Swabs prepared from reproductive tracts without any visible pathology showed that the does' uterus postpartum (as indicated by the yet to be resolved cotyledons) was contaminated with a range of organisms (Table 3.4).

Table 3.3

The expected delivery dates based on crown rump length (CRL) measurements taken during the slaughterhouse survey.

Month	No. of pregnant uteruses	Percent of the total
January	6	9
February	5	7
March	5	7
April	6	9
May	2	3
June	2	3
July	1	1
August	7	10
September	4	6
October	5	7
November	16	22
December	11	16
Total	70/461	100

Over 21% of all bacterial isolates from uteruses collected from abattoirs were E. coli, 66% were a mixed culture of E. coli, proteus sp. and Pseudomonas sp., while Streptococcus sp., Bacillus sp. and S. aureus, in mixed or pure cultures, made up the remaining 13% (Table 3.4). Positive bacteriology corresponded to positive cytology in > 5% of the times. Out of the 103 swabs plated 46% had no growth even after incubation for 48 hours (Table 3.4).

Drug sensitivity tests, carried out using the disc diffusion technique, indicated that E. coli strains isolated were resistant to most commonly used antibiotics except gentamycin (Dawa Pharmaceutical, Kenya) and Penstrep^{R} (Penicillin - 200,000iu/ml, 250mg/ml Streptomycin - Norbrook, UK) (Table 3.5). There were great variations in the sensitivity pattern of the other non coliform isolates.

4.4.1.5. Pathology of the reproductive tract.

Congenital malformations and structural deformities were observed in only 1% of the organs examined. Pathologies thought to be capable of affecting reproduction were kinked, almost "V" shaped, cervix (1 case), 2x2 - 2x4cm paraovarian cysts (4 cases) and hypoplastic ovaries (1 case) (Table 3.1 and 3.2).

The major functional infertility observed in slaughterhouse material was cystic ovaries observed in 0.87% (4) of the specimens (Table 3.1 and 3.2).

Table 3.4.

Frequency of bacterial isolates from uteri collected from a local slaughterhouse.

Isolate	No. of isolates	Percent of total
E. coli	12	21
E. coli and Streptococcus sp.	14	24
E. coli, Streptococcus sp. and Pseudomonas sp.	7	12
Streptococcus, sp.	6	10
E. coli and Pseudomonas sp.	5	9
E. coli, Proteus sp. and Pseudomonas sp.	5	9
E. coli and Proteus sp	3	5
Proteus sp.	2	4
Pseudomonas sp.	1	2
Streptococcus sp and Pseudomonas sp.	1	2
Pasteurella sp.	1	2
Bacilli sp.	1	2
Total number of isolates	56	
No growth	47	

4.4.2. Field survey.

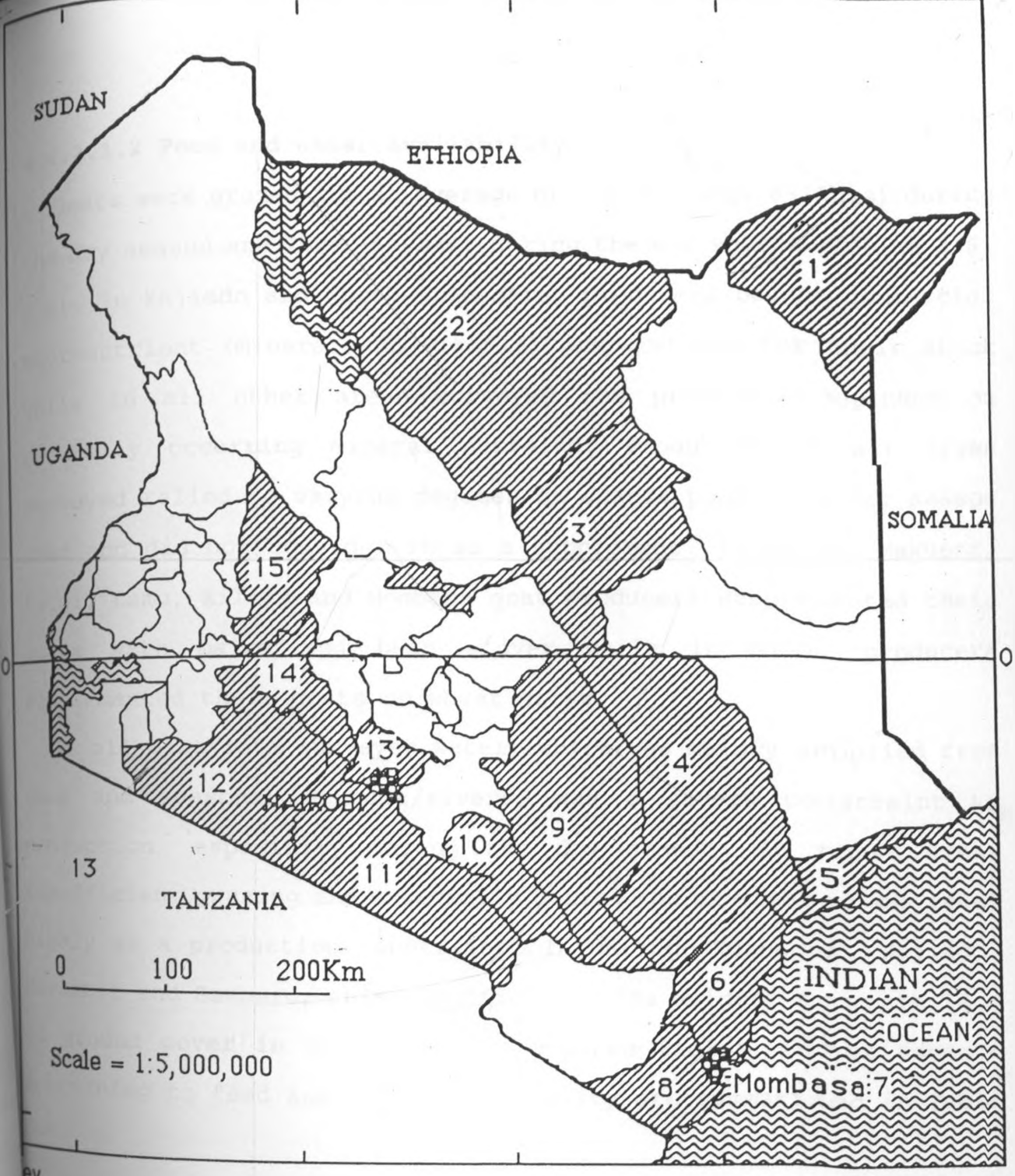
The goat producing districts surveyed for the present study between July 1990 and December, 1994, include Lamu, Kilifi, Mombasa, Kitui, Machakos, Makueni, Marsabit, Baringo, Koibatek, Kajiado, Narok, Transmara, Samburu, and Mandera districts (Figure 3.1).

4.4.2.1. Biophysical characteristics.

4.4.2.1.1 Land size and tenure.

Land in Baringo-Koibatek, Kajiado and Narok-Transmara District was owned by groups (Group ranches) while in Makueni, Kitui, Lamu, Kilifi and Mombasa, which are settled areas, land was individually owned. Under the pastoral production system in Mandera, Samburu, Marsabit and parts of Kajiado, land was communally owned and under clan control. The mean acreage for individually owned land was 170 acres and ranged from 2 to 1000 acres.

There was organized grazing practice or programme in all areas studied. In agro-pastoral and sedentary systems in Koibatek, Baringo, Kajiado, Narok, Transmara, Kitui, Makueni, Lamu and Kilifi, where some subsistence farming was practised, it was apparent that each individual took advantage of the low population density to increase their flocks and graze animals on all unoccupied or unfenced land. In Mandera, Samburu, Marsabit and parts of Kajiado clan elders practised some form of control on the size of the flocks and herds, as well as migration patterns.



ey
Mandera, 2 - Marsabit, 3 - Isiolo, 4 - Tana River, 5 - Lamu, 6 - Kilifi, 7 - Mombasa 8 - Kwale,
Kitui, 10 - Makueni 11 - Kajiado, 12 - Narok/Transmara, 13 - Kiambu/Thika, 14 - Nakuru,
- Baringo/Koibatek

Figure 3.1

The map of Kenya showing areas selected for the field and on-farm studies

4.4.2.1.2 Feed and water availability.

Goats were grazed for an average of 10hrs (range 8-12hrs) during the dry season and 7hrs (6-9hrs) during the wet season (Tables 3.5, 3.6). In Kajiado and Narok-Transmara, producers bought commercial micronutrient (mineral and vitamin) preparations for their stock while in all other areas surveyed the producers depended on naturally occurring mineral deposits. Producers in all areas surveyed relied to varying degrees on acacia pods as a dry season feed and did not consider it as a supplement. In Narok, Makueni, Kitui, Lamu, Kilifi and Mombasa goat producers supplemented their goats with maize and bean stover while in Narok producers supplemented their goats on wheat straw.

In all districts surveyed water, which was mainly supplied from dams and seasonal streams/rivers, was a severe constraint to production, especially during the dry season. In these areas insufficient grazing and especially during the dry season was rated highly as a production constraint. In Baringo-Koibatek, Kajiado, Marsabit and Samburu, this insufficiency was evident from the lack of ground cover in 30-50% of the visited fields. Other aspects pertaining to feed and water availability are summarized in Table 3.6.

Table 3.5

Land ownership and grazing practices in the areas surveyed, expressed as a percentage of the respondents and grazing time expressed in actual hours spent in the field.

VARIABLE	CATEGORY	BRG[1] n25	MSA[2] n=6	KLF[3] n10	KTI[4] n12	NRK[5] n12	KJD[6] n18	MAR[7] n2 0	SAM[8] n20	LAM[9] n=6	MAN[10] n=12
Land owner-ship	Individual Group Communal State	0 80 20 0	100 0 0 0	50 50 0 0	100 0 0 0	66 34 0 0	0 66 34 0	0 0 100 0	0 0 100 0	50 0 0 50	0 0 100 0
Grazing Method if singly owned	Free range Control	0 0	0 100	0 100	50 50	66 34	0 0	0 0	0 0	0 100	0 0
Grazing Method if Group owned	Free range controlled	80 20	0 0	0 0	0 0	80 20	80 20	100 0	100 0	50 50	100 0
Acreage	per family	50	20	30	50	250	300	0	0	20	0
Grazing time	dry season (hrs)	10	10	10	9	9	10	9	9	8	9
Grazing time	wet season (hrs)	6	8	9	7	7	6	6	6	8	7

KEY.

Districts

BRG[1] - Koibatek-Baringo, MSA[2] - Mombasa, KLF[3] - Kilifi, KTI[4] - Kitui, NRK[5] - Narok, KJD[6] - Kajiado, MAR[7] - Marsabit, SAM[8] - Samburu, LAM[9] - Lamu, MAN[10] - Mandera,

Numbers - n = Sample size in a given area.

Table 3.6

Feed, including supplementation, and water availability in the goat producing areas surveyed, expressed as percentage of the respondents.

VARIABLE	CAT	BRG	NRK	KJD	KTI	MAR	SAM	MSA	KIF	LAM	MAN
Supplem. dry season	Yes	0	100	0	0	0	0	50	50	50	0
	No	100	0	100	100	100	100	50	50	50	100
Type of supplem	1	0	100	0	100	0	0	100	100	100	0
	2	0	100	100	0	0	0	50	50	50	0
	3	0		0	0	0	0	100	100	100	0
Rate of Sup/tation	Ad	0	100	0	100	0	0	50	50	50	0
	LTD	0	0	100	0	0	0	50	50	50	0
Water source	1	0	0	0	0	0	0	50	50	50	0
	2	0	0	0	0	0	0	50	0	0	0
	3	100	100	100	34	34	34	0	0	50	100
	4	100	100	50	66	100	100	0	50	0	100
	5	0	0	50	100	66	66	0	0	0	0
Communal water points	Yes	100	100	100	100	100	100	0	50	50	100
	No	0	0	0	100	0	0	100	50	50	100
Animals sharing water	1	100	100	100	100	100	100	100	100	100	100
	2	100	100	100	100	100	100	0	50	50	100
	3	100	100	100	100	100	100	N/A	50	50	100
Water problem in dry season	Yes	100	50	100	100	100	100	0	50	0	50
	No	0	50	0	0	0	0	100	50	100	50

Key.

Supplementary feed (supplem.)
1 - maize stover, 2 - salt and 3 Ad lib,

Water
1- trough, 2 - bucket, 3 - dam, 4 - stream and 5 - bore hole,

Animals
1 - domestic, 2 - wild and 3 - both, LTD - Limited,

Districts
BAR - Baringo/Koibatek, MSA - Mombasa, KLF - Kilifi, KTI - Kitui, NRK - Narok, KJD - Kajiado, MARS - Marsabit, SAM - Samburu, LAM - Lamu and MAND - Mandera.

4.4.2.1.3 Other relevant practices.

Over 85% of the farmers deworm their goats on the average twice a year, using commercially available anthelmintics. Of those who drenched their flocks 20% administered the anthelmintics as per manufacturers recommendations, 60% either under-dosed or only drenched those they considered to be "severely affected" while 20% overdosed. The anthelmintics commonly used (descending order) were: Wormicid^{R} (Cosmos, Kenya), Nilzan^{R} (Cooper, Kenya), Rintal^{R} (Bayer, EA), Vetworm Plus^{R} (Mimea Mifugo, Kenya), Valbazene^{R} (Kenya Swiss, Kenya) and Pancur^{R} (Hoechst, Kenya). High cost of commercial preparations or the use of herbal remedies, in Makueni, Kitui, Baringo, Koibatek, Kwale and Kilifi districts instead of the commercial anthelmintic were the reasons given by some of the producers who did not drench their animals (Table 3.7, Figure 3.2).

4.4.2.1.4 Livestock housing and livestock:wildlife interactions.

Most (90%) of the producers housed their goats at night. The few (10%) who did not were in Baringo-Koibatek and Kilifi districts. Animal houses were mainly of four types, namely: mud walls and makuti / grass roof (Lamu and Mombasa), fencing poles and iron sheet roofing (Baringo, Koibatek and Kitui); fencing poles, twigs and thorny bushes or wire without a roof (Narok, Transmara); thorny bushes and poles (Mandera, Marsabit, Samburu and Kajiado); and old deserted residential houses (Makueni and Kilifi).

Fencing poles and iron sheet roofs were exclusively found in Makueni and Kilifi, while fencing poles and plain wire enclosures were mainly observed in Baringo-Koibatek, Narok, Transmara and

Kajiado (75%)(Table 3.8).

Table 3.7

Management and production objectives that may influence reproductive performance and wastage in the areas surveyed, expressed as percentage of the respondents.

VARIABLES		BRG	NAR	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
Goat milk used	Yes	100	66	40	40	100	100	0	100	0	100
	No	0	44	60	60	0	0	100	0	100	0
% of farmers dewormin g[1]	Yes	100	80	100	100	100	100	100	50	100	50
	No	0	20	0	0	0	0	0	50	0	50
Dewormer used	1	60	80	100	100	100	100	100	0	50	100
	2	0	0	0	0	0	0	34	100	50	0
	3	20	0	66	100	34	50	0	0	0	66
	4	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	100	100	0
	6	20	20	34	0	66	50	66	0	0	34
	7	0	0	0	0	0	0	0	0	0	0
Percent of farms not dewormin g[2]	No fund herb	0 20	0 20	0 0	0 0	0 50	0 50	0 0	100 0	100 0	0 0

Key.

Dewormer used

1 - Nilzan^{R}, 2 - Rintal^{R}, 3 - Wormicid^{R}, 4 - Valbazene^{R}, 5 - Vetworm Plus^{R}, 6 - Wormicid Plus^{R} and 7-Panacur^{R}.

No funds

Farmers indicated that they cannot afford to buy the anthelmintic and herbs - farmers apply ethnoveterinary practices.

Districts

BRG - Koibatek-Baringo, MSA - Mombasa, KLF - Kilifi, KTI Kitui, NRK - Narok, KJD - Kajiado, MAR - Marsabit, SAM - Samburu, LAM - Lamu, MAN - Mandera,

Wild animals were said to be a problem mainly in Baringo, Koibatek, Kajiado, Narok, Transmara, Marsabit and Samburu districts, where they acted as predators and, to a lesser extent, competitors for feed (Table 3.9).

The provision of affordable veterinary drugs and chemicals, farmer education / extension and availing improved breeding stock were cited by producers as the main areas of concern, which if addressed, would enhance livestock production (Table 3.9).

Goat milk was drunk by humans on 85% of the farms surveyed. Sixty percent of these farms were in Kajiado, Baringo-Koibatek, Marsabit, Samburu, Makueni, Kitui and Mandera and 40% from Narok-Transmara and Kilifi. Goat producers in Mombasa and Lamu did not drink goat milk (Table 3.7). Producers used a combination of traditional and modern practices to manage and control diseases (Figure 3.2, Table 3.7)

4.4.2.1.5 Other livestock owned by the goat producers.

Producers in all the areas surveyed also owned cattle, sheep and donkeys, while producers in Mandera, Samburu and Marsabit districts also owned camels and donkeys. Poultry was only kept in the by sedentary producers. Producers interviewed indicated that goats and sheep were herded separately from cattle (Table 3.8).

Subsistence farming was the other main agricultural activity n farms in Narok, Transmara, Kitui, Makueni, Mombasa, Lamu and ilifi districts (85%). Producers in Kilifi, Lamu and Mombasa ractised both subsistence and cash crop (coconut and cashew nut) rming (Table 3.8).

Table 3.8.

Livestock housing structures, management practices and other agricultural activities undertaken by respondents, expressed as percentage of the responses.

VARIABLES AND RESPONSES		BRG	NAK	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
Animals housed at night	Yes	100	20	75	100	50	50	80	80	80	100
	No	0	80	25	0	50	50	20	20	20	0
Materials used for housing[1]	1	0	0	0	0	0	0	100	100	100	0
	2	40	0	0	0	0	0	0	0	0	0
	3	60	100	100	100	100	100	0	0	0	100
	4	0	0	0	0	0	0	50	50	0	0
Both smallstock and cattle herded together	Yes										
	No	0	0	0	0	0	0	0	0	0	0
		100	100	100	100	100	100	100	100	100	100
Other farm activities undertaken by farmers[2]	1	50	50	0	100	0	0	100	100	100	0
	2	0	0	0	0	0	0	100	100	100	0

Key.

Districts

BRG-Baringo, NAK - Narok, KJD - Kajiado, KTI - Kitui, MAR -Marsabit, SAM - Samburu, MSA - Mombasa, KLF - Kilifi, LAM - Lamu and MAN - Mandera,

[1]**Type of housing (enclosures)**

Mud walls Makuti/grass roof, 2 -Poles/Iron sheets, 3 - Poles, wire/branches and Ex-residential (deserted houses),

[2]**Other on-farm activities**

Subsistence farming (1) and cash crop farming (2).

Table 3.9.

Producers's opinions on the constraints of production including the effect of wildlife:livestock interaction, expressed as a percentage of the respondents in the areas surveyed.

VARIABLES AND RESPONSE		BRG	NAK	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
Farmer's opinion of production constraints and solutions[1]	1	100	100	100	100	100	100	100	100	100	100
	2	50	100	0	0	50	0	0	50	0	0
	3	50	50	50	100	50	50	50	0	0	50
	4	100	100	50	0	100	100	0	0	50	100
Is wildlife a menace	Yes	0	66	50	50	50	50	0	50	100	500
	No	100	34	50	50	50	50	100	50	0	50
Problems of wild animals[2]	1	100	100	100	30	0	50	0	100	100	100
	2	0	100	0	100	0	50	0	0	0	100
	3	0	100	0	0	100	100	0	0	0	100

Key.

Districts

BRG -Baringo, NAK - Narok, KJD - Kajiado, KTI - Kitui, MAR -Marsabit, SAM - Samburu, MSA - Mombasa, KLF - Kilifi, LAM - Lamu and MAN - Mandera,

[1]Farmers' opinions on how to improve goat production

1. Provision of affordable Veterinary drugs and chemicals, 2. Good breeding stock, 3. Farmer education, 4. Better Marketing of livestock and livestock products.

[2]If wild animals are a problem as predators

(1), competitors for the available feed and water resources (2) or both (3).

4.4.2.2. Breeds and basic flock structure.

Thirty percent (30%) of the flocks surveyed were the Small East African (SEA), 40% the Galla and 30% SEA - Galla crosses. In the purely pastoral communities in Mandera, Samburu, Marsabit and Kajiado producers keep an average of 200 goats per family, while in areas where land is individually owned and subsistence farming is practised, each family owned an average of 25 goats. Of these, entire males comprised about 2-8%, castrates 2-30%, mature females 50-60%, weaners 0-19%, and kids 0-17% (Table 3.10).

4.4.2.3. Reproductive performance.

The main kidding seasons, which were between October and January and May and August, were timed to coincide with the onset of rains and the subsequent vegetation growth pattern.

4.4.2.3.1 Age at first kidding, service period and inter-kidding interval. The average age at first kidding, which was greatly influenced by management practices and nutrition, was estimated to be 1.5 years, (range 1-2 years) (Tables 3.10).

The average kidding to mating interval was 3 months, with a range of 2-4 months, while the kidding interval averaged 12 months (range 11 - 14 months). Producers held does from breeding whenever they anticipated unfavourable weather, thereby influencing the kidding to service and inter-kidding intervals (Table 3.10).

Table 3.10.

Average flock structures and some reproductive efficiency parameters in the selected flocks in areas surveyed.

VARIABLES	BAR	NAR	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAND
Av. # of goats per flock	20-350 x100	30-270 x90	50-170 x100	10-35 x25	20-300 x180	40-350 x200	5-15 x10	10-30 x20	20-60 x30	100-300 x200
% Bucks	7	5	4	12	3	4	13	8	6	4
% Castrates	19	13	16	26	9	13	0	19	6	17
% Females	51	45	52	47	51	50	60	38	51	48
% Weaners	4	8	10	7	16	18	7	8	9	12
% Kids	19	29	18	8	21	15	20	27	28	19
Age at first Kidding (Years)	1.5	1.0	1.5	1.5	1	1.5	1.5	1.0	1.5	1
Kidding mating (Range in months)	2-4	3-4	2-4	3-4	2-4	2-7	2-4	3-4	2-4	2-4
Kidding interval (range in months)	10-12	12	10-12	12-13	10-13	11-12	12	12-13	12	12-14
% Twinning % of surviving	5-15 50-100	10 0-100	8 0-100	8 50-100	6 50-100	LOW LOW	LOW LOW	LOW LOW	5-50	5 50-100

Key

x - average

Table 3.11.

The criteria used for the selection of breeding material and disposal of both does and bucks in the study area, expressed as a percentage of the respondents.

VARIABLE	FACTORS	BAR	NAR	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
Selection of breeding does	1	0	0	66	66	100	100	50	100	100	100
	2	100	100	44	44	0	0	50	0	0	0
Reason for disposal of female	1	20	20	34	20	20	20	100	100	100	20
	2	100	100	100	100	100	100	0	100	50	100
	3	100	50	50	100	100	100	0	0	0	40
	4	100	100	100	100	100	100	100	100	100	100
Selecting breeding males	1	100	100	100	100	100	100	100	100	100	100
	2	0	0	0	0	0	0	0	0	0	100
Main reasons for culling males	1	100	100	100	100	100	100	100	100	100	100
	2.	100	50	100	100	100	100	100	100	100	100
	3	100	100	100	100	100	100	100	100	100	100
	4	30	34	0	50	50	50	50	50	50	20
	5	0	0	34	50	50	50	50.	50	100	50

Key.

Selection of buck

1 - male based on Sire/dam characteristics, 2 - female and all qualify;

Reasons for culling

1 - Home use, 2 - Old age, 3 - Drought, 4 - Infertility;

Selection criteria for "dairy characteristics

1 - Growth rate, 2 - Colour,

Reasons of culling bucks

1 - infertility, 2 - Income, 3 - Old age, 4 - Avoid over-stocking and 5 - Avoid in-breeding.

4.4.2.3.2 Twinning rate. In comparison to a twinning rate of 5 to 20% under the traditional production, the Multiplication Centres achieved between 20-70%. Kilifi had the lowest twinning rate, while Baringo and Makueni had the highest. The survival rate of the twins varied from 0-100%, with a half of the farms (50%) having a survival rate of around 50% (Table 3.10).

4.4.2.3.3 Selection of breeding stock and culling practices. In the areas surveyed breeding bucks were selected between the age of 6-12 months based on growth rate, size of the sire and milk production by the dam. In Mandera the brownish coat colour around the head was an added advantage, as the producers believe this to be an indication of high milk production potential (Table 3.11). All females born in flocks in the areas surveyed automatically qualified to join the breeding stock. The mating system in use in all the areas surveyed was the 'free for all' type using selected bucks, although breeding was controlled when weather and forage conditions were considered adverse.

Exchange of bucks or purchasing of fresh bloodlines in the local market or from neighbours was widely practised. Infertility, income generation, avoiding in-breeding and old age were the main reasons cited for culling males. Inbreeding, as a reason for culling, was only cited by about 5 - 10% of the producers. Among does, old age and domestic use (income) were found to be the main reasons for culling (Table 3.11).

Figure 3.2.
An open air livestock and commodities market in Marigat, Baringo, where ethnopractitioners offer for sale herbal remedies to livestock producers.

4.4.2.4. Reproductive wastage.

4.4.2.4.1 Abortions, stillbirths and parturient deaths. The rate of abortion in a year, expressed as the number of abortions over the number of mature females in flocks, was between 5 and 20%. No cases of stillbirths were reported (Table 3.14).

Abortions accounted for up to 15-30% of the losses, although most producers admitted that they could not differentiate between abortions, stillbirths and parturient deaths. Abortion rates given by the producers were higher in Samburu, Marsabit, Mombasa, Kilifi, Lamu and Baringo-Koibatek than in Transmara, Narok, Kitui and Mandera districts (Figure 3.1, Table 3.12). These producers and the local Animal Production and Veterinary department staff listed trypanosomosis, brucellosis and co-infection with streptothricosis and mange to be the main causes of abortion, while brucellosis was said to be the major cause of abortion and infertility in Narok, Transmara, Baringo and Koibatek districts. Leptospirosis and rift valley fever were not incriminated in any of the areas surveyed.

Table 3.12

Breeding pattern and the most probable causes of abortion according to the producers and personnel in the Departments of Veterinary Services and Livestock production in the areas surveyed.

VARIABLES		BRG	NAR	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
Kidding Season[1]	Fix	100	80	80	100	100	100	50	100	50	100
	All year	0	20	20	0	0	50	50	0	50	0
Breeding season	One	0	0	0	0	0	0	50	50	50	0
	Two	100	100	100	100	100	100	50	50	50	100
Possible causes of abortion[2]	1	100	100	100	0	100	100	100	100	100	100
	2	80	0	0	0	0	0	0	0	0	100
	3	50	0	100	0	66	100	100	50	100	100
	4	80	0	100	50	0	0	0	0	0	0
	5	0	100	50	100	100	100	100	100	100	0
	6	0	0	0	0	100	100	0	0	0	100

Key

[1]**Kidding season**

Fix = kidding is at fixed times of the year,

[2]**Possible causes of abortion**

1- Trypanosomosis, 2 - Pneumonia, 3 - Streptothricosis and Mange, 4 - abortion due to consumption of Acacia pods, 4 - Brucellosis and 6 - abortion due to consumption of plants other than acacia pods.

Table 3.13

The average reproductive performance and wastage parameters achieved by the Sheep and Goat Multiplication Centres between 1987-1990, expressed as a percentage.

	Mat.	Bach.	Kit.	Naiv.	Kim.	Mar.	Mac.	Narok
% Fertility rate	73	73	-	72	93	53	-	79
% birth rate in flock/yr	44	34	35	71	60	30	33	45
% birth rate in does/yr	88	58	67	134	94	50	57	72
% weaning rate	68	72	-	85	97	57	-	72
% mortality rate per annum	23.0	16.7	13.0	15.4	9.9	14.7	31.0	10.0
% offtake rate per annum	15.6	17	16.5	40.2	14	30	9.8	24.4

Key.

Station

Mat.- Matuga, Bach.- Bachuma, Kit.- Kitengela, Naiv.- Naivasha, Kim. - Kimose, Mac. - Macalder, Mar - Marindas, Nar -Narok

yr - year

During one site visit in Isiolo, 400 does bought by the Uaso Nyiro North Development Authority to serve as the nuclear flock, were found at various stages of abortion (Figure 3.3). The cause was confirmed to be brucellosis by RBPT, SAT and CFT.

In Baringo, Koibatek, Kitui and Makueni districts, the consumption of "spoilt or immature" acacia pods "chetibit" (Tugen) or "eldumeyon or sashawick" (Jemps) or "kiaa" (Kamba) was believed by the local producers to cause abortion, within weeks of being consumed (Table 3.12).

In comparison in Tharaka-Nithi, Kiburine and Marimanti Sheep and Goat Multiplication Centres, abortion accounted for 3-20% of the losses while loses due to stillbirths and 48 hours mortality (parturient deaths), ranged between 1-70% (Table 3.13).

4.4.2.4.2 Delayed and late postnatal mortality - 1 week to weaning.

Pre-weaning mortality rate was expressed as a percentage deaths occurring among kids born (age-specific preweaning mortality) rather than total deaths occurring in the flock (total flock mortality). In preweaning mortalities, stillbirths and parturient deaths were lumped together due to difficulties in ascertaining the status (i.e abortion versus stillbirth versus parturient deaths) (Tables 3.12, 3.14).

Figure 3.3
A doe showing imminent signs of abortion during an abortion storm on the UASO Nyiro North Development Authority holding grounds in Isiolo. Seventy percent of the serum collected had high brucella antibody titres on RBPT, CFT and SAT.

Table 3.14.

Some reproductive wastage parameters, expressed as average percentage of the respondents, in selected goat flocks.

VARIABLES	BAR	NAR	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
% Abortion/ Year	6	8	2	8	5	8	15	10	20	10
% mastitis cases Season										
- rain	100	50	80	100	50	50	50	50	100	80
- Dry	0	50	20	0	50	50	50	50	0	20
% preweaning mortality	10-25	5-50	20-30	5-50	40-50	5-40	30-70	30-40	10-30	10-50
% adult mortality/yr (range)	5-30	20-50	5-10	5-10	20-30	10-20	5-20	5-10	5-15	5-20

Table 3.15

Causes of preweaning and adult mortalities as ranked in order of importance by goat producers and Animal Production and Veterinary personnel in the areas surveyed.

VARIABLES		BAR	NAR	KJD	KTI	MAR	SAM	MSA	KLF	LAM	MAN
Ranked possible causes of preweaning mortality	1	1	2	7	6	4	7	2			1
	2	2	1	1	1	2	2		1	1	3
	3	3	3	5	2	1	1	1	2		
	4	4	5	3				3	4	2	2
	5	11	6	6				5	3	5	7
	6	5	4	2	4	3	3				5
	7	6	11			8	8				6
	8	7	7			6	4			4	7
	9	8	9		5					5	
	10	9	8		3	7	6			3	
	11	10	10	4		5	5				
Causes of death in adults	1	3	0	4	5	5	0	4	5	0	0
	2	2	0	2	2	2	2	5	2	5	2
	3	4	0	0	0	7	5	0	0	0	0
	4	8	0	0	6	4	3	0	0	0	6
	5	7	0	0	0	0	0	3	0	0	0
	6	9	4	3	7	3	6	6	4	1	4
	7	6	5	0	0	0	7	0	0	4	5
	8	5	1	5	3	6	4	1	3	3	3
	9	1	2	1	1	1	1	2	1	2	1
	10	0	0	0	0	8	8	0	0	0	0
	11	10	0	0	0	0	0	0	0	0	7

Key.

Causes of preweaning mortality

1 - Born weak and dies of Starvation, 2 - Gastroenteritis, 3 - Gastroenteritis and pneumonia, 4 - Pneumonia alone, 5 - Trypanosomosis, 6 - Helminthosis, 7 - Mange, 8 - Orf, 9 - Heartwater, 10 - Predation and 11 - Fleas and/or lice infestation.

Causes of adult deaths

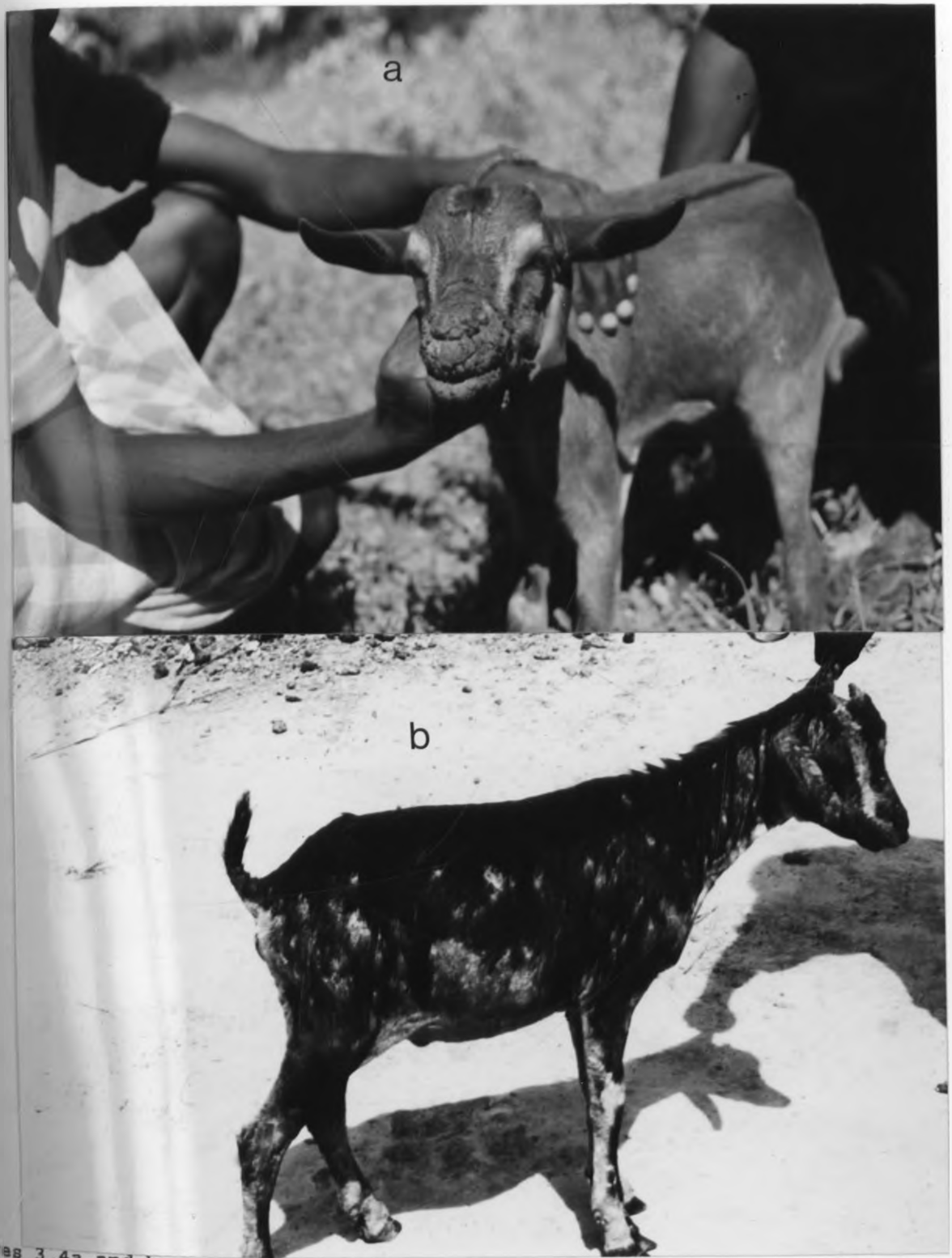
1 - skin diseases, 2 - Helminthosis, 3 - Starvation, 4 - Water and/or plant poisoning, 5 - Bloat, 6 - Heartwater, 7 - Predation, 8 - Trypanosomosis, 9 - Pneumonia (CCPP), 10 - Anthrax and 11 - Footrot

Early (parturient) and delayed mortality (the former was recognized by only about 10% of the producers interviewed, averaged about 10% (0-70%), while preweaning mortality (late postnatal) was slightly lower (average 5% - range 5 to 50%). According to the producers and Veterinary and Animal Production staff the most likely causes of preweaning mortality listed in order of importance were:- kids born weak and unable to suckle (secondary starvation), pneumonia, diarrhoea (gastroenteritis), helminthosis, flea, mange and lice infestation, fungal infections, trypanosomosis and heartwater. Outbreaks of orf and fungal infection were observed to have severe debilitating effects on kids (Figures 3.4a and b). The producers listed parity and season of birth as the most important variables influencing the rate of postnatal deaths (Table 3.15).

The causes of preweaning mortality recorded in the Multiplication Centres only differed with those listed in the areas surveyed only in priority (Table 3.16).In comparison parturient deaths (stillbirths and 48 hour mortality) in the Centres, including those in Kiburine and Marimanti, where parturition was supervised and proper records kept, ranged between 5-50% (Appendix 4.2a).

4.4.2.4.3 Adult mortality rate.

Annual adult goat mortality rate in the areas surveyed averaged 5% (range: 0 to 20%), while total flock mortality in the centres was between 10-30% (Tables 3,15, 3.16).



Figures 3.4a and b.
Two kids suffering from Orf (Contagious papular dermatitis)(a) and severe co-infection with mange and trichophyton (b), both of which predispose the kids to secondary starvation and bacterial infections.

The producers, Veterinary/Livestock department staff cited the major causes of death as pneumonia (contagious caprine pleuropneumonia -ccpp), helminthosis, starvation, footrot, bloat, trypanosomosis, predation and accidents (Tables 3.15). In the Sheep and Goat Multiplication Centres, pneumonia, enteritis, general body weakness, poisoning and predation accounted for more than 70% of the causes of death (Table 3.16).

4.4.2.5. Mastitis and udder abscesses.

The mastitis attack rate, based on the number of cases in a year divided by the number of mature females, was about 1.0% (range 0-10%). Where the disease occurs, it occurs mainly during the rain season, except in Baringo-Koibatek where it was said to occur throughout the year (Table 3.14). In the Kiburine and Marimanti Sheep and Goat Multiplication Centres S. aureus (37%) and A. pyogenes (4%) and beta haemolytic Streptococci (4%) were the most common bacterial isolates from udder secretions, milk/pus, obtained from does with mastitis characterized by abscess formation and necrosis (Table 3.17; Figure 3.5). Chronic mastitis in these two multiplication centres resulted in the loss of a half of the udder in 5% of the affected does while para - acute mastitis was estimated to cause deaths in 10% of the does. One buck with rudimentary teats, gynaecomastacia and an abscess had a pure S. aureus isolate (Table 3.17).

Figure 3.5
A doe with severe gangrenous staphylococal mastitis.

Table 3.16

The major causes of mortality and the mean percent mortality between 1987-1990 in state owned sheep and goat multiplication stations in Kenya.

DISEASE	MAR	NAR	KIM	KIT	BUC	MAT	MAC	Percent of Total
Pneumonia	27	19	32	49	18	48	28	9
Enteritis		12			1	22	17	5
Sudden death					12		0.7	52
Poisoning (plant)	2	5	5	1	2			3
Predation		3	4	18	2			5
In-appetence or Starvation			1	16		30		6
Dip poisoning	3		5	4				2
Trypanosomosis	13			8	18			4
Haemonchosis	2		3	4	14			4
Heartwater	4	6	6	2	14	1		4
Unknown		20	11					3
Others								32.5

Key.

Naivasha - NAI, MAR - Marindas, NAR-Narok, KIM-Kimose, KIT-Kitengela, BUC-Bachuma, MAT-Matuga and MAC-Macalder.

Table 3.17

Frequency of bacterial isolates from does with udder abscesses and mastitis in Marimanti and Kiburine Sheep and Goat Multiplication Centres (1993).

Isolate	No. of isolates	Percent of total.
S. aurues	12	39
E. coli	3	10
A. pyogenes	4	13
Beta haemolytic Streptococcus	4	13
Pasteurella sp.	1	3
Klebsiella sp.	1	3
Total	31	
No growth	6	19

4.4.2.6. Buck infertility and control of breeding.

Producers and Veterinary / Animal production staff in Baringo-Koibatek district listed hyperkeratinization of the scrotum with generalized alopecia due to either streptothricosis, mange, or trichophyton infection as the major cause of male infertility. Other causes of buck infertility in Baringo-Koibatek were listed as physical testicular injuries, brucellosis, lameness, weakness after drought or trypanosomosis.

In Narok and Kitui, brucellosis and orchitis of unknown etiology were listed as the main causes of buck infertility, while besnoitiosis and scrotal injury were listed as the major causes in Mandera and Kajiado. Besnoitiosis was reported in Kajiado, in areas such as Elang'ata Wuasi and Kangiri in bucks that had been bought from Tharaka-Nithi district. Brucellosis and trypanosomosis were suspected to be the main causes of buck infertility in Mombasa, Kilifi, Lamu and Marsabit. Producers in Transmara district indicated that they had not observed or recorded any cases of buck infertility,

Flocks in Baringo-Koibatek (10%), Marsabit (10%), Mandera (35%), Kajiado (10%), Mombasa (5%), Tharaka-Nithi (25%) were found affected by besnoitiosis (Besnoitia capri) while the flocks examined in Lamu, Kwale and Kilifi did not show any signs of the disease. Eleven bucks, 2 with subacute, 5 with acute, and 4 with chronic besnoitiosis at the Kiburine/Marimanti (Tharaka-Nithi) Sheep and Goat Multiplication Centres, were donated to the Clinical Studies Department, for further examination. On electroejaculation, the bucks with subacute and acute involvement, had semen that was comparable to that from

unaffected bucks (Table 3.18). There were however wide variations in semen quality between individual bucks. The primary and secondary defects were higher (20-30%) in semen obtained from bucks with subacute orchitis compared to those that had acute involvement. The bucks with chronic besnoitiosis characterized by fibrosis, with marked reduction in size of the testicles, had poor quality semen which was severe enough to interfere with fertility (Table 3.18, Appendix 3.4a-c).

Reproductive control was effected by separating males from females and by the use of an apron tied in front of the prepuce, to act as a contraceptive device.

4.4.3.0. Screening for diseases capable of affecting reproductive performance.

4.4.3.1 Leptospirosis - Positive reactions, a titre of 1/50 or above using plate agglutination test, were detected in serum samples obtained from all areas surveyed. Lamu (100%) and Mandera (75%) had the highest prevalence rate while those from Makueni (30%), Mombasa and Kilifi (25%) and Baringo/Koibatek (10%) had low prevalence rates. For comparison serum samples obtained from goats in Turkana, Thika and Nairobi were included (Table 3.19). Samples from Kajiado and Narok were not screened due to loss of reference antigen.

Table 3.18

Quality of semen collected from bucks donated from the Marimanti and Kiburine Sheep and Goat Multiplication Centres, Tharaka-Nithi, suffering from besnoitiosis.

Semen parameter	Acute[1] n=5	Subacute[2] n=2	Chronic[3] n=4
Volume	2.2±0.38	2±0.50	1.4
Colour	Milky-Yellowish	Milky	Milky
Density	Creamish	Milky	Milky
Concentration	$8.2x10^5$ $\pm1.8x10^4$	$5x10^5$ $\pm5x10^5$	$2.8x10^3$ $\pm2x10^3$
Wave motion of swirl[4]	None	None	None
Percent motile (individual)	74±40	65±15	30±17.8
Mass motility[5]	3.0	2.0	1.0
% Live	65± 11.4	62.5± 17	46.25± 15.50
pH	6.68±0.04	6.7±0.10	6.8
Other cells	Epithelial	None	Epithelial
Defects Primary	20%	30%	2%
Secondary	10%	20%	4%

Key.

[1] = Acute orchitis, [2] - Subacute orchitis, [3] - Chronic orchitis.

[4] Wave motion of swirl - a visual examination of semen in the collecting tube ranked 0-6 with 0 = very poor, 1 = poor, 2 = fair, 3 = fairly good, 4 = good, 5 = very good, 6 = excellent.

[5] Mass motility - a microscopic examination of undiluted semen ranked as A(or1) = poor, B(or2) = fair, C(or3) = good and D(or4) = Very good.

4.4.3.2 Rift Valley fever, (RVF) - Based on the practice at Vetlabs titres of 1/50 and above, using the virus neutralization test, was interpreted as positive. Using this criteria the prevalence of RVF antibodies, which was widely distributed in the areas surveyed, was between 10 and 90%, with the highest (>70%) prevalence rates being in Baringo, Mandera and Narok (Table 3.19). The lowest (<30%) prevalence rates were detected in samples obtained from Nairobi, Turkana and Lamu.

4.4.3.3 Brucellosis - Based on the Rose Bengal precipitation test (RBPT) results, brucellosis was widely spread and especially in open flocks from Narok, Mandera and Baringo-Koibatek (Table 3.19). Based on the CFT and SAT results, however, none of the serum samples were positive for brucellosis (Table 3.19).

4.4.3.4 Trypanosomosis - Based on blood smears only two (Makueni and Narok/Transmara) of the survey areas returned positive results. In comparison the results of antigen detection test indicated that T. congolese and T. vivax were distributed over most of the areas surveyed (Table 3.20).

Table 3.19.

Prevalence of leptospirosis, rift valley fever and brucellosis based on antibody titre in sera collected during the field survey and on-farm studies. (All sera with a titre of 1:50 and above was recorded as positive).

Location and sample size	Percent of serum positive for Leptospirosis	RVF[1]	Brucellosis
Mandera (n=196)	77	58	28
Mombasa (n=84)	25	38	0
Lamu (n=58)	100	24	0
Machakos (n=70)	30	29	0
Baringo (n=86)	30	70	30
Narok (n=180)	Nt	90	51
Nairobi (n=100)	Nt[2]	10	0
Thika (n=156)	18	40	0
Turkana (n=120)	Nt	18	40

Key. - 1. Rift valley fever, 2. Nt - Not tested.

Table 3.20.

Prevalence of T. vivax and T. congolese antigens in serum collected during the field survey and on-farm studies.

Location and No. samples(n)	Percent of serum positive for T. vivax	T. congolese
Narok (n=16)	13	7
Mandera (n=58)	8	9
Lamu (n=20)	10	11
Machakos(n=27)	7	0
Baringo (n=86)	0	2
Mombasa (n=23)	0	0
Thika(n=17)	6	12

4.4.0. DISCUSSION.

The greater activity exhibited by the right ovary observed in the present study confirms reports of Lyngset (1968), Gonzalles (1977) and Rao and Bhattacharyya (1980). The low number of multiple ovulations, which were mostly encountered on the left ovary, compared well with the low (<10%) twinning rates observed in slaughterhouse organs and field studies. These findings are similar to those observed in the Indian goat (Rao and Bhattacharyya 1980).

In the present study the low (<5%) incidence of structural and functional defects, genital tract infections and embryonic/fetal loss observed may have been a reflection of the low numbers of organs examined or the high rate of home slaughter of infertile does rather than their low ranking as causes of reproductive losses in goats. The erosion of the endothelium, strata compactum and spongiosum associated with chronic purulent endometritis would, however, tend to give a guarded prognosis to future breeding. This is because healing may, as is common in the mare and the sow under similar circumstances, be by fibrosis which may interfere with future implantation (Nieberk and Cohrs, 1966).

Based on uterine and vaginal cytology bacterial cultures were poor indicators of an active infection, suggesting that there was little relationship between the presence of potential disease causing pathogens and an active infection. This finding would, as in the mare, cast doubt on the usefulness of a single positive bacterial vaginal swab in the diagnosis of metritis in the doe, unless accompanied by a positive cytology (Munyua 1982; 1985; Williamson *et al.*, 1985).

Uterine fluid collected from uteri of does with severe acute and chronic purulent endometritis had protein levels of between 7-10mg/ml and 44-47mg/ml (45± 1.7mg/ml) respectively. It is possible therefore, in cases where cervical drainage is not hindered, that high protein levels in vaginal flushing may be useful adjuncts to vaginal bacteriology and cytology in arriving at a diagnosis of caprine metritis, as is the practice in the mare (Williamson et al., 1983).

The occurrence of diseases that affect reproduction including caprine brucellosis (Kagunya and Waiyaki, 1978) and leptospirosis (D'Souza, 1983; Ndarathi et al. 1991) in goats in the arid and semi-arid areas of Kenya have been reported. The occurrence of various leptospira serovars in different parts of Kenya has previously been found to be related to ecological zones with L. wolffi and L. hardio thriving well in arid and semi arid zones IV and V (D'Souza, 1983; Ndarathi et al., 1991). Serological examination of the goat sera collected during the field survey indicated that rift valley fever, brucellosis, leptospirosis and trypanosomosis were prevalent in most areas. The wide distribution of rift valley fever and leptospira antibodies was rather surprising and especially to the Veterinary and Animal Production Department staff who tended to incriminate brucellosis and trypanosomosis for most abortions without subsequent laboratory confirmation. The high prevalence rate of positive reactors to leptospirosis, brucellosis and rift valley fever in apparently healthy goats and flocks without history of abortions suggests a possible carrier state for leptospirosis, brucellosis and rift valley fever in goats which may serve as a source of

infection to other animals and humans. It is important that the goat producers and the Veterinary and Livestock Development staff in these areas be alerted on the presence of these diseases not only because they are economically important but also because they are zoonotic.

Plant poisoning was listed as a possible cause of abortion in most of the areas surveyed with producers in Baringo-Koibatek incriminating "spoilt" acacia pods while those in Kitui and Makueni blamed the "immature" ones. While it is possible that the abortion may be due to chemical(s) inherent to the pods at a particular stage of development it is also possible, as suggested by producers in Baringo-Koibatek, that the pods were contaminated with a fungus that was responsible for the abortion. Studies are necessary to elucidate this finding.

The presence of besnoitiosis in flocks in the Sheep and Goat Multiplication centres in Kiburine, Marimanti, Bachuma and Matuga is worrying, given the severity of testicular lesions and their effects on semen quality. The nationwide distribution of breeding materials from these stations and the lack of awareness among field personnel and producers of manifestation and possible impact of the disease on production posses great risk to the future of goat production in Kenya. In the present study the disease was detected in goat flocks in Baringo, Koibatek, Mandera, Isiolo, Meru, Tharaka-Nithi and Kajiado. It is suspected that the initial breeding stock, bought from Wajir and Mandera and stationed in the Kiburine and Marimanti centres may have been the source of the besnoitia infection to the other Sheep and Goat Multiplication Centres and districts. To protect the Kenyan goat

industry it is critical that producers and veterinary personnel are appraised on this disease, its clinical manifestations and possible economic impact.

The prevalence of mastitis, which was mainly due to S. aureus, A. pyogenes, alpha and beta haemolytic Streptococcus, E. coli and Pasteurella sp. (Maina et al., 1992) was between 5-10% in the areas surveyed. In Kiburine and Marimanti stations where the condition was studied in greater detail, the disease resulted in loss of udder function and death in 5% and 10% of the cases respectively. This observation suggested that the disease may be of great economic importance where does are milked daily and the disease is unchecked. The organisms isolated in the cases of mastitis were similar to those isolated from postmortem materials obtained from kids with evidence of pneumonia and gastroenteritis. This was taken to indicate that milk could be an important potential source of goat kid pulmonary and gastrointestinal pathogens (Chapter 4). In addition where milk is shared with children, as was the case in most (>90%) of the areas, high incidence of mastitis and loss of udder function would mean a high exposure of children to potential pathogens and a drop in the amount of milk available for home consumption.

Productivity in small ruminants is more sensitive to survival of young lambs and kids than to any other factors (Upton, 1984, Panin, 1996). In similar studies Wilson et al. (1985) showed that poor reproductive efficiency, which greatly determines the profitability of a production system, was an important constraint to the attainment of optimal production in goats in tropical Africa. Other workers have concluded that the major contributors

to the poor reproductive efficiency observed in free range goats were diseases, malnutrition, poor management and lack of veterinary inputs (Kyomo, 1978; Wilson et al., 1985; Belay et al., 1996). In the present study preweaning mortality, which ranged between 10-70%, was a major constraint to improving reproduction in goats. In Machakos, Kajiado, Baringo-Koibatek, Marsabit, Samburu and Kilifi districts E. coli gastroenteritis, with or without septicemia, and/or pneumonia and helminthosis were the most important causes of pre-weaning kid mortality.

Data available from the present study showed that about 85% of the respondents used commercially available anthelmintics. Based on the manufacturers recommendations, 60% of the respondents underdosed while 20% overdosed. The former rendered the drug ineffective, while the latter made the producers incur unnecessary expenses. Of those that did not drench their goats 20% of the producers in Baringo-Koibatek, Narok and Transmara and 50% of the producers in Samburu and Marsabit used herbal concoctions (Munyua et al., 1995b, 1996c). None of the producers interviewed administered or applied coccidiostats, insecticides or acaricides to preweaned kids. This practice is believed to have led to a rapid build up of external and internal parasites which often resulted in anaemia. This state may have contributed to the increased susceptibility to disease or to poor response to disease once established. This practice may also account for severity of low grade gastrointestinal infections. The situation was compounded by the reluctance of affected producers to procure antibiotics as they did not consider it "economical" to treat goat kids. This may be a reflection of their value judgement and

production objectives (Mazzucato, 1997). It is, however, important that goat producers in arid and semi-arid areas are made aware of the fact that anaemia due to lice and flea infestation and gastrointestinal parasitism, including helminthosis and coccidiosis, predisposes preweaned kids to other diseases. And that high preweaning mortality represent a loss of potential breeding material and the stock available for sale in future.

Care should, however, be taken when setting out the intervention packages as the high perinatal mortality observed in Sheep and Goat Multiplication Centres shows the availability of qualified personnel and veterinary inputs is not a panacea to high reproductive wastage. The type of intervention package selected should vary with the production objectives and system, producer acceptability and the availability and cost of drug(s), vaccine(s) and personnel to administer the package correctly.

Non availability of drugs and chemicals at affordable prices, poor marketing outlets and lack of producer training were said to be the major constraints to improve livestock production in the areas surveyed. These constraints are compounded by resource scarcity, including investment capital, feed and water, and recurrent drought. As in other studies producers in the areas surveyed pointed out that while the recurrent drought was an expected phenomenon, their traditional responses were being hampered by changing land tenure, population pressure and increasing scarcity of resources, including water and grazing grounds (Mucuthi and Munei, 1996).

From the findings of the present study it is apparent that

there is a need to make veterinary services more accessible and to train producers to perform simple procedures including recognition and treatment of common diseases and conditions. It is also important that the proper use of drugs and chemicals to reduce drug/chemical abuse that is currently widespread be emphasized at all levels.

As predators or competitors of feed and water, wild animals were considered by 50-100% of the respondents as pests and a menace. This attitude was more apparent in Marsabit, Samburu, Baringo-Koibatek, Narok, Transmara, Kajiado, Kitui, Makueni, Kwale and Lamu, where the producers have given way to the setting up of common property resources in form of national parks and reserves. Sharing the proceeds from tourism and introduction of alternative sources of production, including eco-tourism and ostrich and game ranching, may go a long way in safeguarding this national heritage that is currently viewed as a common nuisance (Munyua and Onyari, 1996).

Based on the findings of the present study it was found to be necessary to carry out a detailed study to determine the factors influencing reproductive performance and wastage on selected farms before and after the introduction of intervention packages. The response of the flocks to the intervention was used to estimate the profitability and income contribution of goat production.

CHAPTER 5

Reproductive efficiency on selected farms, with emphasis on the management of preweaning mortality and economics of veterinary intervention - an on-farm study.

5.1.0. Introduction.

On-farm research (OFR) in farming systems research (FSR) involves the identification of problems and opportunities, development of a research base, design of an on-farm research plan, execution of the research, analysis and appraisal, implementation, evaluation and extension of the research (Amir and Knipscheer, 1987; 1989). Unlike traditional agricultural research, FSR aims at understanding the farm, the farmer/producer and farm environment holistically, using technology and participatory approach to solve farming system problems (Devendra, 1987; Amir and Knipscheer, 1987; 1989; Tripp and Wolley, 1989; Stround, 1989; Chambers, 1987; 1992). There are two programmes and approaches that can be adopted in FSR, an upstream and a downstream programme (Simmonds 1985; Devendra, 1987). The upstream FSR programmes, which take several years to complete, generate prototype solutions which lead to major shifts in potential productivity of farming systems in general (Simmonds 1985). The downstream FSR programmes, on the other hand, identify and test possible site specific innovations that can be easily integrated into existing farming systems via on-farm trials (Simmonds 1985).

Veterinary intervention packages, including vaccinations

against anthrax, pasteurellosis and "pestes des petits ruminants" (PPR), and external and internal parasite control, given in an attempt to improve reproductive efficiency have produced conflicting findings (Traore and Wilson, 1988; Bosman and Ayeni, 1993; Ba and Udo, 1995, Munyua et al., 1996b). Working in Mali Bosman and Ayeni (1993) and Ba and Udo (1995) concluded that veterinary intervention packages, including vaccinations against pasteurellosis, anthrax and PPR, external and internal parasite control, did not have a significant effect on kid mortality, despite the fact that 50% of the reported deaths were due to infectious diseases. Bosman and Ayeni (1993) on the other hand argued that priority in reducing preweaning mortality in kids should be given to improving management practices. In contrast Traore and Wilson (1988) and Munyua et al., (1996b), showed that mortality can be reduced by 30% and 70% by the use of a vaccine produced from a local strain of Pasteurella spp. and strategic drenching and treatment respectively.

The work described in this chapter was undertaken to document reproductive efficiency and the economics of veterinary intervention on selected farms.

5.2.0. AIMS.

The specific aims of the study were to:

i) Establish the factors influencing reproductive performance and wastage on selected farms in sedentary and semi-sedentary production systems, with emphasis on causes and management of preweaning mortality.

ii) Assess the effectiveness and economics of the proposed veterinary intervention strategy.

5.3.0. MATERIALS AND METHODS.

5.3.1. The selected study areas.

The farms selected for on farm study were: Naroopa Ongila (Narok - 2 farms), Enkasit (Kajiado - 2 farms), Stony Athi (Machakos - 1 farm) and Juja (Thika - 2 farms). In these areas, except Juja, the main occupation is livestock production with limited subsistence crop production. These areas have semi-arid tropical climate characterised by: a reliable short rainy season between October and December, a long dry season between January and March, an unreliable long rain season between March and May and a cold dry season between June and August. The mean annual temperatures are 27°C (14.5°C July - 33.4°C February). Vegetation in all study areas is greatly influenced by the rainfall and temperatures.

5.3.2. Selection of animals and design of the intervention package.

Goats, mainly Small East African and Small East African x Galla crosses, in 6 traditionally managed flocks and one commercial flock in Stony Athi Ranch, Machakos were studied between 1989 and 1994. In both the traditional and the commercial flocks, the goats were taken to pasture by day and kept in enclosures made of thorny branches, barbed wire and poles or timber off-cuts and poles by night.

All breeding bucks and at least 40 does and their offsprings in the commercial farm and the two farms in Juja were weighed and

tagged. The producers in Narok and Kajiado would not allow tagging as this amounted to counting which was a taboo. The selected flocks were visited once or twice a month when their nutritional status was assessed, body conditions scored (Santucci et al., 1991), the dams and kids weighed and appropriate samples collected. The breeding bucks were weighed before, during and after the breeding season.

In the first and second year of the study no veterinary intervention was undertaken and producers were requested to continue managing the conditions and / or diseases as they always had. During the second and third years all sick kids were examined, samples taken and sick kids treated appropriately.

The details noted during each visit included nutritional status, reproductive events such as age at first heat and parturition, kidding season, service period, interkidding interval, litter size, changes in dam bodyweight postpartum, kid growth rate, preweaning mortality and causes of stock disposal. Autopsies were performed on any fresh carcases at the Pathology Department of the University of Nairobi, Kabete.

5.3.3. Clinical examination and sample collection.

5.3.3.1. Clinical examination of preweaned kids.

All sick kids and at least 10% of the unaffected kids were restrained and clinically examined on each of the farms at each visit. This approach was found to be adequate for the present study.

5.3.3.2. Samples obtained from kids.

5.3.3.2.1. Internal and external parasites - All kids restrained in (i) above or at least 10% of the kids, whichever was higher, were checked for external parasites, including ticks, lice and fleas, at each sampling. Kids were bled for routine haematology in cases of heavy infestation or indications of anaemia.

5.3.3.2.2. EDTA and clotted blood - EDTA blood for routine haematology and clotted blood for harvesting serum for immunoglobulin (IgA and IgG), E. coli antibodies and total protein assays was collected from birth to weaning at 4 months and processed as described in Chapter 2.

5.3.3.2.3. Faecal samples - Faecal samples, for egg count and parasite identification, and mycoplasma, viral and bacterial isolation, from kids suffering from gastroenteritis characterized by diarrhoea, were collected and processed as described in Chapter 2. All E.coli isolates were subcultured in McConkey and blood agar media and preserved in cooked meat media for subsequent serotyping, drug sensitivity and pathogenicity tests (Chapter 2).

5.3.3.2.4. Postmortem - All fresh aborted fetuses, stillborns and dead kids were collected and presented for postmortem at the Pathology Department, University of Nairobi, Kabete, as described in Chapter 2. In addition producers were also left with scalpel blades and pre-labelled universal bottles containing 10ml of 10% formalin into which they were requested to place 2x2cm sections of the liver, lungs, kidney and small intestines obtained from kids that died of a "disease" in between the visits.

5.3.3.2.5. **Lung flushing** - Lung flushing and/or aspirates were collected aseptically from all fresh carcasses of kids presented and processed for bacterial isolation as described in Chapter 2.

5.3.3.3. **Samples obtained from dams.**

5.3.3.3.1. **EDTA and clotted blood samples** - EDTA blood samples for routine haematology and clotted blood for serological screening of reproductive diseases, total protein and 1mmunoglobulin (IgG) levels and E. coli antibody titre was obtained from does during the farm visits and processed as described in Chapter 2.

5.3.3.3.2. **Colostrum and milk** - Colostrum (20ml) and milk (20ml) were collected from the tagged does for immunoglobulin and E. coli antibody assays as described in Chapter 2.

5.3.3.3.3. **Vaginal swabs** - Two vaginal swabs were obtained from each of the tagged does at 2 week intervals for 6 weeks postpartum. The first swab was used for bacterial isolation while the second was used for routine cytology as described in Chapter 2.

5.4.0. **Economics of the veterinary intervention package.**

5.4.1. **Veterinary intervention programme.**

Between the third and fourth year of the study a quarterly drenching programme and a policy of treating all kids in the flock when >10% of the kids were affected by any condition, including infestation with external parasites, was instituted. Where <10% of the kids were sick, only the affected kids were treated. The does were drenched at least 3 times per year or whenever the eggs per gram (epg) rose to over 500 or packed cell volume fell to less than 15%, or the blood smear showed marked eosinophilia. The pre-weaned

kids on the other hand were drenched when faecal egg count (FEC) was above 200 epg, packed cell volume fell to less than 21% or they were observed clinically to have pale mucous membranes and/or increased capillary refill time.

5.4.2. Economics of veterinary intervention.

The economics of instituting these interventions in the goat production enterprise were assessed using budgetary analytical methods based on costs and returns before and after intervention (Jost, 1972; ILCA Manual, 1986; Panin, 1996).

Total costs were obtained by estimating both the operating and fixed costs. The operating costs consisted of the variable inputs used by producers including drugs and chemicals, supplement, risk of mortality and replacement stock while the fixed cost was obtained by valuing family labour (or opportunity cost), night and day enclosures and implements, income for invested capital and interest on shed and circulating capital.

To calculate the benefits of veterinary intervention realized during the on-farm study the flock performances before (April 1990-91) and after (December, 1992-93) in Juja A and B and Enkasit, Kajiado were used. It was assumed that the average flock size was 160 (100 does, 4 bucks, 20 castrates, 36 kids) preweaning mortality before and after intervention was 70% and 5% respectively and the value per litre of goat milk was 16.0Ksh./l. Based on the results of the field surveyed, and assuming that production objectives do not change, it was projected that the producers would sell all one year old castrates, dispose of about 5% of the does due to age or

infertility and hold one buck in stock or exchange it with neighbours and friends. It was assumed that the adult mortality risk would hold at 5%. An average interest rate of 26% representing the then market interest rate for capital was used to reflect the opportunity cost tied up in form of investment in goats (Tables 4.8a, b).

5.5.0. Sheep and Goat Multiplication Centres.

To accurately assess reproductive efficiency in goats, including birthweights, age at first kidding, preweaning deaths, disease situation and sales, in the traditional production systems, secondary data for the years 1989-1994 was obtained from Olmagogo and Top Farm (Naivasha), Kimose (Koibatek), Marimanti and Kiburine (Tharaka-Nithi) Sheep and Goat Multiplication Centres for comparison.

5.6.0. RESULTS.

In the traditional and the Stony Athi ranch flocks all females born qualified for inclusion in the breeding flock while only a few males were selected. All males not selected for breeding were castrated at 6-12 months of age. Under the traditional production system breeding was controlled by tying a plastic or canvas apron just cranial to the prepuce, while no attempt was made to control breeding on the commercial ranch. The male kids not selected for breeding on the commercial farm were grazed in a separate flock intended for sale to other producers.

5.6.1. Changes in flock structures.

Flock structure changes, indicating an apparent increase in numbers in all groups of animals, are shown on tables 4.1a-d. The main kidding season was October - November of each year, and to a lesser extent April - June of each year. Breeding bucks, which ranged between 12 and 20% of the breeding flock between 1989 and 1994, were recruited into the breeding flocks at the age of 6 months depending on growth rate and the past performances of the sire and dam. Producers either exchanged or bought bucks to avoid in-breeding.

In the flocks studied the proportion of females remained the highest (32-80%) over the 3 year period, while castrates were highest in number (13-25%) in Naroopa-Ongilla, Narok, due to low offtake rates (Tables 4.1a-d). The ratio of male:female kids born in 1989 was 0.72:1.0, while early 1990, January to May, it was 1.0:1.0 and later in 1990 (June to August) 1.45:1.0. In 1991 the ratio was 1.0:1.6. Thus for most of the period that the flocks were under observation more female kids were born and survived than male kids.

The Machakos commercial ranch had two main kidding seasons, June-August and November-December. Kid mortality ranged between 30 and 40% over the first 2 years but this rose to over 80% in 1991 following an outbreak of contagious caprine pleuropneumonia (CCPP). Twinning in this flock remained less than 10% throughout the period of study.

Table 4.1a.

The flock structures on farms selected for the on-farm studies, expressed as a percentage of the numbers in the flock at the time of the visit, and the average percent preweaning mortality for the period preceding the visit (April - August 1990).

Location	Total	Does %	Males %	Castrates %	Weaners %	Kids %	Preweaning % mortality
Thika	90	43	8	3	31	15	40
Juja A	120	81	4	-	13	2	50
Juja B							
Narok	796	43	3	25	11	18	70
Suswa	200	75	2	0	5	18	40
Elasit							
Kajiado	230	48	9	16	10	17	30
Enkasit A	450	56	11	21	1	11	70
Enkasit B							

Table 4.1b.

The flock structures on farms selected for the on-farm studies, expressed as a percentage of the numbers in the flock at the time of the visit and the average percent preweaning mortality for the period preceding the visit (November 1990 - February 1991).

Location	Total	Does %	Males %	Castrates %	Weaners %	Kids %	Preweaning % mortality
Thika							
Juja A	112	43	13	1	27	16	30
Juja B	136	74	15	-	9	2	60
Narok							
Suswa	300	44	13	-	9	34	45
Elasiti	1362	33	20	-	13	34	55
Kajiado							
Enkasit A	75	66	10	-	10	14	40
Enkasit B	150	57	10	11	12	10	50

Table 4.1c.

The flock structures on farms selected for the on-farm studies, expressed as a percentage of the numbers in the flock at the time of the visit and the average percent preweaning mortality for the period preceding the visit (April - August 1992).

Location	Total	Does %	Males %	Castrates %	Weaners %	Kids %	Preweaning % mortality
Thika.							
Juja A	39	43	2	-	20	25	0
Juja B	84	47	7	-	11	35	5
Kajiado							
Enkasit A	77	31	3	12	29	25	5
Enkasit B	137	58	2	3	19	18	5
Narok							
Suswa	600	SUBSEQUENTLY EXCLUDED FROM THE STUDY DUE TO					
Elasit	225	FREQUENT CHANGES IN OWNERSHIP AND MIGRATION.					

Table 4.1d.

The flock structures on farms selected for the on-farm studies, expressed as a percentage of the numbers in the flock at the time of the visit and the average percent preweaning mortality for the period preceding the visit (November 1992 - February 1993).

Location	Total	Does %	Males %	Castrates %	Weaners %	Kids %	Preweaning % mortality
Thika							
Juja A	39	51	5	-	24	20	27
Juja B	50	64	2	-	18	16	39
Kajiado							
Enkasit A	66	36	15	14	-	35	0
Enkasit B	137	55	1	-	24	20	0

5.6.2. Reproductive performance.

5.6.2.1. Age at first parturition.

The mean of age at first parturition observed at the Machakos ranch in 1989 was 517.5±61.8 days (n=5, range 450-600 days), while in 1993 pubertal does (n=7) in Juja (A) first kidded at an age of 540-600 days weighing 22.0±1.15kg. Eleven kids tagged in Juja (B) between March-April 1992 (n=11), were mated in March-April 1993 at the age of 12-14 months and weighing 16.75±0.87 kg (Appendices 4.1a and b). In comparison the first heat was observed at 11-18 months of age Kimose, Kiburine and Marimanti while the pubertal does were mated at 11 and 24 months in Kimose and Kiburine respectively (Tables 4.2 a, b and c and Appendix 4.2).

5.6.2.2. Interkidding (parturition, kidding) interval.

The mean parturition interval of 510±50 days (range 450-600, n=5) in Juja and 405.7±25.6 days (n=5) on the Machakos Ranch was greatly influenced by nutrition and the decision of the producers to control mating. In comparison among the Sheep and Goat Multiplication Centres, interkidding interval was lowest in Kiburine (240 days) while in the other stations the interval was between 330-365 days (Tables 4.2a, b and c and Appendix 4.2).

5.6.2.3. Distribution of births and litter sizes.

Does in the selected farms has two peak kidding seasons per every year, which fell in April-June and October-December (Tables 4.1a-d).

Table 4.2a Secondary reproductive performance and wastage data for goats from the Kiburine Sheep and Goat Multiplication Centre in Kenya.

Reproductive efficiency parameter	Year under study and the flock number.					
	1985 Jun/ Aug FI	1985 Jul/ Sept FII	1986 Mar FI	1986 Mar FII	May-Jun FI	May-Jun FII
1. No. of does mated	258	64	23	96	195	60
2. Abortions	22 8%	7 11%	4 17%	6 6%	5 3%	7 12%
3. Barren does	38 15%	3 5%	5 22%	9 10%	49 25%	5 8%
4. Does that kidded	198 77%	54 84%	14 61%	81 84%	141 72%	48 80%
5. Number of kids born	228	85	20	101	167	55
6. Stillbirths/48hrs mortality	5 2%	17 20%	- -	1 1%	2 1%	4 70%
7. Kids tagged	223	6	20	100	20	-
8. % Kids/females to buck (mated)	88%	133%	87%	105%	86%	92%
9. Number of twins	28	31	6	18tri -plets	26	7
10. % multiple births	15%	57%	43%	25%	18%	15%
11. Average litter size	1.2	1.6	1.4	1.2	-	-
12. % Mortality to 120 days	3%	3%	3%	3%	3%	3%
13. Ratio male: Female (of offspring)	57:43	58:42	50:50	49:51	-	-

14. Other reproductive performance parameters recorded included:-
* Age at first heat 12-18 months (nutrition dependent).
* The station policy was to mate pubertal does at 24 months of age.
* Age at first Kidding 27-29 months.
* Interkidding interval 8 months.

Key FI - Flock one, FII - Flock - two.

Table 4.2b
Secondary reproductive performance and wastage data for goats from Kimose Sheep and Goat Multiplication Centre.

Reproductive efficiency parameter	Year under study						
	1986	1987	1988	1989	1990	1991	1992
Does mated	145	170	143	143	215	268	218
Abortions	3	5	5	4	6	13	-
Barren	20	14	28	74	59	50	67
Does kidded	129	137	112	109	174	183	136
No. of kids born	120	154	203	236	213	229	151
Stillbirths/48hrs mortality	-	-	1	1	0	-	-
Kids tagged	120	154	203	236	213	229	151
% Doe kidding joined to buck	0.9	0.8	0.8	0.8	0.8	0.7	0.6
No of twins	47	66	63	85	58	100	50
% multiple births	23	26	22	19	20	27	12
Average litter size	1.2	1.3	1.2	2.2	1.2	1.3	1.1
% mortality (kid)	23	11	26	22	30	40	40
Ratio Male:Female	1:1.6	1:1	1:1	1:1	1:1.3	1:1	1:1
Age at 1st heat	11mo	11mo	11mo	11mo	11mo	11mo	11mo
Age 1st kidding	16mo	16mo	16mo	16mo	16mo	16mo	16mo
Inter-kidding	12mo	12mo	12mo	12mo	12mo	12mo	12mo

Key mo - months, hrs - hours and yrs - years.

Table 4.2c Secondary reproductive performance and wastage data for goats from Top Farm, Naivasha Sheep and Goat Multiplication Centre.

Reproductive efficiency parameter	Year under study						
	1986	1987	1988	1989	1990	1991	1992
Does Mated	148	75	109	106	77	99	71
Abortions	1	0	1	3	1	5	2
Barren does	51	26	29	44	20	16	23
Does kidded	96	49	79	59	50	78	46
No. of kids born	113	62	94	71	64	101	59
Stillbirths/48hrs mortality	5	2	1	2	4	4	-
Kids tagged	108	60	93	69	58	97	59
% kids to buck No of twins	24	22	28	24	16	38	26
% multiple births	18	22	18	20	16	24	28
Average litter size	1.2	1.2	1.2	1.2	1.3	1.3	1.3
% mortality (kid)	12	19	21	21	24	17	19
Ratio male:female	1:2.5	1:2.5	1:2.2	1:1	1:1	1:1	1:1.4
Age at 1st heat	11mo	11mo	11mo	11mo	11mo	11mo	11mo
Age 1st kidding	2yrs	2yrs	2yrs	2yrs	1½-2	1½-2	1½-2
Inter-kidding (mo)	3.5	3.5	3.5	3.5	3.5	3.5	3.5

Key

mo - months,
hrs - hours
yrs - years.

On farms selected for the on-farm study the mean litter size was 1.01±0.10, with less than 5% of the does giving birth to twins. In comparison the Sheep and Goat Multiplication Centres (Kiburine, Marimanti, Kimose, Top Farm and Olmagogo) multiple births ranged between 15 and 60% while the average litter size ranged between 1.2 and 1.6. Marimanti and Kiburine stations had twice as many multiple births as Top Farm, Olmagogo and Kimose stations (Tables 4.2a,b,c; Appendix 4.2).

5.6.2.4. Birthweight and daily weight gain to weaning (120 days).

The mean kid birthweight at Juja in 1991-1992 season was 2.77±0.22kg (n=46 single males), 2.36±0.76kg (n=43 single females), 1.8±0.19kg (n=5 female twins) and 2.05±0.07kg (n=3 male twins), while in Machakos (1990 - 1991 season) the mean birth weights were 2.48±0.04kg (n=36 single kids) and 2.05±0.04kg for twins (n=10) (Appendix 4.1a and b). From birth to weaning at 120 days single male kids attained 85.33g/day, single female kids 80.25g\day and twins 69gm/day.

In comparison the average weight at birth for single Galla kids in Marimanti - Kiburine was 2.7kg. (1984). This was approximately 6% of the mean weight of the dams at kidding. Through selected breeding over a 4 year period (to 1987) the average weight at birth increased to 3.4kg, reflecting an increase of 25.9%. The weight at weaning for single kids increased from 14.5kg (120.8g/day) in 1984 to 18.2kg (151.7gm/day) by 1987. In the same period the body weights of twin kids at birth increased from 2.4kg to 2.7kg. Twins continued to perform poorly upto weaning age of 120

days, with the weight at weaning increasing from 10.4kg (or 86.7gm/day) to 14.2kg (or 118.3gm/day) between 1984 and 1987 (1988-1989 Marimanti / Kiburine reports).

5.6.2.5. Changes in bodyweight of bucks and does.

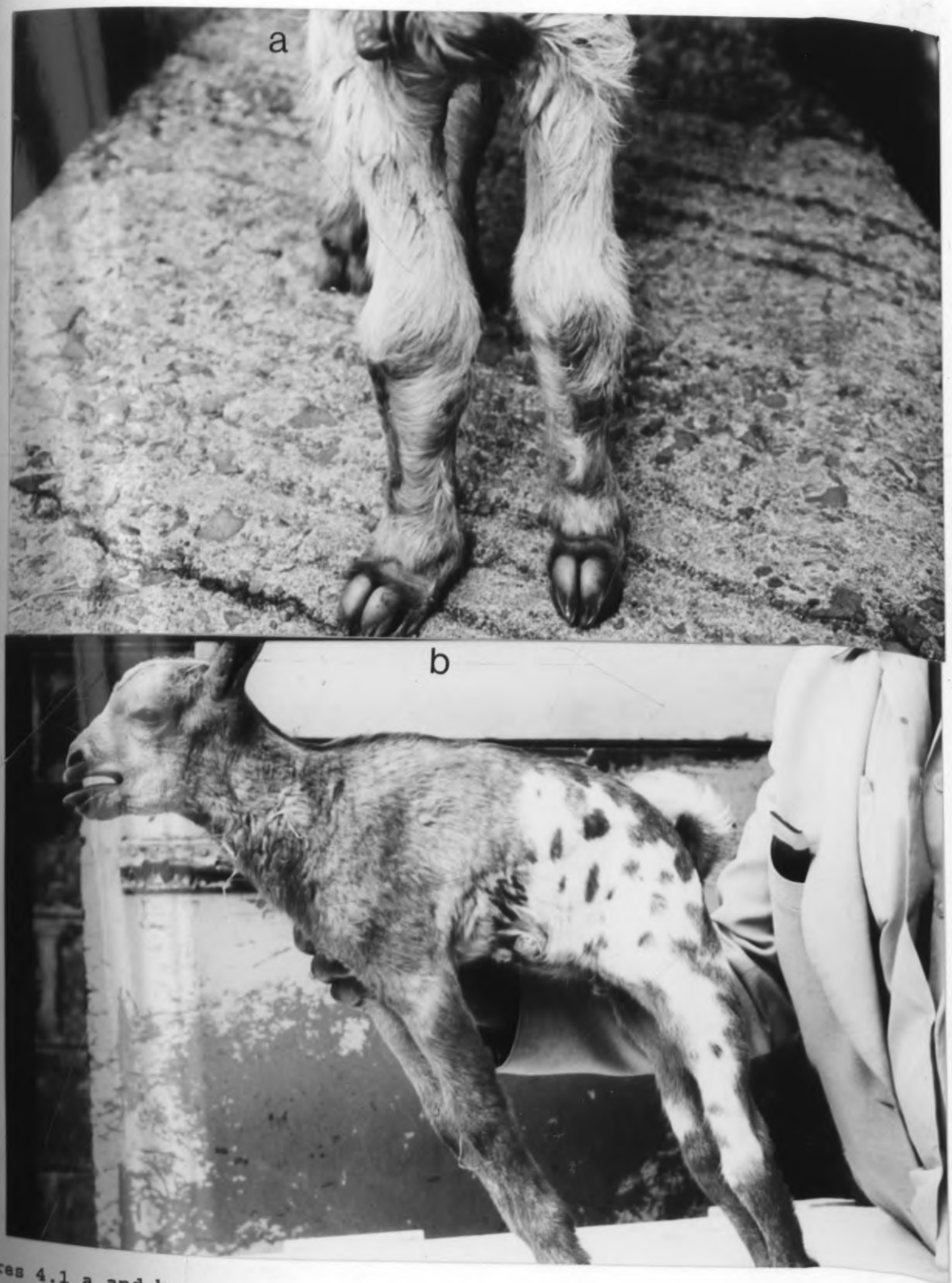
The weights of mature serving bucks fluctuated within 1-1.5kg of their weight from the beginning to the end of the breeding season. During the postpartum period does lost up to 4kg over a 3 months period. Drenching one month before and 2 months after parturition enhanced recovery of body condition of the dam (33.10±9.2 to 32.2±2.74kg (n=10) for treated does compared to 33.3±0.40kg to 29.75±0.31kg (n=10) for the untreated does (Appendix 4.1).

5.6.3. Reproductive wastage.

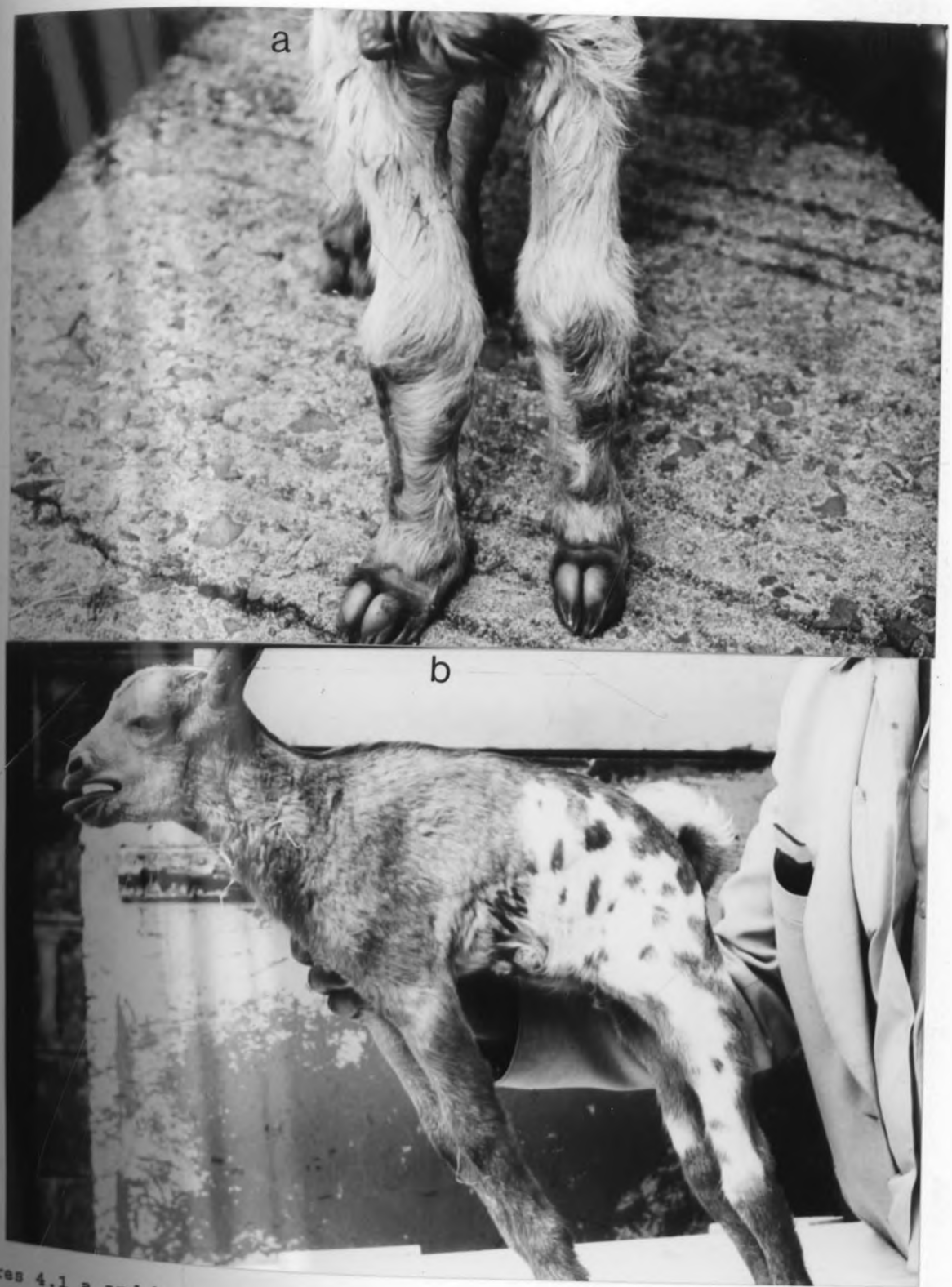
5.6.3.1. Preweaning mortality and annual reproductive rates.

On the selected farms, stillbirths and parturient deaths were not considered as independent entities due to difficulties in ascertaining the status (i.e abortion versus stillbirths versus parturient deaths).

On these farms preweaning mortality between 1989 and 1991, before the veterinary intervention, varied between 30 and 70%, with majority (50 - 80%) of the deaths occurring within the first two weeks (Tables 4.1a-d, 4.2a-c, Appendix 4.2). Preweaning mortality between 1989 and 1992 in the Multiplication Centres varied between 1.0 and 30%, with majority (50 - 80%) of the deaths occurring within the first two weeks (Tables 4.2a,b,c,d; 4.3a,b,c; Appendix 4.2).



Figures 4.1 a and b.
Two kids (a and b) suffering from varying degrees of E. Coli encephalitis/polyarthritis complex.



Figures 4.1 a and b.
Two kids (a and b) suffering from varying degrees of E. coli omphalitis/polyarthritis complex.

Table 4.3a.

Histopathological findings of tissues obtained from kids that died on farms selected for the on-farm study (1991-1992).

Pathological diagnosis	Number of kids affected
Hepatitis and pneumonia	8
Gastroenteritis and pneumonia	7
Hepatitis	5
Nephritis	4
Hepatitis and nephritis	4
Nephritis and pneumonia	3
Gastroenteritis	3
Pneumonia	3
Myocarditis and pneumonia	3
Hepatitis and gastroenteritis	2
Myocarditis and pneumonia	2
Hepatitis, nephritis and pneumonia	1
Myocarditis, hepatitis and pneumonia	1
Hepatitis, nephritis and gastroenteritis	1
Nephritis and gastroenteritis	1

Table 4.3b

Gross pathological findings in nine fresh carcases obtained from farms selected for the on-farm study (1991-1992).

Pathological diagnosis	Number of kids affected
Pneumonia	3
Gastroenteritis and pneumonia	3
Pneumonia and helminthosis	2
Omphalitis and peritonitis	1
Inconclusive	1

5.6.4. Results of laboratory analysis of samples.

5.6.4.1. External and internal parasites.

Fleas, Ctenocephalides canis and C. felis and, to a lesser extent ticks, more commonly Rhipicephalus appendiculatus and Boophilus sp., were the most common external parasites seen on the kids. On a half body count the most severely infested kids had an estimated 100 fleas. Ticks were noticed more often in kids close to weaning age.

Haemonchus sp. and coccidia were the most common and clinically significant internal parasites in untreated preweaning kids. All kids were observed to have low grade (50-200 epg) infection by 2-3 months of age which became debilitating by the fourth month if left untreated. The kids with diarrhoea at the age of 2-4 months were confirmed to have moderate infection (200-500 epg).

5.6.4.2. Haematological profiles.

Kids with moderate to heavy flea infestation between 2 weeks and 3 months after birth, in the selected farms in Machakos, Enkasit and Juja, showed varying degrees of anaemia. Fleas were easily controlled with Baygon flea-powder^{R} and flea bait^{R} (Bayer, Kenya LTD). In Suswa (Elasit) and Naroopa Ongila, where fleas were not controlled kids with anaemia died secondarily of pneumonia and septicemia (Appendix 4.3a,b).

Leucocytosis, with neutrophilia, was observed in cases of severe gastroenteritis, pneumonia and polyarthritis, while eosinophilia was frequent in most cases of low grade helminthosis.

During the outbreak of strain F38 contagious caprine pleuropneumonia (CCPP) in the Stony Athi ranch, Machakos, the haemograms showed a leucocytosis with a lymphocytosis.

5.6.4.3. Bacteriological evaluation of the swabs and flushing.

5.6.4.3.1. Rectal swabs. Of the fifty six kids with gastroenteritis characterized by diarrhoea, 82% (46/56) of the bacterial isolates were E. coli, while 18% (10/56) were a mixture of Streptococcus sp. and Staphylococcus sp. Fifteen kids had, in addition, helminthosis (10) and/or coccidiosis (5) (Table 4.4, Appendix 4.5). There were asymptomatic carriers in all the flocks examined (Appendix 4.5).

Enteroadherent E. coli (EAEC) were detected in 12% (6/52) of the samples obtained from affected kids while only one of the samples, obtained from the kids without any clinical signs of infection, had a similar isolate. Enterotoxigenic (ETEC) and enteropathogenic E. coli (EPEC) were isolated in 15% and 29% of the affected kids respectively. None of the E. coli isolates from the swabs made from the stall floor were enteroadherent (Table 4.4, Appendix 4.5). Of the EPEC serotypes isolated 27% (4/15) were 026:K71 (B16) while 026:K60 (B6), 0114:K90 (B) and 0128:K67 (R12) had two (13%) isolates each.

Detection of EPEC, EAEC and ETEC was significantly higher in kids with gastroenteritis characterized by diarrhoea ($P = <0.05$), than in kids without any evidence of gastroenteritis. Twenty nine isolates, seventeen (33% - 17/52) from kids with gastroenteritis with diarrhoea, 9/14 (64%) from unaffected kids and 3/5 (60%) from the stalls, could not be fully typed as they were out of the range

of the kits and systems used (Table 4.4, Appendix 4.5).

A total of 76 isolates of both pathogenic and non-pathogenic E. coli, collected during the survey and on-farm trial, were tested for drug sensitivity. The concentration of antibiotics in the sensitivity discs was, gentamycin (30ug/disc), tetracyclines (25ug/disc), ampicillin (25ug/disc), Trimoxin (25ug/disc), Penicillin (10ug/disc) and Penicillin and Streptomycin (10ug/disc) (Oxoid LTD, UK) (Table 4.5).

Gentamycin and penicillin-streptomycin showed the highest inhibitions of most strains of E. coli. It was notable that non pathogenic strains of E. coli showed greater resistance to gentamycin, chloramphenicol, trimoxin, tetracyclines, and penicillin-streptomycin combinations (Table 4.5).

5.6.4.3.2. Lung flushing. From the 15 lung samples E. coli was isolated from 47% (7/15) of the samples, while Pasteurella sp. and Beta haemolytic Streptococcus were isolated from 13% (2/15) of the samples. A mixed culture of S. aureus and Proteus sp. was observed in 27% (4/15) of the samples. All E. coli isolates were resistant to penicillin, ampicillin and streptomycin, but sensitive to gentamycin. The other isolates showed varied susceptibility to most commonly used antibiotics.

5.6.4.3.3. Bacterial culture and concomitant vaginal cytology. The isolates (15/15) from vaginal swabs obtained 2 weeks postpartum were either pure cultures of S. aureus (30%) or E. coli (13%) or mixed cultures (40%) of Streptococcus pyogenes, A. pyogenes, Bacillus sp., and E. coli (Table 4.6).

Table 4.4.

The prevalence of diarrhoeagenic agents from kids with gastroenteritis characterized by diarrhoea and unaffected kids ("controls").

Agent	Affected kids (n=52)	Unaffected Kids (n=14)	Stall floor (n=5)
EAEC	6/52 - 11.5%	1/14 - 7%	0
EPEC	15/52 - 28.9%	0	0
ETEC	8/52 - 15.4%	0	0
Con[1]	11/52 - 21.2%	6/14 - 43%	1(2±)
Con	15/52 - 28.9%	1/14 - 7%	0
Helmin[2]	10/52 - 19%	14 - 7%	ND
Coccid[3]	5/52 - 10%	1/14 - 7%	ND[4]
O/S[5]	17/52 - 33%	9/14 - 64%	3
Others	10/52 - 19%	2/14 - 14%	ND

Key.

Con[1] Conjunctivitis, 1 = after 24 hours, 2 = after 48 hours,

Helmin[2] - Helminthosis

Coccid[2] - Coccidiosis

ND[4] - Not done.

±* - suspicious

O/S[5] = out of scope of the test kits used.

EAEC - Enteroadherent E. coli.
EPEC - Enteropathogenic E. coli.
ETEC - Enterotoxigenic E. coli.
EHEC - Enterohaemorrhagic E. coli.

Table 4.5.

Antibiotic sensitivity results of E. coli strains isolated from kids with or without diarrhoea.

Status	Antibiotic tested against					
	Pen.	Amp.	Genta.	Tetra.	Penstr.	Chlor.
Resistant	56	8	0	20	8	22
Susceptible						
+	2	30	1	16	5	5
2+	0	16	33	20	21	14
3+	0	4	24	2	24	17
Total	58	58	58	58	58	58

Key.

Drugs against which the isolates were tested.

Pen. - Penicillin, Amp. - Ampicillin, Genta. - Gentamycin, Tetra. - Tetracyclines, Penstrep. - Penicillin - Streptomycin combination and Chlor. - Chloramphenicol.

+ - 3+

Represented the degree of susceptibility with + being the least susceptible and 3+ the most susceptible.

The concomitant vaginal smears returned a positive cytology characterized by neutrophils, red blood cells, cellular debris and bacterial particles.

Swabs obtained at three weeks revealed a similar pattern of isolation with E. coli in pure colonies (3) or in mixed culture (3) being the predominant (40%) isolate (Table 4.6). About 40% of the swabs returned positive cytology.

Between the fourth and sixth weeks none of the isolates cultured were associated with a positive cytology. Three does, 1 in the fifth week and the other in the sixth week, had positive cytology but no significant isolates (Table 4.6).

Assuming that positive bacterial isolation was the true indicator of genital tract infection then vaginal cytology was neither sensitive (se) nor specific (sp) (se+sp= <1.0) and had poor diagnosability (0) and high probability (>60%) of picking false positive when applied between week 3 and 6 postpartum.

In comparison assuming that positive vaginal cytology was the true indicator of genital tract infection then bacterial isolation was neither sensitive (se) nor specific (sp) (se+sp= <1.0) and had poor diagnosability (0) and high probability (>70%) of picking false positive when applied between week 3 and 6 postpartum.

Table 4.6.

Frequency of bacterial isolates from vaginal swabs obtained from does between the second and third week postpartum and concomittant vaginal cytology.

Organism isolated	Number of Isolates in week				
	2	3	4	5	6
S. pyogenes	1(1/1)	1(1/1)	1(0/3)	-	-
S. aureus	5(5/5)	-	-	2(0/2)	2(0/2)
E. coli	2(2/2)	3(1/3)	3(0/3)	-	-
E. coli & Bacillus	0	0	0	2(0/2)	2(0/2)
A. pyogenes	1(1/1)	1(1/1)	-	-	-
Bacillus sp.	1(1/1)	1(0/1)	1(0/1)	-	1(0/1)
Pasteurella sp.	1(1/1)	-	-	-	-
E. coli & Streptococci	3(3/3)	3(1/3)	3(0/3)	-	-
No significant isolate	-	1(0/2)	2(0/2)	6(2/6)	7(1/7)

5.6.4.4. Viral isolation.

No virus(es) or mycoplasma (courtesy of SR-CSRP and Veterinary Investigation Laboratories, Kabete) were isolated or observed on negative stained preparations from cases of kids with gastroenteritis characterized by diarrhoea (110 samples) and without diarrhoea (25 samples) or lambs held in the same properties (25 samples).

5.6.4.5. Total protein and immunoglobulin A and G (IgA and IgG) levels in colostrum, milk and sera obtained from does and kids.

Goat colostrum, milk and serum were found to have only traces of IgA, which was isolated in small quantities using both DEAE and sephacryl methods, while IgG was detected in large quantities in the same samples using the same methods (See Chapter 2; Table 4.7, Appendix 4.1a,b).

At two weeks of age the 10 kids tagged in Juja A and B had an average total protein concentration of 60.3± 6.9g/l serum (range 50.0-73.0g/l), IgG level of 41,460±10,061mg/l of serum (range 26,000 -56,000mg/l) and an *E. coli* antibody titre of between 1:640 and 1:5,160. Only traces of IgA were observed in all samples collected (Figures 4.2a and b, Table 4.6, Appendix 4.1a and b).

At four weeks of age the total protein levels fell, though not significantly, to 58.7± 3.9g/l serum (54-64.0) while IgG level fell to 37,884±10,960mg/l of serum (14,640 -56,000mg/l). Of the 10 serum samples none had detectable levels of *E. coli* antibodies and only 3 (30%) had traces of IgA (Figure 4.2a and b, Table 4.6, Appendices 4.1a-b, 4.6).

At 8 weeks of age the total protein and IgG levels rose, though not significantly, by 16% and 13% respectively. Of the 10 serum samples 7 (70%) had no traces of IgA while 6 had detectable levels (1:160) of E. coli antibodies.

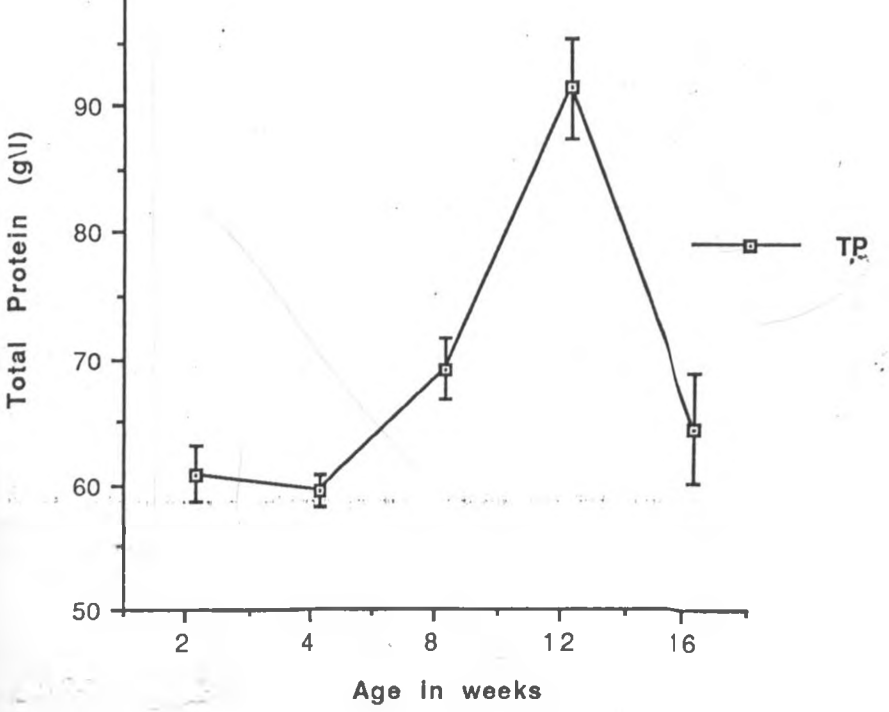
The levels of total protein rose significantly (P=>0.05) by the 12th week while those of IgG fell by more than 50% (37,884 to 18,170mg/l). Only one of the samples was positive for IgA while 4 samples had E. coli antibody titres of 1:320. The other 6 samples were negative for E. coli antibodies (Figures 4.2a,b, Table 4.6, Appendices 4.1a,b, 4.6).

At weaning (16 weeks of age) the total protein levels fell to those observed at 8 weeks while those of IgG remained constant. Only 2 samples had traces of IgA while 5 samples had traces of E. coli antibodies (1:160) (Figure 4.2a,b, Table 4.6, Appendices 4.1a,b, 4.6).

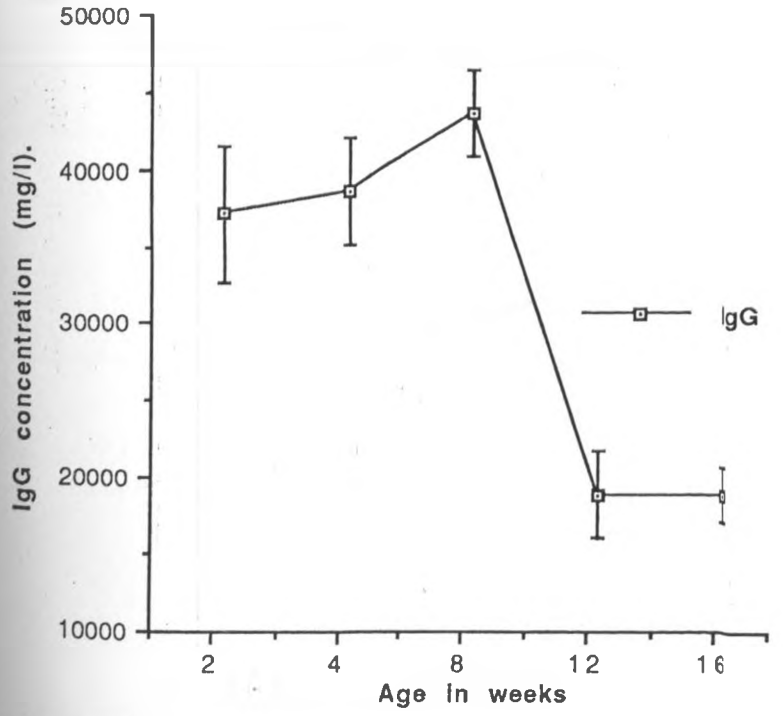
The levels of IgG attained in serum after the eighth week of age were similar to those found in pooled serum samples obtained from 5 pregnant dams. Individual and pooled sera from pregnant dams did not have any traces of E. coli antibodies.

5.6.5. Cost of intervention packages.

A policy of treating all kids whenever any in the flock became sick and instituting internal and external parasite control reduced pre-weaning kid mortality to $\leq$ 5% (Table 4.8, Appendices 4.7, 4.8a and b).



Figures 4.2 a.
The mean total protein (g/l) (a), immunoglobulin G (mg/l) (b) in serum obtained from goat kids between 2 and 16 weeks postpartum.



Figures 4.2 b.
The mean total protein (g/l) (a), immunoglobulin G (mg/l) (b) in serum obtained from goat kids between 2 and 16 weeks postpartum.

Table 4.7.

The mean (± se) total protein (TP - g/l), Immunoglobulin levels (IgG - mg/l) and E. coli antibody titre (E. coli Ab) of kids born during the on-farm study (Juja A and B).

Kids' ages	TP	IgG	E. coli Ab
2 weeks	60.03±2.20	36,420±4,386	2572±624
4 weeks	58.70±1.23	37,884±3,466	0.0
8 weeks	68.30±2.43	42,930±2,750	96±26
12 weeks	90.40±3.91	18,170±2,880	112±48
16 weeks	63.60±4.31	18,172±1,813	80±27

The cost of the intervention package / kid / season in April-June 1991/1992 ranged between Ksh. 14.10 and Ksh. 35.80, while in November-December 1992 and January-February 1993 it was Ksh. 24.50 - Ksh. 439.90. The cost of treatment in Suswa - Elasit in Narok remained the highest throughout the period of study and showed least benefits (Table 4.8, Appendix 4.8a,b).

5.6.6. Economics of veterinary intervention.

The assumptions used in path of calculation for traditional goat production (meat and milk) are shown (Appendix 4.7).

The results of the budgetary analysis for goat production in the selected farms are presented in tables 4.9a and b. Based on the assumptions taken goat production in the year under review would have earned the household a gross income of Ksh. 89,570.00 and Ksh. 166,270.00 at a cost of Ksh. 30,342.60 and Ksh. 52,190.10 before and after intervention respectively. This translated to a net profit of Ksh. 59,227.40 and Ksh. 114,079.90 before and after intervention respectively (Tables 4.9a and b).

Table 4.8.

Survival of kids following veterinary intervention and the cost of the intervention package on selected farms during the on-farm study.

Year of study	Locality	Number of kids surviving	Number of kids dead	Treatment cost/kid in Ksh.
1991-1992				
	Suswa/Elasit	22	30	22.10
	Juja A & B	39	0	14.10
	Enkasit	82	0	25.10
1992-1993				
	Juja A	11	3	35.80
	Juja B	8	5	48.65
	Enkasit A	23	0	14.55
	Enkasit B	26	0	25.10
	Suswa/Elasit	69	65	439.90

Table 4.9a.

The estimated income before and after the implementation of the veterinary intervention package based on reproductive performance and wastage data obtained during the field and on-farm studies.

i. Expected income (Ksh./year).

COST ITEM	Before	After
1. Sale		
- castrates	31,500	94,500
- culled bucks	2,800	2,800
- culled does	35,070	35,070
2. Value of weight gained by does postpartum after drenching	0	21,000
3. Value of		
- dying does	-10,500	-10,500
- milk	14,400	14,400
- manure	6,300	9,000
Total	89,570	166,270

Table 4.9b

The estimated production costs based on the proposed intervention package and reproductive efficiency achieved.

ii. Anticipated costs of realizing the above income (Ksh/year).

COST ITEM	Before implementation	After implementation
1. Replacing breeding does	4,880.60	4,880.60
2. Risk of mortality in does	19,250	19,250
3. Veterinary drugs and chemicals	2,592	18,576
4. Marketing and transport	720	1,440
5. Tools	1,400	2,120
6. Cost of day/night enclosure	1,500	1,500
7. Interest on the enclosure, circulating and animal capital	4,423.30	4,423.30
Total	30,342.60	52,190.10

NB.

8. Concentrates - No "concentrates" were fed.

9. Minerals - Cost of providing natural salts was internalized into labour costs

10. Cost of leasing breeding bucks - No costs in "leasing or exchanging bucks".

5.7.0. DISCUSSION.

During the 1990-1993 period of the on-farm study the flocks in Juja and Kajiado showed an increase of between 10-30%, with a male:female ratio of 1:1 which was similar to that reported in India by Prasad et al. (1979a,b) and in Kenya by Blackburn and Field (1986) and Kimenye and Karimi (1987). Entire males made up about 5 and 10% of the flocks in Naroopa-Ongilla (Narok) and Kajiado and Juja, which was higher than the recommended rate of 2.7% (Jost, 1972). Using such ratios, however, dictates that the bucks are routinely screened for conditions/diseases that can affect the testicular function including brucellosis, besnoitiosis, trypanosomosis and non-specific epididymo-orchitis to reduce the adverse impact of buck infertility on flock performance.

The average weight at birth for single Galla kids in Kiburine and Marimanti stations between 1984 and 1987, increased by 26% through selection, which represented a daily weight gain of 151.7gm per day to weaning at 120 days (18.2kg weight at weaning). In comparison the local SEA goat kids, which weighed between 2-2.7kg for single kids and 1.5-2.0kg for twins, attained a much lower daily weight gain (80gm/day). Despite these low weight gains, they were higher than those reported from Malawi (42-47g/day) (Zefars and Stotz, 1987; Karua, 1988). While the higher performance of the Galla may be an indication of breed characteristics, high milk production and selection, it should be appreciated that the ratio of the kid:dam weight was not significantly different (6-9% for the SEA and their crosses versus 6% for the Galla).

Two hundred millilitres of goat milk can provide 10.5g of protein, 13.5g of fat and 250g of calcium, which would go along way towards improving the diet of children aged between 1-5 years (Akinsonyu et al., 1977; Cooper et al., 1996). These workers showed, against all popular belief, that removing this volume of milk once a day did not adversely effect the doe or her offspring. In the present study does were observed to provide about 150ml of milk per day, which was consumed by over 90% of the producers interviewed. Thus, as in Malawi, goat milk is a major source of nutrients and its production should be encouraged through selection of local breeding stock.

In the present study pubertal does that were bred early, whether by design or default, gave birth to kids with low birthweights and poor survivability. These observations credits the traditional management practices in which producers withhold pubertal doe kids from service. Similar observations and conclusions were arrived at by other workers (Shelton 1960a; 1977; Singh and Sengar 1970; Wilson 1976; Blackburn and Field 1986).

The length of the breeding season is primarily the result of genetics and environmental interactions with factors such as reduced variation in photoperiod, rainfall, vegetation and herbal growth, which results in one or more breeding and kidding peaks per year (Devendra and Burns, 1970; Haumesser, 1975; Simplicio et al., 1982a,b). The distribution of births in the areas surveyed, and especially Machakos and Narok where breeding was not controlled, indicated that does were capable, under favourable conditions, of

cycling and conceiving while lactating. This observation lends support to the notion that it is possible to reduce the interkidding interval by manipulating the service period (Wilson et al., 1985; Carles, 1986).

Among the factors known to contribute to the newborn kid's condition at birth and its chances of survival, include the quality and quantity of colostrum, trauma, exhaustion and\or poor nutritional state of kid and dam at birth, poor mothering ability, cold and/or wet weather with excessive draught and reduced locomotor vigour (Blood and Radostits, 1989). As reported by Barlow et al. (1987) respiratory and heart rate and their character and rectal temperature were observed to be good prognostic indicators of goat kid survival. Hypogammaglobinemia and agammaglobinemia have been associated with high early and delayed postnatal mortality (Jeffcott 1974; 1975; Otesile and Oduye 1991; Satapathy et al., 1992; O'Brien and Sherman, 1993a,b). These workers concluded that adequate supply of colostrum, in terms of timing, quality and quantity, was essential for improved survival rate of kids. McGuire and Crawford (1973) and Snodgrass (1986) further observed that immunoglobulins were absorbed to produce similar concentrations in the offspring's serum as that in the dam's within 24 hours in the mare and the sow respectively.

The findings of the present study indicate that both colostral (upto day 4) and kid serum IgG levels (upto day 7) were at least 3 times those in maternal serum while only traces of IgA were detected. It is therefore possible, that as in the mare but unlike

in the sow, colostral IgG has a greater role to play in the protection against intestinal infections than IgA. Villouta et al. (1980) suggested that IgG has an important role to play. While not preventing the establishment of diarrhoea, the high levels of IgG may reduce the severity of the infections by preventing massive outpouring of fluids and electrolytes into the intestinal lumen.

In the present study, the newborn kids had serum IgG levels and E. coli antibody titres similar to or higher than those found in adult serum within the first week of birth. The E. coli antibodies, presumably in response to an infection, were however only occasionally detected after 4 weeks of age. In similar studies other workers have shown that while immunological competence is present at birth the endogenous antibody production does not usually reach protective levels in most domestic animals until one month (and maximum levels until 2-3 months) (Jeffcott, 1974; 1975; Snodgrass 1986; Rabbani et al., 1990; Vihan, 1993; Constant et al., 1994).

In the present study several bacteria, including E. coli, S. aureus and Streptococcus sp., were incriminated to be the causative agents of pre-weaning gastroenteritis, pneumonia and septicaemia and the ensuing mortality observed. The source of infection in the present study was thought to be contaminated environment, while oral route and contaminated umbilicus were thought to be the main portals of entry. It has, however been postulated that intrauterine infection and postpartum uterine discharge contamination were possible (Beaver, 1980; Blood and Radostits, 1989). Unlike in the

queen (Beaver, 1980), the present study does not support intrauterine source of bacterial infection as cultures of foetal fluid and membranes did not yield any of the incriminated pathogenic bacteria. It is, however, difficult to rule out postpartum uterine discharges as sources of contamination and infection as the organisms isolated were similar to those isolated from the animal sheds.

Poor reproductive efficiency, which greatly determines the profitability of a production system, is an important constraint to production in goats in tropical Africa (Wilson, et al., 1984; 1985). Upton (1984) indicated that productivity was more sensitive to survival of young lambs and kids than to any other factors. The high preweaning mortality rate reported in the present study is similar to that reported in Kenya, without the benefits of anthelmintic therapy (Wilson, 1976; Carles, 1986; Blackburn and Field, 1986; Carles et al., 1987) and with intervention (Angwenyi and Bebe, 1989). During the on-farm study (1990-1993), however, it was observed that it was possible to reduce pre-weaning mortality from 30-70% to around 5% by implementing a modest veterinary intervention package, costing between Ksh. 14 and Ksh. 490 (Munyua et al., 1996b).

The intervention package in does, which consisted of antibiotics, acaricides and anthelmintics, reduced wastage and enhanced the recovery of body condition postpartum. This "intervention enhanced performance" not only indicated that it is possible to reduce the impact of nursing, external parasites and

helminthosis on the does' body condition but also that there was a possibility of an early return to oestrus. In addition there was an economic gain that translated to Ksh. 240 / doe / year (based on the price of meat at Ksh. 120/kg) associated with the intervention. This gain in meat value would help offset the cost of internal and external parasite control per year, which was estimated to be between Ksh 40-100 (Ksh. 10-25 / drenching depending on the drugs used) (Munyua, et al., 1996a;b).

Using an economic projection based on given assumptions and established flock performances in Kajiado and Juja it was estimated that there would have been a profit of Ksh. 114,079.90 annually had "a goat producer" chosen to use the proposed intervention package in a flock of 160 goats. Thus it was concluded that it was profitable to manage and prevent diseases and parasitic conditions in preweaned kids under both traditional and commercial production systems in arid and semi arid areas. Similar conclusions were arrived at by Mucuthi et al. (1992), in Kenya and the government of Botswana and Panin (1996), in Botswana.

In the present economic set up these profits are difficult to realize as the farmers' production objectives often conflict with those of researchers and policy makers (Mrema and Rannobe, 1996). One such area of conflict is the culture of keeping animals as wealth or savings, thus hindering the increase of offtake rates, while the other is the competition for inputs with other enterprises including cattle, camels and crops which deprives goat production the necessary resources, including labour, capital and

feed, needed to improve production.

Even if we were to assume that the weather and environmental conditions hold, the producer, however, can only realize the projected returns if she/he has resources and sufficient knowledge and information on how best to allocate and commit the available resources from the outset. The veterinary extension service in its present structure and funding level can only assist with the information and can not guarantee security, reliable market outlets and basic infrastructure. These have to be in place if livestock production is to be a reliable source of income in the arid and semi arid areas of Kenya.

Based on the findings of the present study, it was necessary to carry out a detailed study to determine the factors influencing the survival of kids in the first 7 days postpartum. In addition it was important to closely study the reaction of preweaned kids to challenge with a known virulent strain of *E. coli*.

CHAPTER 6

Haematological profiles, immunoglobulin levels and E. coli antibody titre of newborn kids and their dams, with emphasis on the response of the kids to challenge with pathogenic strain of E. coli - On-station study.

6.1.0. Introduction.

Haematological, biochemical and serological analysis of blood of animals is an indispensable tool in the diagnosis of a variety of diseases and conditions (Lloyd, 1982; Sherman and Robinson, 1983; Mbassa and Poulsen, 1991; Otesile and Oduye, 1991). In the goat, these parameters may be influenced by breed, season and physiological state (Blood and Radostits, 1989; Mbassa and Poulsen, 1991).

Different reports on blood parameters reveal a wide disparity in relation to these factors (Mbassa and Poulsen, 1991; Otesile and Oduye, 1991). The contradicting results complicate the evaluation of clinical / haematological values for diagnostic purposes in different breeds of goats (Mbassa and Poulsen, 1991).

Newborns of most domestic animals including calves, kids, lambs, piglets and foals are born without significant levels of immunoglobulins (Perryman et al., 1977; Hauser et al., 1986; Blood and Radostits, 1989; Rabbani et al., 1990, O'Brien and Sherman, 1993a,b). However foals have been shown to be immunocompetent at birth (Perryman et al., 1977). In other related studies Newby et

al. (1979) and Hauser et al., (1986) observed that the high levels of corticosteroids, produced by lambs and calves 8-10 days before parturition, resulted in lymphopaenia and a decrease in the phagocytic defense capability in the newborn which may affect the cellular immune mechanisms thereby decreasing perinatal resistance. Vihan (1993), O'Brien and Sherman (1993a,b) and Rowan et al., (1993), on the other hand, demonstrated that morbidity and mortality rates due to infectious diseases affecting the intestines and respiratory tract were significantly higher in goat kids with low levels of serum immunoglobulin than in those with adequate levels. Similar observations have been made in foals (Newby et al., 1979; Blood and Radostits, 1989) and calves (Corbeil et al., 1984; Blom, 1982; Davidson et al., 1981).

The actual relationship between the levels of serum immunoglobulin in newborn farm animals at 24-48 hours of age and subsequent morbidity and mortality is, however, controversial (Bradley et al., 1979; Vihan, 1993; O'Brien and Sherman, 1993a,b). This controversy is based on observations in some beef herds, which showed that levels of serum immunoglobulin in calves at 48 hours of age were of no value in predicting the incidence or severity of acute undifferentiated diarrhoea (Bradley et al., 1979).

Acres (1985), Nagy et al. (1985) and Vihan (1993) using cows, sows and does respectively, observed that it was possible to enhance the specific resistance of newborn to infectious diseases by vaccinating the dam during pregnancy. These workers showed that vaccinating dams with an E. coli or E. coli and rotavirus vaccine

stimulates the production of specific colostral antibodies which provided protection against diarrhoea caused by the two enteropathogens.

This phase of the project was undertaken to study closely the events of the early and delayed postnatal period that may influence the survival ability of the newborn goat kid. To undertake the study it was necessary to understand the dynamics of changes in serum immunoglobulin G and A, E. coli antibody titre, and haematological parameters in kids born of vaccinated and non vaccinated dams. In addition kids at an age (4 weeks), where it had been established that they did not have any detectable levels of E. coli antibodies, were to be challenged with a known strain of pathogenic E. coli to elucidate the factors determining the establishment and colonization of the goat kid's gastrointestinal tract by the pathogen.

6.2.0. AIMS.

1. To study changes in serum immunoglobulin G and A levels, E. coli antibody titre, and haematological parameters in kids born of vaccinated and non vaccinated dams.
2. To study the response of one month old kids to oral challenge with a known strain of pathogenic E. coli.

6.3.0. Material and methods.

6.3.1. Pre-shipment management of the experimental flock.

This study was undertaken partly at the University of Nairobi, College of Agriculture and Veterinary sciences, Faculty of Veterinary Medicine, Kabete Campus and partly on a farm in Enkasit,

Kajiado. Thirty pregnant Galla (synonyms Boran, Somali) and Galla x Small East African cross does aged between 2 and 4 years and one buck were purchased from Elang'ata Wuas and Kilonito areas of Kajiado district. Each does was clinically examined and confirmed to be over 3 months pregnant by the use of a vaginal glass probe and/or abdominal palpation before purchase. To reduce transportation and adaptation stress the does were treated with long acting tetracyclines at the rate of 10mg/kg bodyweight intramuscularly (Norbrook, UK) before being transferred and held at Enkasit, Kajiado for 7 days. After the break-in period, in Enkasit, the flock was treated with a second dose of long acting tetracyclines before being transported to Kabete by road.

6.3.2. Flock management.

On arrival the does were dipped in acaricide (Stelladone(R), Kenya Swiss LTD) and drenched (Rintal(R), Bayer, Kenya LTD) based on instructions from the manufacturers. This treatment regime was repeated monthly. The does were initially divided into 2 groups of 15 each before being tagged and housed in three well aerated and lit 8x10 ft cubicles.

By the end of the adaptation period, set at two weeks, the 15 does that had not lost the conceptus were drenched again using Rintal(R) and split into two groups of 8 and 7 does. The first group (8 does) were vaccinated on the neck region, in 3 divided doses, with crude sonicated E. coli antigen (Strain 0126 K71 (B16) - protein concentration 130mg/l). Each of the does received 1ml of the crude antigen in 2ml of complete Freuds' adjuvant. This

vaccination regime was followed by a booster vaccination with 1ml of the same E. coli preparation in 2ml incomplete Freuds' adjuvant 2, 13 and 20 weeks later. Seven does, which served as controls, were injected with 1ml saline solution in 2ml adjuvant at similar intervals.

Throughout the study period the goats were provided with water and salt licks ad lib, 2 bales of hay, 3kg of a mixture of bran and maize germ (3:1) per cubicle every morning and allowed to graze in and around the College compound from mid morning to late afternoon.

All sick does were examined individually and appropriate samples obtained before treatment. Does dying during the experimental period were subjected to full postmortem examination at the Department of Pathology and Microbiology, Kabete.

6.3.3. Sample and data collection from does.

6.3.3.1. Performance and disease situation.

Records of any diseases and/or conditions, including perinatal losses such as abortions, stillbirths and parturient deaths, and general performance including weight at birth, righting reflex and suckling reflex observed during the study were recorded as they occurred.

Weights of does were taken on arrival, after two weeks and then after every month throughout the 36 weeks of the study. All kids born during the study were weighed at birth and at 2 week intervals till weaned. Kids were allowed to run with their dams and suckle colostrum, and later milk, freely. Daily weight gains were calculated by dividing final weight at weaning with the number of

days.

All sick kids and adult goats were examined individually and treated according to clinical and laboratory findings. All dehydrated kids were rehydrated, using physiological saline containing 10% glucose, at the rate of 6-12% of the body weight, depending on the severity of the condition. They were also treated with a broad spectrum antibiotic (Penicillin -Streptomycin^{R}, Norbrook, UK).

6.3.3.2. EDTA and clotted blood samples.

EDTA and clotted blood for routine haematology and for harvesting serum for the measurement of total protein, E. coli antibody titre and immunoglobulin (A and G) were obtained from all does before vaccination and at 2 week intervals till the end of the study. The serum was preserved in 200-500ug of sodium azide and stored at -20°C till assayed.

6.3.3.3. Colostrum and milk samples.

From each of the does that kidded, 4-10 ml of colostrum, and later milk, was collected in sterile universal bottles or plastic containers with 200 - 500ug of sodium azide.

6.3.3.4. Vaginal swabs.

Two vaginal swabs were obtained from all does at fortnightly intervals from the second week postpartum for 6 weeks. One swab was rolled onto a gelatin (5%) coated slide and used for routine cytology and the other was processed for routine bacteriology (See chapter 2).

6.3.4. Sample and data collection from kids.

6.3.4.1. EDTA and clotted blood samples.

EDTA and clotted blood, for routine haematology and for harvesting serum for the measurement of total protein, E. coli antibody titre and immunoglobulin (A and G), were obtained from all kids, whenever it was possible and practical to do so without endangering its life. This was done before suckling, and during each clinical examination every day for the first 96 hours (6, 12, 24, 48 and 96 hrs), and subsequently at 2 weeks. Any kids that showed signs of weakness or pale mucous membranes and accelerated heart rate,(>120 heart beats per minute), after blood collection were not bled again until their condition stabilized. The serum was preserved with 200-500ug of sodium azide and stored at -20°C till required.

6.3.4.2. Rectal swabs and faecal samples.

Two rectal swabs, for bacteriology and viral isolation, were obtained from all kids with diarrhoea and one from a healthy kid for comparison (See chapter 2). All E. coli isolates were preserved in cooked meat media until they were typed and tested for pathogenicity (adherence and toxin production) (See Chapter 2). Faecal samples obtained from 2-4 months old kids were processed for faecal egg count (See Chapter 2).

6.3.4.3. External parasites.

All kids were individually checked for external parasites during each clinical examination and any parasites collected were presented to the Parasitology laboratory, Kabete for

identification.

6.3.4.4. Postmortem examination.

All kids found dead were subjected to a full postmortem examination and appropriate samples for bacterial, mycoplasma and viral culture and histopathology obtained. The latter sections were collected in universal bottles containing 10% formalin and stored until processed as described in detail (See chapter 2).

6.3.5. Stall swabs.

The stalls and resting court were swabbed for bacterial isolation whenever more than 10% of the kids contracted gastroenteritis. E. coli isolates were compared to those obtained from kids dying from whatever causes.

6.4.0. Challenge experiment.

6.4.1. Selection of experimental kids.

One of the properties used for the on-farm study in Enkasit, Kajiado was selected for the challenge trial (See Chapter 3). On this farm 15 kids born within 4-5 days of each other were tagged at birth and managed with the other kids in the flock under traditional ownership. At three weeks of age, one week before the challenge experiment, the selected kids were drenched with Rintal^{R} and washed in 1:1 Defungit^{R} / Alugan^{R} mixture (Hoechst, Kenya LTD) and a Flea Bait^{R} (Bayer E.A.) spread in the pens where the kids were housed to enhance flea control. The fifteen kids were then randomly divided into 2 groups of 8 (A) and 7 (B) kids each.

6.4.2. Challenge material and trial.

The challenge organism, E. coli strain 0126 K71 (B16), isolated from a kid with severe gastroenteritis and polyarthritis was selected for use in the challenge experiment. The challenge dose was prepared from fresh McConkey agar cultures which were inoculated into nutrient broth over-night before being concentrated by centrifuging at 10,000g for 30 minutes. The resulting pellet was washed twice in physiological saline before being suspended in saline solution to give a concentration of $1x10^9$ colony forming units per ml (Munyua, 1985). Four ml aliquot of the bacterial suspension in bijoux bottles were then transported in containers with crushed ice, to the test site at Enkasit, Kajiado.

Kids in group A were challenged by placing 4 ml of the E. coli suspension at the back of the tongue and flushing the suspension with 4 ml of sterile physiological saline. The 7 kids in group B (controls) were given 8 ml of saline each. The kids were then released to graze with others in the open fields.

6.4.3. Sampling during the trial.

Blood samples for glucose analysis, routine haematology and harvesting of sera were obtained before challenge and at 6 hours and 1, 2, 3, 4 and 10 days after challenge. Rectal swabs were obtained at the same intervals and at 14 days post challenge. The rectal swabs were transported to the laboratory and processed for E. coli isolation and characterization as described earlier (See Chapter 2).

6.5.0. Statistical analysis.

The differences between the mean immunoglobulin levels and antibody titre for the kids born of vaccinated and non-vaccinated dams, and the mean total protein, leucocyte and glucose levels in kids that died from whatever cause and at whatever stage before weaning, were compared using Analysis of variance (ANOVA), sign test and descriptive statistics. As all kids were raised in the same stalls and husbandry practice, the influence of all other factors, except vaccination, were assumed to be the same.

6.6.0. RESULTS.

6.6.1. Performance of the experimental does.

6.6.1.1. Flock adaptation.

Severe temperature and humidity changes that hit Kabete in October of 1992 seriously affected the ability of the does to adapt to experimental conditions at the station. At the time of purchase the temperatures in Elang'ata Wuas and Kilonito was around 30-35°C, with dry winds. In contrast Kabete, which was hit by a cold and wet spell, had temperatures ranging from 15-20°C and high humidity. This climatic difference and the changes in feed and housing made adaptation of the flock slightly less than favourable. This poor show of adaptation was characterized by high (50%, 15/30) perinatal losses, high adult mortality rate of 30% (9/30) and 20-25% weight loss in does, within the first 30-45 days of arrival (Figure 5.1, Appendix 5.1). The does' body conditions stabilized after supplementation with bran and maize germ (3:1) sprinkled with mineral salts,

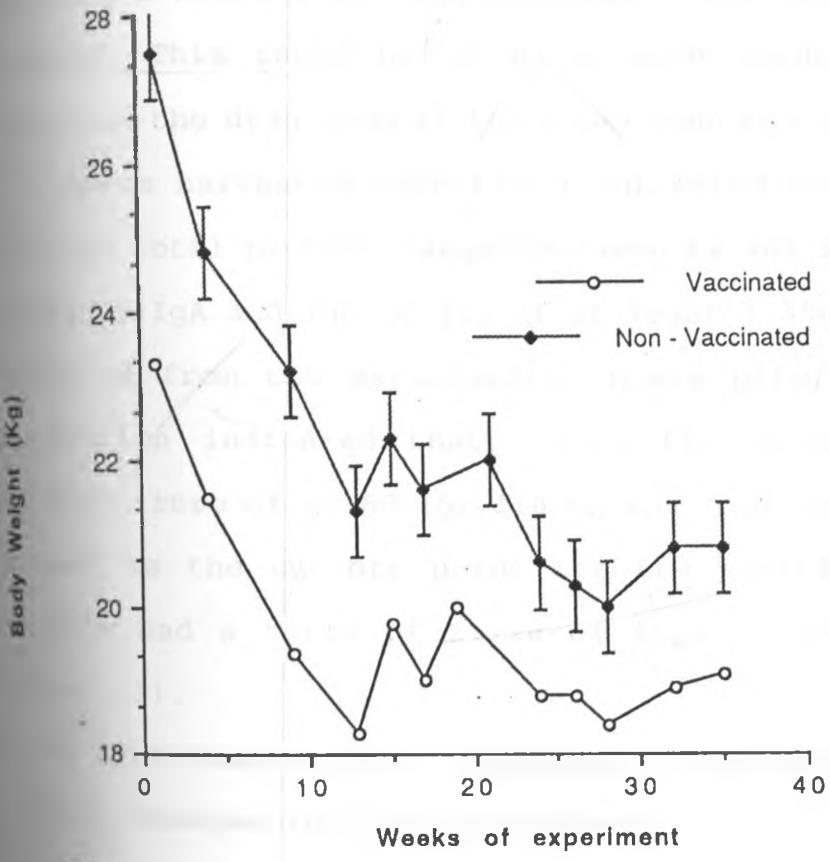


Figure 5.1

Changes in body weight of vaccinated and non-vaccinated does during the experimental period

day long grazing and provision of hay overnight from January 1993 (Figure 5.1, Appendix 5.1).

6.6.1.2. Baseline blood parameters and faecal egg count.

Examination of thick and thin smears and haemograms on admission did not reveal the presence of any blood parasites or abberations in blood profiles (Appendix 5.2). Routine examination of faecal samples, however, indicated that the does were rapidly building a moderately high (≥500epg) worm burden within the first 2 weeks. This rapid build up in worm burden kept on recurring entailing the drenching of the experimental flock once every month.

Serum harvested from blood collected on admission indicated that the total protein ranged between 62 and 98.0g/l (Figure 5.2), traces of IgA and IgG levels of at least 3,350mg/l of serum. Serum harvested from the experimental goats before and after booster vaccination indicated that, using the ELISA test, an E. coli antibody titre of 1:160 (or 1:8 on agar gel immunodiffusion) could be used as the cut-off point for the positive responses as all controls had a titre of 1:120 or less on ELISA (See chapter 2, Figure 5.3).

6.6.2. Experimental does' response to vaccination.

6.6.2.1. Changes in blood parameters.

The red blood cell count per ul (RBC), the packed cell volume (PCV, %) and the total protein (TP, g/l) in blood obtained from both vaccinated and non vaccinated does fluctuated within the normal ranges throughout the study period (Figure 5.2, Appendix 5.2). There were, however, marginal increases in white blood cell

count (WBC) after the initial or booster vaccination (Appendix 5.2).

6.6.2.2. E. coli antibody titre in serum and colostrum.

Sera obtained from both vaccinated and non vaccinated groups before the experiment did not have detectable E. coli antibodies (Figure 5.3, Appendices 5.3, 5.4, 5.5). Within a week of receiving the first booster, the antibody titre in the vaccinated group rose to between 1/640 and 1/10,240, with 90% of the does having titre of >1/5120. E. coli antibody titre in the vaccinated does remained above the 1/5120 titre after the second and third boosters (Figure 5.3, Appendices 5.3, 5.4, 5.5). E. coli antibody titre in both vaccinated and control does were significantly ($P<0.05$) higher in colostrum than in concomitant serum. Antibody titres were significantly higher in colostrum collected from vaccinated does ($P<0.05$) (Figure 5.3, Appendix 5.2).

6.6.2.3. Immunoglobulin A and G levels in serum and colostrum.

In the first three days postpartum serum IgG level in vaccinated does ranged between 18,000 and 19,000mg/l, while the levels in colostrum, which were significantly higher ($P<0.05$) ranging between 5,320 and 53,000mg/l. Serum IgG level in non vaccinated does ranged between 6,000 and 19,000mg/l, while the levels in colostrum, which were significantly higher, ($P<0.05$), ranged between 4,000 and 45,000mg/l. The non vaccinated does had lower, though not significant, ($P>0.05$) levels of IgG in both serum and colostrum (Tables 5.1a,b).

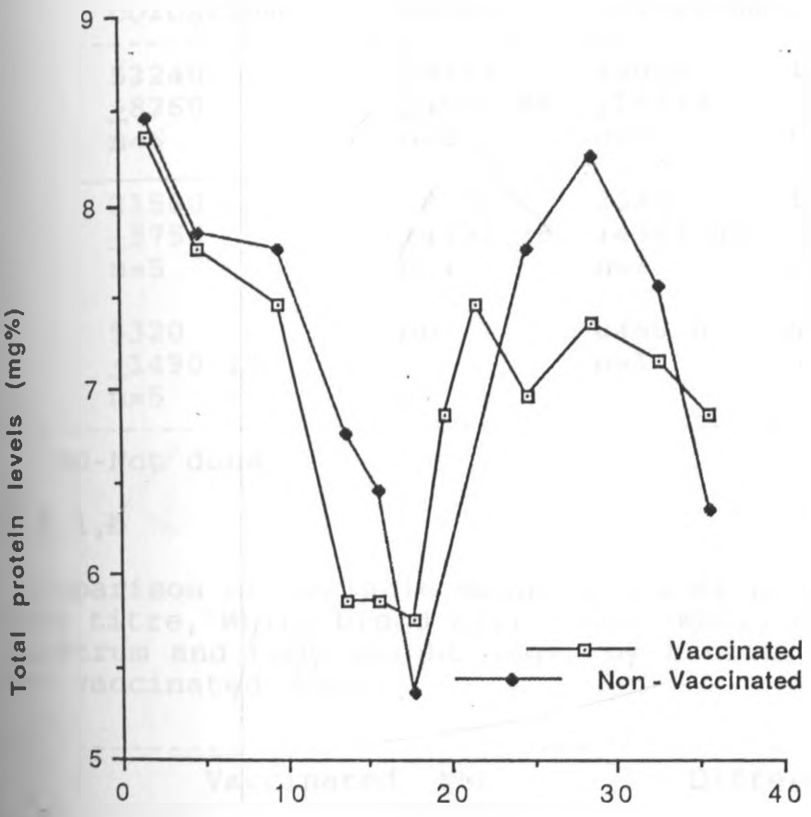


Figure 5.2

Total protein levels (mg/ml) in serum obtained from experimental does during the on-station study.

Table 5.1a

The mean (±se) immunoglobulin concentration (mg/l) in colostrum and sera obtained from experimental does within three days of parturition.

Days postpartum	Vaccination status: Vaccinated		Non vaccinated	
	colostrum	Serum	Colostrum	Serum
1	53240 ±8260 n=6	19113 ±4546.96 n=6	45028 ±16713 n=7	19493 ±3031.85 n=6
2	21580 ±5756 n=5	18550 ±4702.38 n=4	25333 ±4387.86 n=3	15033 ±6778.56 n=3
3	5320 ±1490.17 n=5	ND -	8460.0 n=1	ND -

Key. - ND-Not done.

Table 5.1.b

Comparison of variable means of total protein (g/l), E. coli antibody titre, White blood cell count (WBC), colostral IgG (mg/l) in colostrum and body weight (kg), by t-test, for the vaccinated and non vaccinated does.

	Vaccinated	Non vaccinated	Difference
Total protein	74.0	72.0	NS
Antibody titre	5,376	640	S
WBC	9,118	10,760	NS
IgG colostrum	30,352	33,680	NS
Weight	22.9	20.1	NS

Key. - S - significant, $P < 0.05$; NS - not significant, $P > 0.05$.

Figure 5.2

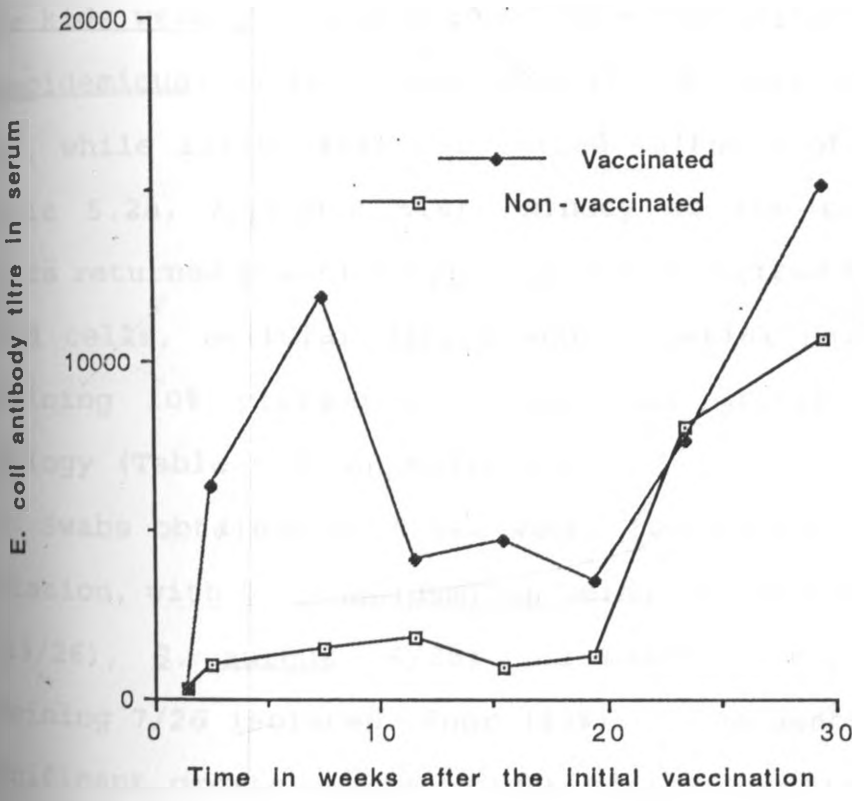


Figure 5.3 E. coli antibody titre in serum obtained from control and vaccinated does, during the on-station study.

The levels of IgG in colostrum and serum fell drastically by the third day postpartum (Tables 5.1a,b, Appendices 5.1-5.5). In contrast only traces of IgA were detectable in serum, colostrum and milk obtained from both groups, vaccinated and non vaccinate does, throughout the study.

6.6.2.4. Bacterial culture and concomitant vaginal cytology.

Fifty four percent of the isolates (15/28) from vaginal swabs obtained 2 weeks after abortion or giving birth to stillborns or live kids were pure cultures of Beta haemolytic Streptococcus (S. zooepidemicus) (32%), S. aureus (11%), E. coli (7%) and A. pyogenes (4%), while 13/28 (46%) were mixed cultures of similar organisms (Table 5.2a, Appendix 5.6). Ninety of the concomitant vaginal smears returned positive cytology characterized by neutrophils, red blood cells, cellular debris and bacterial particles, while the remaining 10% yielded no significant growth but had positive cytology (Table 5.2, Appendix 5.6).

Swabs obtained at three weeks revealed a similar pattern of isolation, with S. zooepidemicus being the predominant isolate (50% - 13/26), S. aureus (6/26) and mixed cultures comprising the remaining 7/26 isolates. Four (13%) of the swabs did not have any significant growth. Eighty eight of the isolates were associated with a positive cytology (Table 5.2, Appendix 5.6).

By week 5 only eight pure isolates were recovered, with 3/8 (38%) of the isolates being associated with positive cytology.

Table 5.2.

Frequency of bacterial isolates from swabs obtained from anterior vagina of experimental does 1-5 weeks after they aborted, had stillbirths or live kids. The results of concomitant cytology are indicated in brackets.

Bacteria isolated	Number of isolates and cytology results		
	Week 2	Week 3	Week 5
Streptococcus spp.	9(9)	13(10)	2(0)
S. aureus	3(3)	6(6)	2(1)
E. coli	2(2)	0	4(2)
A. pyogenes	1(1)	0	0
Mixed cultures	13(13)	7(7)	0
NSG*	3(3)	4(0)	2(1)

Key.

*NSG - No significant growth.

These does were considered to have contracted postpartum infection of the genital tract (Table 5.2, Appendix 5.6). Of the 22 swabs without any significant growth only one (5%) had positive cytology.

Vaginal swabs obtained at 2 weeks from does that had aborted or had stillbirths or live kids returned positive cytology, whether there was a positive culture (26/26) or not (3/3) (Appendix 5.6). In comparison bacterial isolates obtained at 3 weeks from does that aborted or had stillbirths all returned positive cytology (8/8), while 15/18 (83%) of the isolates recovered from swabs obtained from does that gave birth to live kids had positive cytology and bacteriology. Three of the eighteen (17%) had no significant growth and had negative cytology (Appendix 5.6).

By the fifth week 50% (3/6) swabs from does had positive bacteriology. A similar pattern of isolation and cytology results was observed in does that had given birth to live kids. Does that had stillbirths had negative bacteriology and cytology (4/4) (Appendix 5.6).

There was no consistent pattern of bacterial isolation when the does were grouped into vaccinated and non vaccinated.

6.6.2.5. Postmortem examination results.

Of the 9/30 (30%) of the does that died during the adaptation period, 7 were vaccinated while 2 were not. Postmortem examination indicated that they all had chronic subclinical heartwater and low grade helminthosis. There was evidence of previous moderate to heavy intestinal helminthosis.

6.6.3. Performance of kids and changes in blood parameters.

6.6.3.1. Performance.

During the study period 15 kids (48%), 7 (23%) from non vaccinated dams and 8 (26%) from vaccinated does, were born alive while 7 (23%) were aborted and 4 (13%) were stillborn. One doe had twins, one of which died within 48 hours of birth. At birth, the kids that survived and those that died within 48 hours, had body temperatures of between 37.5 and 38.0°C (Appendix 5.4).

At birth kids born of non vaccinated dams had an average body weight of 2.09± 0.16 (n=7) or 9.2% of the dams' body weight at parturition (22.71±2.63kg, n=7), while those born of vaccinated dams weighed 2.03± 0.29 (n=8) or 10.68% of the dams' body weight at parturition (19.71±2.0kg, n=8) (Appendix 5.4).

The righting reflex, which was defined as the ability of the kid to get to sternal recumbency and attempt to stand and suckle, took between 30 minutes and 2 hours. Based on this definition the kids were placed in category 1 if they got to sternal recumbency and attempted to stand and suckle within 30 minutes, category 2 and 3 if the same happened within 45 and 60 minutes respectively and category 4 if it took more than one hour. Based on this criterion all kids falling in categories 3 and 4 died within 48 hours of birth while those in category 1 and 2 survived (Appendices 5.4, 5.5).

6.6.3.2. Blood parameters.

Sera obtained from kids born of both vaccinated and non vaccinated dams had a total protein concentration of 36-59.0g/l, a

packed cell volume (PCV) of 29-41%, a haemoglobin (HB) concentration of between 10 and 13.0mmol/l, while the white cell count (WBC) ranged between 2,500 and 7,800. In kids that had category 1 and 2 righting reflex, the white blood cell count (WBC) rose rapidly to above 5,000 while in those that were in category 3 and 4 and died within 48 hours (parturient deaths) the WBC remained below 4,000. No blood parasites were seen on both thick and thin smears prepared from blood samples collected from the kids at the station throughout the experimental period (Appendix 5.4).

Kids in both groups responded with a leucocytosis characterized by a neutrophilia whenever they contracted gastroenteritis, pneumonia and/or polyarthritis. Packed cell volume and total protein in terminally ill kids were relatively high (Appendices 5.4, 5.5).

6.6.3.3. Immunoglobulin A and G and E. coli antibody titre.

Sera obtained from both groups of kids before suckling did not contain detectable levels of immunoglobulin A and G and E. coli antibodies (Appendix 5.4). At 12 hours the sera from kids born of vaccinated dams had an average IgG concentration of 19,460± 7,479.72mg/l and E. coli antibody titre of between 1/160 and 1/640. At the same interval sera obtained from kids born of non vaccinated dams had an IgG concentration of 22,346.67± 7,885.70mg/l and E. coli antibody of between negative and 1/160. The levels of E. coli antibody titre were about 50% of those recorded for kids born of vaccinated dams (Appendices 5.3, 5.4).

Total protein soon after birth and before suckling was

<40.0g/l, in both groups of kids. The levels were observed to increase to 50-60.0g/l by 12-24 hours post suckling and to 50-80.0g/l by 72 hours (Appendices 5.3 and 5.4). Kids that died within 48 hours of birth (parturient deaths) without showing signs of severe dehydration had low (<40.0g/l) total protein levels while those that died with evidence of severe dehydration had slightly elevated levels of total protein (55.0g/l) (Appendices 5.3, 5.4).

In both groups of kids only traces of IgA were detectable in post-suckling (up to 96 hours) serum samples.

6.6.3.4. White blood cell count and blood glucose levels.

Both groups of kids had between 3,000-4,900 WBC within 12 hours, with the higher counts (9,800-15,000) being encountered in kids that became infected soon after birth (Appendix 5.4).

Blood glucose levels at birth in under weight twins weighing 800 and 900gm were low (<2.0mmol/l) while those of surviving twins were 4.9 and 5.3mmol/l. Those of single kids weighing between 2.4 and 2.7 kg were 4.7 and 5.3mmol/l. At 4-6hrs of age the underweight twins still had low (<2.0mmol/l) blood glucose levels while the surviving twins and single kids had blood glucose levels ranging between 7.3 and 8.4mmol/l. These levels were similar to those recorded for blood glucose levels in 4 week old kids. Blood glucose levels of the underweight kids that died within 48 hours of birth (parturient death) did not exceed 4.9mmol/l at peak. This level was equivalent to the lowest recorded for surviving single kids (Figure 5.4).

Figure 5.4

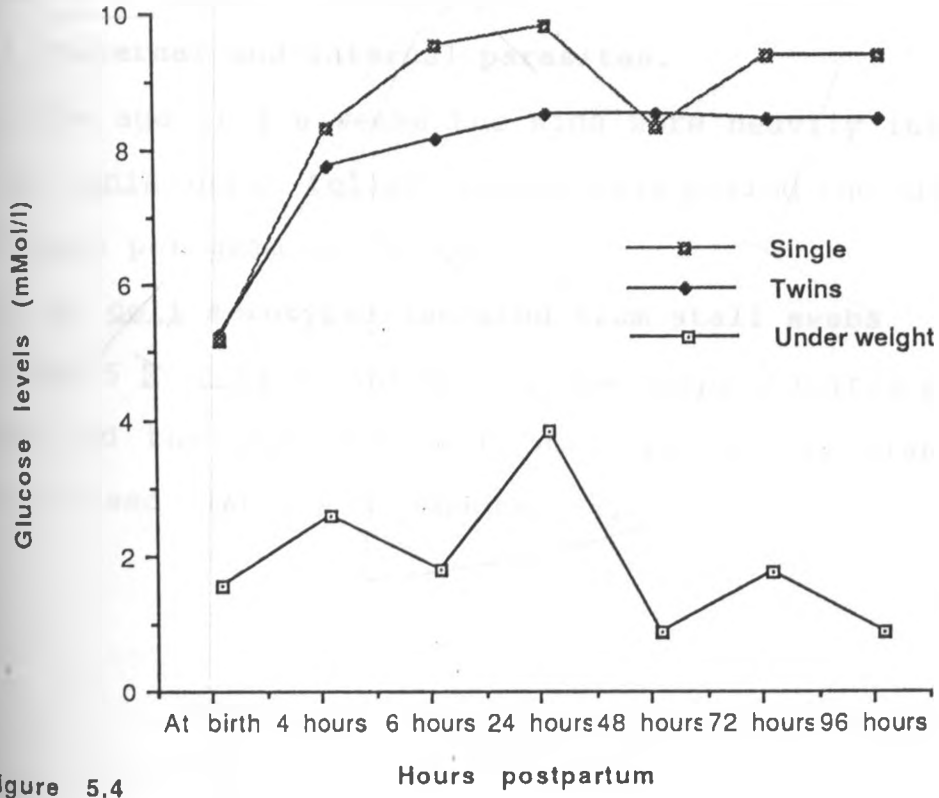


Figure 5.4

Blood glucose (mmol/l) levels in underweight, single and twin kids at various interval from birth to 96 hours

6.6.3.5. Post mortem findings and bacterial isolates from affected lungs.

The fifteen kids died at different ages between 4 days and 12 weeks. Those (6) that died within 7 days postpartum died of a combination of conditions, including pneumonia, gastroenteritis, hepatitis and nephritis, following starvation or severe gastroenteritis with septicemia, while the eight kids that died later suffered from severe gastroenteritis and/or pneumonia. One kid died of E. coli polyarthritis.

6.6.3.6. External and internal parasites.

At the age of 4-6 weeks the kids were heavily infested with fleas (C. canis and C. felis). During this period the kids had less than 50 eggs per gram of faeces.

6.6.3.7. E. coli serotypes isolated from stall swabs.

Of the 5 E. coli isolates, one was conjunctivitis positive at 24 hours and the rest were out of scope of the classification procedures used (Table 4.5, Chapter, 4).

6.6.3.5. Post mortem findings and bacterial isolates from affected lungs.

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Table 5.3.

The frequency of bacterial isolates from lungs obtained from kids that died with respiratory involvement during the on-farm and on-station studies.

Isolate	Number of isolates and sensitivity results								
		Pen[1]	Sul	Amp	Gen	Chl	Neo	Oxy	Kan
Haemolytic Streptococci	2	+	-	+	3+	2+	R	R	3+
E. coli	7	R	R	R	2+	3+	R	R	R
Proteus sp & S. aureus	4	R	R	R	2+	+	+	R	R
S. aureus	2	2+	+	2+	3+	3+	R	+	+
NSG*	5	±	R	-	+	2+	-	-	-

Key.

*NSG - No significant growth,

Drugs tested[1]

Pen - Penicillin, Sul - Sulphur, Amp - Ampicillin, Gen - gentamycin, Chl - chloramphenicol, Neo - neomycin, Oxy - oxytetracycline and Kan - kanamycin,

Scoring

± = Suspicious, R = Resistant, + = fairly susceptible, 2+ = susceptible and 3+ = very susceptible.

6.6.4. The response of kids to the E. coli challenge.

The kids challenged with pathogenic E. coli had a slight elevation in body temperature and leucocytosis by 48 hours after challenge. This transient response subsided by 72 hours (Tables 5.4a-b, Appendices 5.7, 5.8 and 5.9). Total protein and IgG levels and E. coli antibody titre in serum remained unchanged throughout the study (Tables 5.4 a-b). Within 24 hours the infected kids were shedding the same E. coli serotype that was used in the challenge. No kid developed pulmonary involvement or gastroenteritis characterised by diarrhoea during the observation period. Three weeks after the challenge trial, there was an outbreak of contagious pustular dermatitis (ORF) in the flock during which the kids used in the challenge trial succumbed to E. coli gastroenteritis.

Table 5.4a

The mean (±se) total protein (TP-g/l), Haemoglobin (Hb) (mmol/l), red blood cells and temperature changes in kids challenged with pathogenic E. coli (control group 1) and physiological saline (challenge group 2).

Days	TP^1	TP^2	Hb^1	Hb^2
1	70.0±.54	74.0±.41	7.66±1.03	8.42±.58
2	70.6±.25	69.5±.13	9.52±.27	8.62±.57
3	65.1±.16	69.0±.32	82.2±.85	8.41±.55
4	73.7±.35	73.7±.23	9.72±.66	10.75±1.19

Days	RBC^1	RBC^2	$Temp.^1$	$Temp.^2$
1	7.55±1.29	9.26±.36	38.15±.07	38.17±.06
2	8.59±1.12	9.57±.51	38.78±.11	38.61±.23
3	8.28±1.20	9.23±.67	38.33±.06	38.34±.06
4	10.92±1.25	14.42±1.19	38.25±.07	38.31±.06

Key.

TP1 = control group, TP2 = challenge group, HB1 = control group, HB2 = challenge group, RBC1 = control group, RBC2 = challenge group, Temp.1 = control group - and Temp.2 = challenge group.

Table 5.4b

The mean (±se) glucose (mmol/l) and WBC in kids challenged with pathogenic E. coli (challenge group) and physiological saline (control group).

Time in hours	Glucose Control	Glucose Challenge	WBC Control	WBC Challenge
0	9.61±.69	9.86±.66	10,650±452	10,020±644
24	9.89±.64	10.19±.39	12,483±1541	14,800±1039
48	6.50±.52	7.13±.41	14,442±476	12,514±1101
72	7.70±..35	10.24±.80	12,320±1841	12,428±1058
96	9.60±.44	10.29±.53	11,520±1127	9,420±247

Key.

The expected normal values (Schalm et al., 1975; Kaneko, 1989) are HB - 8.0-14.0mmol/l (11.0), WBC - 4,000 - 13,00, RBC 8.0-18.0 (13.0), TP 64-70mg/l (69.00), blood glucose 3-4.16mmol/l (3.5) and Temperature of 38-38.5°C

6.7.0. DISCUSSION.

Severe climatic changes that occurred within a week of establishing the experimental flock in Kabete influenced their adaptation, as indicated by the high rate of perinatal losses (50%), weight loss (25-30%) and high adult mortality (30%). The poor adaptation, which was reflected in the performance of the offsprings, was attributed to the source of the does, timing of the vaccination and possible latent/sub-clinical chronic heartwater. All the does that died during the experimental period were found to have had heartwater.

Serum harvested during the field survey, on-farm study and from non vaccinated experimental does indicated that, using the Elisa test, an E. coli antibody titre of 1:160 (or 1:8 on agar gel immunodiffusion) could be used as the minimum cut-off point for the positive responses. E. coli antibody titre in both vaccinated and control does were significantly ($P<0.05$) higher in colostrum (obtained up to 4 days postpartum) than in concomitant serum. Antibody titres were significantly higher (<0.05) in colostrum collected from vaccinated does. The rapid fall, within three days of kidding, in colostral IgG and E. coli antibodies, observed in both groups of does in the present study reaffirmed the importance of feeding sufficient amount of colostrum as soon after parturition as is practical (Blood and Radostits, 1989, O'Brien and Sherman, 1993a,b; Constant et al., 1994). Total protein, IgA and IgG levels, in the same serum samples did not differ significantly between the two groups.

Pre-sucking serum obtained from kids born of vaccinated and non vaccinated does did not have detectable levels of E. coli antibodies, IgA, or IgG. At 12 hours postpartum the kids from both groups had detectable levels of E. coli antibodies, though the kids born of vaccinated dams had levels that were twice as high as those from non vaccinated dams. The levels of IgG in serum collected after suckling were, however, similar in the two groups of kids. In contrast only traces of IgA were detectable in sera obtained from both groups of kids up to 96 hours postpartum. Similar findings have been observed in the calf, kid and the lamb where there is little IgA and its role is taken over by colostral and milk IgG derived from serum and antigen stimulus probably in the intestines (Bourne et al., 1974; 1978; Rabbani et al., 1990; Constant et al., 1994). The situation in the ruminants contrasts sharply with that in the sow where colostral IgG falls rapidly in the first few days of birth while those of IgA, which is synthesized locally in the mammary gland tissue, remain high rendering IgA the most important mucosal defence mechanism (Bourne et al., 1974; 1978; Snodgrass, 1986).

The age at which the fetus becomes immunocompetent varies from species to species (Acres; 1985; Blood and Radostits, 1989). Acres (1985), in lambs, Bourne et al. (1974, 1978), in piglets and Perryman et al. (1977), in the foal, have shown that a conceptus is able to respond to antigens by the end of the first trimester. In addition Perryman et al. (1977) demonstrated that normal foals are immunocompetent at birth but have little or no immunoglobulin G

(IgG). These workers concluded that it is likely that cellular defence mechanisms are more critical in the foal.

In the present study kids were observed to be capable of responding to natural challenge with a marked leucocytosis within 12 hours of birth. It was postulated that, like in the foal, the cellular defence mechanisms play a key role in the prevention of early postnatal infections.

Hauser et al. (1986) observed that the high levels of corticosteroids, produced by lambs and calves 8-10 days before parturition, resulted in lymphopaenia and a decrease in the phagocytic defense capability in the newborn which may affect the cellular immune mechanisms, thereby decreasing perinatal resistance. This phenomenon may partly account for the short lived low WBC (<4,000) level recorded in kids at birth.

Satapathy et al. (1992) and O'Brien and Sherman (1993a,b) demonstrated that morbidity and mortality rates due to infectious diseases of the intestines and respiratory tract in goat kids are significantly higher in newborns with low levels (<7,500mg/l) of serum immunoglobulin than in those with adequate levels. Similar observations in foals and calves have been made (Deem, et al., 1979; Corbeil, et al. 1984). There is, however, controversy as to the actual relationship between the levels of serum immunoglobulins in newborn farm animals at 24-48 hours of age and subsequent morbidity and mortality (Bradley et al., 1979; Blood and Radostits, 1989). This controversy is based on observations in some beef herds, which indicate that levels of serum immunoglobulins in

calves at 48 hours of age are of no value in predicting the incidence or severity of acute undifferentiated diarrhoea (Bradley et al., 1979).

Though the number of kids observed in vaccinated and non vaccinated groups were not large enough for any firm and generalized conclusions to be arrived at it was apparent that kids that died after suckling, but within 48 hours of parturition, had comparable E. coli antibody titres and immunoglobulin A and G levels to those kids that survived. In comparison kids that died soon after parturition and before suckling had low WBC count (<4,000 cells) no traces of Immunoglobulin A or G or E. coli antibodies, low total protein (<40g/l) and persistently low glucose (<2.5 mmol/l). These latter group of kids were observed at postmortem to have suffered from septicaemia or varying combinations of pathologies including gastroenteritis, pneumonia, hepatitis and nephritis.

Thus, from the limited evidence available from the present study it was observed that the chances of fatal infections were higher in kids of low birth weights (<1.5kg for singles and <1.0kg for twins), low WBC (<4,000) and low (<2.0mmol/l) blood glucose levels, low TP (<40.0g/l), low <1:160) E. coli antibody titre and Immunoglobulin G (≤3,350mg/l) at least 12 hours after birth. It was also observed that such kids responded poorly to routine therapy and that it was not practical or economical to treat them. This conclusion was similar to that arrived at, in calves, by Sawyer et al. (1977) and Blood and Radostits (1989) but differed with that

made by Rowan et al. (1994) while working with goat kids.

Barlow et al. (1987) observed that lambs which died in the early and delayed post natal period had significantly lower average body temperature 30 minutes after birth than those that survived. Barlow et al. (1987) concluded that draught exacerbated the heat loss. These workers reported that rectal temperature of a newborn was an important factor for survival and that often perinatal deaths result from the inability to maintain adequate body temperature outside the uterus. Similar observations were made in the present study.

In the present study the selection of weeks as the point at which to challenge the kids was based on the inability to detect of E. coli antibodies in serum. This was taken to mark the period of transition from maternal antibodies to the initiation of production of E. coli antibodies by the kids in response to exposure to antigen (Jeffcott, 1974; 1975; McGuire et al., 1976; Snodgrass, 1986; Rabbani et al., 1990; Constant et al., 1994). In this trial it was observed that other than a transient response to challenge the kids did not develop the expected clinical manifestations of gastrointestinal or pulmonary involvement. The slight elevation in body temperature and leucocytosis noted indicated that the E. coli strain and the dose administered were sufficient to elicit a response. The fact that the effects of the challenge were transient, was taken to indicate that other factors, other than the presence of pathogenic organisms alone, were necessary for E. coli to colonize a kid's gut. This suggestion was enhanced by findings

in a chance occurrence in which the kids used in the trial succumbed to a naturally occurring enteropathogenic strain of E. coli during an outbreak of contagious pustular dermatitis (Orf).

In a review on neonatal defence mechanisms, Newby et al. (1979) and Blood and Radostits (1989) concluded that many workers had shown that colostral immunoglobulin A and G present in the intestine prevent the establishment of enteric diseases, while circulating immunoglobulins are necessary for the protection against septicaemia. The latter, however, do not prevent diarrhoea as they do not reach the lumen of the intestine in protective amounts. Villouta et al. (1980), in earlier studies, had concluded that, though not preventing the establishment of diarrhoea, high serum immunoglobulin levels reduced the severity of such infections by preventing massive outpouring of fluids and electrolytes into the intestinal lumen. Thus while it might be beneficial to enhance the kids defence mechanisms by vaccinating the dam against the most common pathogens (Acres, 1985; Nagy et al., 1985; Snodgrass, 1986, Vihan, 1993), it is more critical to improve the doe's management including nutrition. This would in effect improve the kids' weight at birth, which is one of the most important factors affecting viability of goat kids (Amble et al., 1964; Quartermain, 1975; Vohradsky and Sada, 1973; Mittal, 1976; Morand-Fehr, 1991; Bosman and Ayeni, 1993; Ba and Udo, 1995).

During the field, on-farm and on-station studies (Chapters 4 and 5), it was observed that E. coli and Actinomyces pyogenes, among other bacteria were isolated from genital tracts with and

without any evidence of tissue or cellular reaction. This finding was taken to indicate that other factors such as cervical drainage, as in the mare and cow (Hughes and Loy, 1969; 1975; Peterson et al., 1969; Woolcock, 1980), period of the oestrous cycle, as in the cow and rabbit (Black et al., 1953; Winter et al., 1960) and women (Novak and Woodruff, 1967) and the individual doe's inherent ability to resist infection may determine whether the invading organism establishes itself or not (Hughes and Loy, 1969; 1975; Peterson et al., 1969; Munyua, 1985).

In the present study vaginal swabs obtained postpartum from does during the field survey yielded positive cytology and bacteriology for the first four weeks, these were considered as regular puerperal period cellular changes. It was observed that less than 10% of the does returned positive cytology four weeks postpartum. This reaction was considered to be due to genital tract infection(s). Thus, four weeks postpartum is suggested as the cut-off point between the "expected" and "abnormal" cellular changes postpartum. It is proposed that practitioners refer to the last kidding date when interpreting the results of vaginal bacteriology and cytology.

Based on the findings of the present study it would be interesting to carry out a similar study on a large flock under traditional production system to verify some aspects of the findings.

CHAPTER 7.

GENERAL DISCUSSION, MAIN OBSERVATIONS AND CONCLUSIONS.

7.0. General Discussion.

In the present study the low (<5%) incidence of structural and functional defects, genital tract infections and embryonic/fetal loss observed may have been a reflection of the low numbers of organs examined or the high rate of home slaughter of culled infertile does rather than their low ranking as causes of reproductive losses. The erosion of the endothelium, strata compactum and spongiosum associated with the few cases of chronic purulent endometritis observed would, however, give a guarded prognosis to future breeding value of the affected does as healing would be by fibrosis (Nieberk and Cohrs, 1966).

Based on uterine and vaginal cytology, it was concluded that positive bacterial cultures were poor indicators of an active infection as there was little relationship between the presence of potential disease causing pathogens and that of inflammatory cells. This finding would, as in the mare, cast doubt on the usefulness of a single positive bacterial vaginal swab in the diagnosis of metritis, unless accompanied by other indicators of an active infection such as elevated protein levels and immunoglobulins in vaginal discharges (Munyua 1982; 1985; Williamson et al., 1983).

The occurrence of diseases that affect reproduction including caprine brucellosis (Kagunya and Waiyaki; 1978) and leptospirosis (D'Souza, 1983; Ndarathi et al., 1991) in goats in the arid and

semi-arid areas of Kenya have been reported. Examination of the goat sera collected during the field survey confirmed these findings and indicated that Rift Valley Fever may also be an important cause of abortion in does. The high prevalence rate of positive reactors to leptospirosis, brucellosis and rift valley fever in apparently healthy goats and in flocks without history of abortions suggests a possible carrier state for leptospirosis, brucellosis and rift valley fever which may serve as a source of infection to other animals and humans. It is important that the goat producers and the Veterinary and Animal Production Department staff in these areas be alerted on the presence of these diseases not only because they are economically important but also because they are zoonotic.

Plant poisoning, with abortion as the main clinical sign, was said to be common in most of the areas surveyed. The goat producers in Baringo-Koibatek incriminated "spoilt" acacia pods while those in Kitui and Makueni theorized that a substance inherent to the "immature" pods was responsible. While it is possible that the abortion may be due to factor(s) inherent to the pods at a particular stage of development it is also possible, as suggested by producers in Baringo-Koibatek, that the pods were contaminated with a fungus that was responsible for the abortion. Further studies are necessary to elucidate this observation.

In the present study preweaning mortality, which ranged between 10-70%, was a major constraint to attaining full reproductive potential in goats. In Machakos, Kajiado, Baringo-

Koibatek, Marsabit, Samburu and Kilifi E. coli gastroenteritis with or without septicemia and/or pneumonia and helminthosis were the most important causes of preweaning kid mortality. It was likely that the survival of these kids was dictated by events related to parturition or immediately thereafter including the availability and quality of colostrum and righting reflex.

Pre-sucking serum obtained from kids born of vaccinated and non vaccinated does did not have detectable levels of E. coli antibodies, IgA, or IgG. At 12 hours postpartum the kids from both groups had detectable levels of E. coli antibodies, though the kids born of vaccinated dams had levels that were twice as high as those from non vaccinated dams. The levels of IgG in serum collected after suckling were, however, similar in the two groups of kids. In contrast only traces of IgA were detectable in serum obtained from both groups of kids up to 96 hours postpartum. Similar findings have been observed in kids, calves and the lambs where there is little IgA and its role is taken over by colostral and milk IgG derived from serum and antigen stimulus probably in the intestines (Bourne et al., 1974; 1978, Vihan, 1993; Constant et al., 1994).

The findings of the present study indicate that both colostral (up to day 4) and kid serum IgG levels (up to day 7) were at least 3 times those in maternal serum while only traces of IgA were detected. It is therefore possible that as in the mare, but unlike in the sow, colostral IgG has a greater role to play in the protection against intestinal infections than IgA. And as suggested by Villouta et al. (1980) the high levels of IgG may reduce the

severity of the infections by preventing massive outpouring of fluids and electrolytes into the intestinal lumen.

It has been observed that high levels of corticosteroids produced by lambs and calves 8-10 days before parturition results in lymphopaenia and a decrease in the phagocytic defense capability in the newborn. This immunosuppression is severe enough to affect the cellular immune mechanisms thereby decreasing perinatal resistance (Hauser, et al., 1986). It is probable that this phenomenon may partly account for the short lived low white blood cells (<4,000) level recorded in kids at birth. As observed by Vihan (1993) and in the present study goat kids were capable of responding to natural challenge with a marked leucocytosis within 12 hours of birth. In the present study this was taken to indicate the crucial role played by the cellular defence mechanisms in the prevention of early postnatal infections.

From the limited evidence available from the present study it was observed that the chances of fatal infections were higher in kids with delayed righting reflex, low rectal temperature, low birth weights (<1.5kg for singles and <1.0kg for twins), low white blood cells (<4,000) and low (<2.0mmol/l) blood glucose levels, low total protein (<40.0g/l), Low <1:160) E. coli antibody titre and immunoglobulin G (≤3,350mg/l) at least 12 hours afterbirth. It was also observed that such kids responded poorly to routine therapy and that it was not practical or economical to treat them. Similar conclusions have been arrived at in calves (Sawyer et al., 1977; Barlow et al.., 1987; Blood and Radostits, 1989). It was therefore

concluded that these parameters were good prognostic indicators of kid survival that are adaptable by practitioners.

Data available from the present study showed that about 85% of the respondents used commercially available anthelmintics. Most producers, however, either underdosed (60%) or overdosed (20%). The former rendered the drug ineffective, while the latter incurred unnecessary expenses. Despite this drawback, this finding indicated that most producers appreciated the need for some form of veterinary intervention.

Of the producers who did not drench their goats 20% (Baringo, Koibatek, Narok and Transmara) and 50% (Samburu and Marsabit) used herbal concoctions. This was taken to indicate that there is need to integrate indigenous knowledge and ethnoveterinary practices into the current veterinary service delivery systems, including disease control programmes (Munyua et al., 1995b).

It was observed in the present study that preweaned kids were neither treated for coccidiosis nor external parasites. This practice led to a build-up of external parasites such as fleas, lice and ticks, and internal parasites such as helminths and coccidia, inevitably resulting in anaemia. This state not only predisposes the kids to specific and opportunistic infections but also results in poor response to disease once established and increased severity of low grade gastrointestinal infections. The disease situation was compounded by the reluctance of affected producers to procure and administer antibiotics as they do not consider it economical to treat preweaned goat kids. Findings of

the on-farm study, however, contradicted this belief as it was observed that it was possible to reduce preweaning mortality and increase flock profitability by implementing a modest costing (Ksh. 40-490) veterinary intervention package (Munyua et al., 1995a, 1996a;b).

In does, this "intervention enhanced performance" not only indicated that it is possible to reduce the impact of nursing, external parasites and helminthosis on the does' body condition postpartum but also that it is possible to shorten the interval between kidding to first postpartum oestrus. The latter can be used to manipulate annual reproductive rates. It was also established that the cost of this intervention in does can be offset by the "meat value" based on the recovery of body condition (240 Ksh/doe/year based on a meat value of 120 Ksh./kg). To farmers, this "intervention enhanced performance" meant that there would be more potential breeding material and stock for sale available in future (Munyua et al., 1995a, 1996a;b).

Using data on flock performances in Kajiado and Juja and given assumptions, it was estimated that a producer with a flock of 160 goats in these production systems would have made a profit of Ksh. 114,079.90 annually had he/she chosen to use the proposed intervention package in the years under study. Thus in agreement with Mucuthi et al., (1992) and Panin (1996), in Kenya and Botswana respectively, it was concluded that goat production can be a profitable enterprise in arid and semi arid areas.

Farmers' production objectives and interpretation of what

constitutes "economical production" often conflict with those of researchers and policy makers (Mrema and Rannobe, 1996; Mazzucato, 1997). One such area of conflict is the culture of keeping animals as wealth or savings, thus hindering the increase of offtake rates, while the other is the competition for inputs with other enterprises including cattle and camels and crops which deprives goat production the necessary resources, including labour, capital and feed, needed to improve production. Assuming, however, that weather and environmental conditions hold, the producer can only realize the projected returns if she/he has resources and sufficient knowledge and information on how best to allocate the available resources from the outset. The current extension services can only assist with the information. It is important that the producers are provided with guaranteed security, reliable market outlets and basic infrastructure if goat production is to remain profitable in future.

7.1. MAIN OBSERVATIONS AND CONCLUSIONS.

Based on the findings of the present study it was concluded that:-

1. Does have a clear pattern of ovarian cyclicity, with peak ovarian activity being between February (25%) and May (27%). This observation, and the fact that does continue to cycle while lactating, was taken to indicate that it is possible to manipulate the kidding to service and interkidding intervals by improving management, and especially nutrition.

2. The loss of conceptus, (early embryonic deaths, maceration and mummification), structural abnormalities and functional defects (cystic ovaries) were not considered to be major causes of infertility in the doe as they were only occasionally encountered (<10%).

3. The management of kids and does, which is highly influenced by production objectives, greatly affect the level of neonatal mortality.

4. The most frequent diarrhoeagenic agents were bacteria, including enteropathogenic E. coli, Streptococcus sp. and Staphylococcus sp., helminths and coccidia, which can be controlled through improved management and treatment. No virus(es) or mycoplasma were isolated or observed on negative stained preparations. Stress was observed to be an important determinant in the establishment of enteropathogenic E. coli in the gastrointestinal tracts of kids.

5. The righting reflex, weight at birth, rectal temperature and

blood parameters, including total protein, white blood cell count and blood glucose levels at birth, which can be easily and cheaply measured, are good prognostic indicators of kid viability. These prognostic indicators and the producer's production objectives and resource allocation priorities need to be assessed before an intervention package is instituted as it may not be cost effective to intervene. Veterinary intervention packages, including vaccination with autogenous vaccines, if appropriately instituted in-terms of composition and timing, are cost effective and can lower reproductive wastage and increase reproductive performance.

6. The genital tract of does postpartum may be contaminated with a wide range of bacteria that may or may not elicit a cellular and/or humoral response(s). This in effect reduces the diagnostic value of a single bacterial swab in the diagnosis of caprine metritis. Other diagnostic aids need to be established and tested.

7. Mastitis in the doe may be an economically important disease, where it occurs, as it can result in the loss of udder function, death of the does or starvation in kids, unless recognized and attended to promptly.

8. Producers and field and laboratory Ministry of Agriculture, Livestock Development and Marketing personnel and private practitioners need to be made aware of preventable and/or controllable causes of doe and buck infertility, including rift valley fever, leptospirosis, besnoitiosis, streptothricosis, mange and trypanosomosis (and especially in non-endemic areas), so that they can evaluate their disease control measures. The need to

create awareness is made even more acute by the fact that rift valley fever, leptospirosis and mange are zoonotic while trypanosomosis was observed in "non-traditional areas".

9. There is a need to make veterinary services more accessible, and to train producers in the arid and semi arid areas to perform simple procedures, including recognition and treatment of common diseases and conditions and the proper use of drugs and chemicals to reduce drug/chemical abuse that is currently widespread.

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9.0. APPENDICES.

Appendix 2.1a.

Typing of E. coli isolates using Hoechst Kenya LTD and Wellcome Kenya LTD commercial test kits.

All E. coli isolates from kids, with or without diarrhoea, were subcultured in cooked meat media and typed using commercial serotyping kits (Hoechst Kenya. LTD and Wellcome Kenya. LTD), as per manufacturers recommendations (Appendices 2.1 and 2.2).

a) Determination of K-antigens in the slide test using the Hoechst kit.

Briefly the working dilution of the test sera was prepared using isotonic saline solution containing 0.5% phenol; in the original vials, diluting pools A, B and C at 1+2 and diluting the monovalent test sera at 1+4. Briefly a drop of coli test serum pools A, B or C was placed on the glass slide and a loopful of bacterial mass added while stirring to obtain a homogeneous, slightly milky suspension, avoiding the formation of clumps. The slide was then gently rotated with a swirling movement 10-20 times (rotations). The result was recorded as positive if agglutination became visible after 10 to 20 rotations (Appendix 2.1a).

b) Determination of the O-antigen in the Gruber-Widal test (Hoechst tube test).

This test was applied to samples found to be positive in (a) above. In this test a suspension of the suspected strain was prepared in isotonic saline solution and heated for 60 minutes at 100°C to destroy the K-antigens. The density of the suspension was adjusted to approximately 1.0×10^9 cells/ml. Two-fold serial dilutions of the appropriate monovalent coli test serum were prepared in isotonic saline solution in volumes of 0.5ml per test tube (diameter 8-10mm, length 80-90mm) starting from the working dilution (1+4). An extra tube was filled with isotonic saline solution for the antigen control. To each tube 50μl of the heat-treated suspension was added and incubated for 2 hours at +37°C and then 18 hours at room temperature.

The results were read with a conventional microscope at low magnification (Mag. x6 or 10). The reaction was considered positive when granular agglutinates were visible with the naked eye or a microscope at low power. The end-point titre was the highest dilution with agglutination clearly visible in the microscope. Samples in which the suspension remained homogeneous and milkily turbid, were considered negative.

If the slide test had a positive reaction with one of the monovalent coli test sera, this was indicative of an enteropathogenic coli strain. The O-antigen was then identified using the corresponding Coli test serum. In the Gruber-Widal test (tube test), the O-antigen is identified when the sample reacts positive with the test serum and reaches the labelled titre of the test serum. All runs were ran alongside a control of known strain.

Appendix 2.1a continued.

Typing of E. coli isolates using Hoechst Kenya. LTD and Wellcome Kenya LTD commercial test kits.

a. Slide agglutination using the Wellcome Coli test kit.

Two separate drops of saline were put on a glass slide and a loopful of a colony of the suspected culture was emulsified in each drop of saline to give smooth, relatively dense suspension. To one suspension, the control, one drop or loopful of saline and was added and mixed. To the other suspension, the test sample, one drop or loopful of undiluted antiserum was added and mixed. The resulting suspension was rocked gently before being observed for agglutination using indirect lighting over a dark background. A positive reaction was that with a strong agglutination, clearly visible within one minute. Non-specific agglutination, expected to occur with the slide technique particularly when carried out on bacteria taken from selective media, was usually fine, slow to appear and broke up on stirring. This may have been due to minor antigenic relationships or roughness. It is recommended that if the saline control suspension is granular in a slide or tube agglutination test, the suspension is not suitable for typing by that method.

b) Tube agglutination test using the Wellcome test kit.

The antigen for the test tube agglutination test was prepared by suspending culture from an agar slant in saline or 0.5 per cent formalinized saline to give a relatively light suspension (about 7.5×10^8 organisms per ml). The suspension was heated for one hour at 100°C to obtain an "O" antigen suspension; alternatively a heated 4-6 hours broth culture of the organisms (see the Hoechst method 2.2.i) was used.

Dilutions of antiserum in 0.5ml volumes were made in saline from 1 in 10 to 1 in 640 in round bottomed glass tubes measuring approximately 9mm x 85mm. To each tube 0.5ml of the antigen suspension was added to the diluted antiserum. A control tube containing only the suspension and diluent was also set up. The tubes were shaken and incubated overnight at 50°C before being examined for agglutination. Positive agglutination was indicated by a clearing of the supernatant with a sediment that rose as a granular mass when the tube was flicked with the finger. The control tube was cloudy and any sediment went into suspension on flicking. Agglutination titre of 1 in 20 were not regarded as significant; titres at or near that stated by the manufacturer indicated that the antigen is of the same "O" group as the antiserum.

Key:

1. If the reaction was positive the sample was tested with the following monospecific sera (Hoechst Kenya LTD).

pool A	Anti-O 26 K 60
	Anti-O 55 K 59
	Anti-O 111 K 58
	Anti-O 128 K 67
pool B	Anti-O 86 K 61
	Anti-O 119 K 69
	Anti-O 125 K 70
	Anti-O 126 K 71
	Anti-O 127 K 63
pool C	Anti-O 114 K -
	Anti-O 142 K 86
	Anti-O 158 K -

2. The Wellcome E. coli agglutinating sera, which is produced in rabbits and preserved with 0.5 per cent phenol and 0.02 per cent thiomersal, is commercially available in bottles of 2ml (liquid), in the following enteropathogenic types:-

E. coli Polyvalent 2. [Types 026:K60 (B6), 055: K59 (B5) 011:K58 (B4), 011:K69 (B14), 0126:K71 (B16)]
E. coli Polyvalent 3. [Types 086:K61 (B12), 0114:K90 (B), 0125:K70 (B15), 0127:K72 (B17), 0142:K86 (B)]
E. coli Polyvalent 4. [044:K74 (L), 0112:K66 (B11), 0124:K72 (B17), 0142:K86 (B)]
E. coli Type 018c: K77 (B21)
E. coli Type 026:K60 (B6)
E. coli Type 044:K74 (L)
E. coli Type 055:K59 (B5)
E. coli Type 086:K61 (B7)
E. coli Type 0111:K58 (B4)
E. coli Type 0112:K66 (B11)
E. coli Type 0114:K90 (B)
E. coli Type 0119:K69 (B14)
E. coli Type 0124:K72 (B17)
E. coli Type 0125:K70 (B15)
E. coli Type 0126:K71 (B16)
E. coli Type 0127:K63 (B8)
E. coli Type 0128:K67 (B12)
E. coli Type 0142:K86 (B)2

Appendix 3.1:
Survey on the reproductive performance and wastage in goats in arid and semi-arid areas.

NAME OF PRODUCER:
PHYSICAL ADDRESS:

I: BIOPHYSICAL PARAMETERS OF SELECTED GOAT PRODUCING AREAS AND STRUCTURE

1. AREA PARAMETERS
   a) LOCATION b) ANNUAL RAINFALL c) SEASONS i) Rainy ii) Dry
   d) ALTITUDE

II. LAND TENURE
   1. What is the type of land ownership?
      a) INDIVIDUAL b) GROUP (Co-operative) c) COMMUNAL d) STATE/LOCAL GOVERNMENT.
   2. If individual ownership - a) what is the acreage ?, b) Is grazing free range? (Explain).
   3. If group ownership, how is grazing organized?
   4. If group ownership, who/what limits the number of animals per household?

III. FEED AND WATER AVAILABILITY
   1. What is the approximate time (hours) allowed for grazing - a) In the Dry season? b) In the Wet season ?
   2. Do you supplement animals with any feed during the dry season ?
      a) YES b) NO
   3. If YES - a) With what do you supplement the animals ?, b) At what rates? c) How do you determine the supplementation rate ? d) When do you supplement?
   4. Where do the goats get their water ? - a) During the wet season - i) water trough, ii) pail/buckets, iii) ponds, iv) rivers/streams, v) Others
      b) During the dry season - i) water trough, ii) pail/buckets,
      iii) ponds, iv) rivers/streams, v) Others
   5. Are these water points communal ?
   6. What groups of animals share the same water point ?, i) Other Livestock (Cattle, Sheep, Donkeys), ii) Wild animals.
   7. Is there a problem of water during the dry season ? a) YES b) NO
   8. If YES, how does this influence stock numbers and densities ?

IV. BASIC DATA
   1. What breeds of goats do you keep, a) GALLA, b) SMALL EAST AFRICAN, c) CROSSES
   2. i) What is the total goat herd number ?; ii) What is the

goat herd structure? (In numbers) - a) ENTIRE MALES , b) MALE CASTRATES, c) FEMALES (Does), d) WEANERS, e) KIDS

3. How do identify your individual herds and those within herds ?.

4. How do you as the farmer estimate, a) animal weights, b) animal ages.

5. a) What is the main season of kidding ?, b) How many breeding seasons are there per year ? - 1 or 2

6. What is the average age does at first kidding ?

7. How many animals abort at any one year ? - a) According to the farmer, what are the possible causes ?. b) According to the Livestock / Veterinary Officer, what are the possible causes?

8. a) How many animals have udder problems (Mastitis) in the flock ?., b) When is the highest incidence of udder problems observed ?. - i) During the rainy season, ii) Before the rainy season, iii) After the rainy season, iv) During the dry season, c) Do humans use the does' milk ?. i) YES, ii) NO (Explain).

9. What criteria is used in the selection of breeding females ?.

10. a) What is the interval between kidding and the next mating ?., b) What is the interval between one kidding and the next ?, c) What mating system is in use ?. - i) Free for all, ii) Hand mating.

11. a) What are the twinning rates? (Or how many does out of 10 drop twins), - i) 1 - 5%, ii) 10 - 20%, iii) 20 - 30%; b) What is the survival rate of twins ?.

12. i) What are the METHODS or TYPES of disposal of females ?. - a) EXCHANGE, b) SALE, c) PREDATION (Explain), d) DEATH (Explain), e) ACCIDENTS (Explain), f) OTHERS (Explain). - ii) What are the main REASONS for disposal by sale ?.

13. a) What criteria is used for the selection of breeding males ?., b) At what age are they selected / recruited ?.

14. a) How many females per season is each male allowed to mate ?. b) What is the basis ?.

15. What are the main reasons of culling / disposing the males ?. a) INFERTILITY, b) SOURCE OF INCOME, c) AVOID INBREEDING, d) AS STOCKING RATE REGULATORY MEASURE, e) SELECTION AGAINST UNDESIRABLE TRAITS, f) OTHERS.

16. What are the preweaning mortality rates ?. - a) % PARTURIENT DEATH (Within 48 hours of birth), b) % PREWEANING (Before 3-4 months of age).

17. What are the main causes of preweaning mortality. - a) According to the farmer ?. b) According to the Livestock / Veterinary Officers ?.

18. How many adult deaths were there in the last year/season ?.

19. What are the main causes of the above deaths ?. a) According to the farmer ?., b) According to the Livestock / Veterinary Officers ?

20. Does the farmer deworm his flock ? a) YES b) NO.

21. a) If YES; i) How often and when ?. ii) What dewormers are commonly

used ?., b) If NO, state why.

22. What diseases affecting goats are prevalent in the area ?. (List diseases, local names and clinical signs seen). a) According to the farmer ?. b) According to the VO/LO?

V. HOUSING

1. Do producers house their animals ?. a) YES (Day/Night/Both ?); b) NO;

2. If YES, a) What kind of housing is provided for:- i) The kids, ii) bucks and does, castrates; b) What type of materials are used for the housing structures ?.

VI. OTHER LIVESTOCK SPECIES AND AGRICULTURAL ACTIVITIES

1. What other livestock species are kept ?. a) CATTLE - i) How many ? (Numbers), ii) Herd structure - entire bulls, castrates, cows and calves; b) SHEEP - i) How many ?, ii) Herd structure - entire rams, castrates, ewes, weaners and lambs; c) OTHERS (Camels, chicken and donkeys).

2. a) Are the goats / sheep herded separately from cattle ?. i) YES, ii) NO, b) If YES, state reason(s).

3. What other agricultural activities are the farmers engaged in ?.

4. In the producer's and LO/VO's opinion, how can livestock production be improved.

VII: WILD ANIMALS

1. Does the producers consider wild animals a problem ?. - a) YES b) NO.

2. If YES, a) Which are the most common species ?. b) Do they influence the pattern of grazing ?. i) By predation, ii) By competition for food.

Appendix 3.2.

Biophysical and goat production parameters of selected goat producing areas in the arid and semi-arid regions of Kenya.

Rift Valley Province, Baringo District - (n=20).

1. Area parameters			
Location	Kitichibit(3)	Kinyachi(3)	Kimalel(4)
Rainfall/annum	300-600	300-600	300-600
Altitude	3240ft	3200ft	3240ft
Average temperatures			
Land tenure	Group Ranch/ Individual	Group Ranch/ Individual	Group Ranch/ Individual
Acreage adjudicated consolidated	Not adjudicated or consolidated	Not adjudicated or consolidated	Not or
2. Reproductive performance and wastage			
a) Performance	Galla x SEA	Galla	Galla x SEA
Main kidding season(s)	Dec/Jan July-August	Same	Same
Age at 1st kidding	2 years	1 year	1½ years
% Twinning	< 5%	< 5%	< 5%
Kidding to mating interval		2-4 months	SameSame
b) Wastage			
% Abortion	< 5%	< 5%	< 10%
Causes of abortion	Immature acacia pods, Tryps, CCPP	Same	------ Same
% Mastitis cases	< 2%	< 2%	< 2%
Pre-weaning mortality	10-25%	5-30%	30-50%
Causes	Diarrhoea (Gastroenteritis)	Gastroenteritis --	Mange Same
	Helminthosis	Same	Same
	Trypanosomosis	Trypanosomosis	CCPP
	Streptothricosis	Streptothricosis	Same
c) Adult deaths			
Causes	5-20%	5-20%	50%
	CCPP	CCPP	Heartwater
	Trypanosomosis	Same	Same
	Drought	Same	Same
d) Reasons for stock disposal		Annual goat Auction	Drought
	Age	Age	Same
	Drought/Starvation	Goat auction	Same
	Personal needs	Home use	Same
e) Males			
Selection criteria	Growth rate	Same	Same
Causes of infertility	Alopecia and hyperkeratinization of scrotum	Mange	Same +
	fungal infection	Same + mange	Scrotum - Mange
	Tryps Foot rot	Tryps lameness	Tryps
	Problems in periods of drought		Same

3. Flock structure ("Selected" farms)			
Total in flock	30-170(90)	30-150(70)	30-120(80)
*Kids	19%	9%	17%
Weaners	0	0	0
Male (entire)	4%	10%	9%
Castrates	18%	17%	40%
Females	61%	64%	34%
4. FEED			
Dry season	Pods/shrubs	Pods/shrubs	Pods/shrubs
Wet season	Leaves/grass	Leaves/grass	Leaves/grass
Remarks	Problems arise during drought		Same
5. WATER			
Dry season	Ponds\dam	Ponds\dam	River\dam
Wet season	Dams	Dam	Dam
Remarks			

Appendix 3.2 continued.

1. Area parameters		
Location	Loboi(5)	Kimose(5)
Rainfall/annum	300-600mm	400-700mm
Altitude	3160ft	3200ft
Average temperatures		
Land tenure	Group Ranch/	Group Ranch/
Acreage	Not adjudicated or consolidated	Not adjudicated or consolidated
2. Reproductive performance and wastage		
a) Performance	Galla x SEA	Galla x SEA Boer-galla
Main kidding season(s)	December-January July-August	October-November
Age at 1st kidding	2 years	16 months
% Twinning	5%	5%
Kidding to mating interval	2-4 months	6 months
b) Wastage		
% Abortion	< 5%	3%
Causes of abortion	Immature/spoilt pods, Tryps, CCPP	Same Same
% Mastitis cases	< 2%	
Pre-weaning mortality	10-25%	10-25%
Causes	Gastroenteritis Helminthosis Trypanosomosis Pneumonia(CCPP) Mange/fungal infections Streptothricosis	Pneumonia Gastroenteritis (bacteria and coccidia) Helminthosis Enterotoxaemia Mange Streptothricosis
c) Adult deaths		
Causes	5-20% CCPP Drought Trypanosomosis	7-8% CCPP Haemonchosis Heartwater
d) Reasons for stock disposal	Home use Age	Same Age
e) Males		
Selection criteria	Growth rate	Same
Causes of infertility	Same Streptothricosis Feet problems	Not observed " "

3. Flock structure ("Selected" farms)		
Total in flock	20-330(250)	50-590(300)
*Kids	30%	24%
Weaners	0	16%
Male (entire)	2%	20%
Castrates	18%	0.005%
Females	50%	40%
4. FEED		
Dry season	Pods	Pods
Wet season	Leaves	Leaves
Remarks	Incases of drought they incur heavy loses	
5. WATER		
Dry season	A problem	Same
Wet season	"	"
Remarks	Producers unable to differentiate between stillbirths and parturient deaths. Abortions difficult to detect.	

Appendix 3.2 continued.

Rift Valley Province, West Pokot District (Questionnaire).

1. Area parameters		
Location	Sigor(3)	Kinyang(3)
Rainfall/annum	300-450mm	300-650mm
Altitude	4500ft	3000ft
Average temperatures		
Land tenure	Communal	Same
Acreage		
2. Reproductive performance and wastage		
a) Performance	Galla x SEA	SEA
Main kidding	August September	September-November
season(s)	April-May	May-June
Age at 1st kidding	13 months	20-26 months
% Twinning	15%	5%
Kidding to mating interval	2-3 months	4 months
b) Wastage		
% Abortion	10%	2%
Causes of abortion	Brucellosis	Trypanosomosis
	Trypanosomosis	CCPP
	--	Brucellosis
% Mastitis cases	10%	1%
Pre-weaning mortality	10-25%	10-50%
Causes	Pneumonia-smoke	Helminthiasis
	Gastroenteritis	ccpp + pneumonia (rains and after long dry spell)
	Hunger (competition with Gastroenteritis by humans)	
	ORF	Lice (during dry season)
	Helminthosis	Predation
	Mange	Mange
c) Adult deaths		
Causes	30%	10%
	CCPP	ccpp
	Helminthosis	Helminthosis
	Plant poisoning	Predation
d) Reasons for stock disposal		
	Family use	Family use
	Revenue	Revenue
	Chronic illness	Ceremonies
e) Males		
Selection criteria	Growth rate and body colour and dam's milk yield	
Causes of infertility	Brucellosis	Scrotal injuries
	Trypanosomosis	Fungal infection

3. Flock structure ("Selected" farms)		
Total in flock	20-70(50)	20-115(60)
*Kids	15%	24%
Weaners	23%	12%
Male (entire)	4%	2%
Castrates	7%	10%
Females	51%	52%
4. FEED		
Dry season	Fair as acacia pods are ripe then	Mobility (migration) ensures adequate feed
Wet season	Ok	No problem
5. WATER		
Dry season	A constraint	A problem
Wet season	No problem	No problem
Remarks	Transhumance	Transhumance

Appendix 3.2 continued.

Rift Valley Province, Samburu District (n = 20).

1. Area parameters		
Location	Siri-olipi(10)	Ndonyo Wuasin(10)
Rainfall/annum	300-600mm	300-650mm
Altitude	3500ft	4000ft
Average temperatures		
Land tenure	Communal	Same
Acreage		
2. Reproductive performance and wastage		
a) Performance	Galla x SEA	SEA
Main kidding	September-october	September-November
season(s)	March-May	April-June
Age at 1st kidding	13 months	20-26 months
% Twinning	5%	5%
Kidding to mating interval	2-3 months	4 months
b) Wastage		
% Abortion	5%	10%
Causes of abortion	Brucellosis	Trypanosomosis
	Trypanosomosis	CCPP
	--	Brucellosis
% Mastitis cases	5%	0
Pre-weaning mortality	5-30%	10-40%
Causes	Pneumonia	Helminthosis
	Gastroenteritis	Pneumonia (rains and after a long dry spell)
	Hunger (overmilking by humans)	Gastroenteritis
	ORF	Starvation
		Lice and fleas (during dry season)
	Helminthosis	Predation
	Mange/fungal infections	Mange
	Fleas and lice	Orf
c) Adult deaths		
Causes	20%	10%
	CCPP	ccpp
	Helminthosis	Helminthosis
	Plant poisoning	Predation
	Water poisoning	Water poisoning
d) Reasons for stock disposal		
	Family use	Family use
	Revenue	Revenue
	Chronic illness	Ceremonies
e) Males		
Selection criteria	Growth rate and body colour and dam's milk yield	
Causes of infertility	Scrotal injuries	CCPP
	Trypanosomosis	Trypanosomosis
	Foot rot	Brucellosis

3. Flock structure ("Selected" farms)		
Total in flock	40-300(200)	30-350(250)
*Kids	15%	20%
Weaners	20%	10%
Male (entire)	7%	2%
Castrates	10%	16%
Females	48%	52%
4. FEED		
Dry season	Fair as acacia pods are ripe then	Mobility (migration) ensures adequate feed.
Wet season	Ok	No problem
5. WATER		
Dry season	A constraint	A problem
Wet season	No problem	No problem
Remarks	Transhumance	Transhumance

Appendix 3.2 continued.

Rift Valley Province - Kajiado District (n=15).

1.Area parameters			
Location	Elang'ata Wuasi(5)	Kangiri(5)	Loitokitok 5
Rainfall/annum	300-800mm	300-600mm	500-800mm
Altitude			
Average temperatures			
Land tenure	Group Ranch	Communal	Group Ranch
Acreage	300 - 500 acres	300-500 acres	
2. Reproductive performance and wastage			
a) Performance	Galla & SEA x's	Galla x SEA	Galla x SEA
Main kidding season(s)	Nov-Jan	Nov-Jan	Nov-Jan
	July-August	July-August	July-August
Age at 1st kidding	1½ years	1½ year	2 years
% Twinning	< 10%	< 5%	< 10%
Kidding to mating interval availability	60-90 days	Controlled-based	on feed
b) Wastage			
% Abortion	< 5%	< 5%	< 5%
Causes of abortion	Plant poisoning	Same	
Trypanosomosis			
	Trypanosomosis	Acacia pods	CCPP
	Acacia pods	CCPP	
% Mastitis cases	< 2%	< 2%	< 2%
Pre-weaning mortality	5%	20-30%	10-20%
Causes	Gastroenteritis	Pneumonia	Pneumonia
	Helminthosis	Gastroenteritis	Gastroent
	Pneumonia	Flea bites	Trypts
		Helminthosis	Helminthosis
c) Adult deaths			
Causes	< 5%	5%	<10%
	CCPP	CCPP	Heartwater
	Gastroenteritis	Heartwater	
Trypanosomosis			
		Helminthosis	Wildlife
			Pneumonia
d) Reasons for stock disposal			
	Old age	Age	Age
	Infertility	Infertility	Infertility
	Home and financial needs		
e) Males			
Selection criteria	Size and growth rate		
Causes of infertility	Besnoitiosis	Besnoitiosis	Trypan/sis
	Brucellosis	Brucellosis	Brucellosis

3. Flock structure ("Selected" farms)			
Total in flock	50-170(120)	40-140(120)	90
*Kids	23%	22%	12%
Weaners	10	8	11
Male (entire)	4%	5%	3%
Castrates	13%	22%	11%
Females	50%	43%	63%
4. FEED			
Dry season	Pods and Reserved grazing areas	Pods	Farm by-products
Wet season	Ok	Ok	Ok
Remarks	Serious overgrazing		Serious overgrazing
5. WATER			
Dry season	Limiting factor	Limiting factor a problem new pipe	Not much of
Wet season	Ok	Ok	Ok
Remarks			

Appendix 3.2 continued.

Rift Valley Province - Narok and Transmara Districts (n=15).

1. Area parameters			
Location	Lolgorien(5)	Kirindoni(5)	Suswa 5
Rainfall/annum	800-1000mm	800-1200mm	500 800mm
Altitude			
Average temperatures			
Land tenure	Group Ranch	Individual	Individual
Acreage	200-300 acres	100-200 acres	400 600
acres			
2. Reproductive performance and wastage			
a) Performance	SEA	SEA	SEA x Galla
Main kidding season(s)	All year round	Throughout year	April-May
			Oct-Dec.
Age at 1st kidding	1½ years	1½ year	1½ years
% Twinning	< 10%	10-15%	10%
Kidding to mating interval	3 months	3 months	4 months
b) Wastage			
% Abortion	< 5%	< 10%	< 5%
Causes of abortion	Trypanosomosis	Trypanosomosis	Brucellosis
	Brucellosis	Brucellosis	CCPP
% Mastitis cases	< 10%	< 2%	10-20%
Pre-weaning mortality	5%	5%	20-50%
Causes	Gastroenteritis	Gastroenteritis	Pneumonia
	Pneumonia	Pneumonia	Gastroent
	Heartwater	Trypts	Helminthosis
	Trypts	Helminthosis	Heartwater
c) Adult deaths			
Causes	20-30%	20-30%	50%
	Trypanosomosis	Trypanosomosis	Helminthosis
	CCPP	CCPP	Pneumonia
	H/water	Heartwater	
	Wildlife	Wildlife	Wildlife
d) Reasons for stock disposal		Age	AgeAge
	Infertility	Infertility	Infertility
	Home and personal needs		
e) Males			
Selection criteria	Size + growth rate	Same	Same
Causes of infertility	Trypanosomosis	Same	CCPP
	Brucellosis	Same	Brucellosis
3. Flock structure ("Selected" farms)			
Total in flock	20-50(30)	40-70(50)	50-270(120)
*Kids	26%	30%	30%
Weaners	4%	14%	5%
Male (entire)	4%	6%	5%
Castrates	10%	14%	17%
Females	56%	36%	43%

4. FEED			
Dry season	Always some herbage available		Maize and wheat stove and full top grazing
Wet season	Ok	Ok	Ok
5. WATER			
Dry season	Dam	Dam	Dam
Wet season	Ok	Ok	Ok
Remarks	No land consolidation		Same fencing
	No land consolidation	moderate fencing	minimal
	migration limited	migration limited	No fencing migration possible

Appendix 3.2 continued.

Rift Valley Province - Nakuru District (State Farms, Sheep and Goat Multiplication centres).

1. Area parameters	Naivasha Olmagogo	Naivasha Top Farm
Location		
Rainfall/annum	300-700mm	300-700mm
Altitude	1854-1900ft	1854ft
Average temperatures		
Ecozone	IV	IV/V
Land tenure	State	State
Acreage		
2. Reproductive performance and wastage		
a) Performance	SEA, Boer Galla and x's	Toggenburg, Anglo Nubian + crosses
Main kidding season(s)	May/June Sept- Oct	Same
Age at 1st kidding	1½-2 years	1½-2 years
% Twinning	18.1%	19.1%
Kidding to mating interval	3½ months	3½ months
b) Wastage		
% Abortion	0%	2.2%
Causes of abortion	-	?
% Mastitis cases	1.9%	0
Pre-weaning mortality Causes	Gastroenteritis Coccidiosis Pneumonia	Gastroenteritis Orf Coccidiosis Collibacillosis Helminthosis Pneumonia Enterotoxaemia
c) Adult deaths		
Causes	4.2% Helminthosis Heartwater Pneumonia Wounds	7.1% Pneumonia "Anaemia" - Heartwater Plant poisoning
d) Reasons for stock disposal	Breeding stock low fertility Congenital abnormalities Age	Breeding stock low fertility Same Age
e) Males		
Selection criteria	Growth rate, conformation & fertility	
Causes of infertility	Diseases affecting the testicles Poor rearing management (does)	Same

3. Flock structure ("Selected" farms)

Total in flock	150	147
*Kids	-	11%
Weaners	21%	22%
Male (entire)	3%	16%
Castrates	0	0
Females	76%	51%

4. FEED

Dry season	Maize, Potatoe vines + silage + Dairy meal
Wet season	Natural shrubs + grasses + lucerne + napier
Remarks	Problems arise during drought

5. WATER

Dry season	Piped\dams	Piped\dams
Wet season	Piped\dams	Piped\dams
Remarks		

Appendix 3.2 continued.

Eastern Province, Marsabit District (n = 20).

1. Area parameters		
Location	Laisamis(5)	Logologo(5)
Rainfall/annum	300-450mm	300-650mm
Altitude	3500ft	4000ft
Average temperatures		
Land tenure	Communal	Same
Acreage		
2. Reproductive performance and wastage		
a) Performance	Galla x SEA	Galla x SEA
Main kidding	August September	September-November
season(s)	March-June	March-June
Age at 1st kidding	13 months	20-26 months
% Twinning	15%	5%
Kidding to mating interval	2-3 months	4 months
b) Wastage		
% Abortion	10%	2%
Causes of abortion	Brucellosis	CCPP
	Trypanosomosis	Trypanosomosis
	CCPP	Brucellosis
% Mastitis cases	10%	15%
Pre-weaning mortality	30-50%	30-50%
Causes	Pneumonia	Helminthosis
	Gastroenteritis	CCPP (rains and after long dry spell)
	Hunger (competition with humans)	Gastroenteritis
	-	Starvation
	ORF	Lice and fleas (during dry season)
	Helminthosis	Predation
	Fleas and lice	
c) Adult deaths		
Causes	30%	20%
	CCPP	CCPP
	Helminthosis	Helminthosis
	Plant poisoning	Predation
	Mange	Mange
	Trypanosomosis	Trypanosomosis
	Fungal infections	Fungal infections
d) Reasons for stock disposal		
	Family use	Family use
	Revenue	Revenue
	Chronic illness	Ceremonies
e) Males		
Selection criteria	Growth rate and body colour and dam's milk yield	
Causes of infertility	Wasting	Trypanosomosis
	CCPP	Scrotal injuries

3. Flock structure

("Selected" farms)		
Total in flock	20-250(150)	60-250(200)
*Kids	20%	24%
Weaners	23%	7%
Male (entire)	5%	2%
Castrates	2%	15%
Females	50%	52%

4. FEED

Dry season	Fair as acacia pods are ripe then	Mobility ensures adequate feed
Wet season	Ok	No problem
Remarks		

5. WATER

Dry season	A constraint	A problem
Wet season	No problem	No problem
Remarks	Transhumance	Transhumance

Appendix 3.2 continued.

Eastern Province - Marsabit district.

1. Area parameters		
Location	Lontolio(5)	Merille(5)
Rainfall/annum	300-550mm	300-650mm
Altitude	3500ft	4000ft
Average temperatures		
Land tenure	Communal	Same
Acreage		
2. Reproductive performance and wastage		
a) Performance	Galla x SEA	Galla x SEA
Main kidding	August-September	September-November
season(s)	March - June	March-June
Age at 1st kidding	13 months	20-26 months
% Twinning	5%	10%
Kidding to mating interval	2-3 months	4 months
b) Wastage		
% Abortion	5%	5%
Causes of abortion	Brucellosis	Trypanosomosis
	Trypanosomois	CCPP
	--	Brucellosis
% Mastitis cases	10%	10%
Pre-weaning mortality	30-40%	20-50%
Causes	Pneumonia	Helminthosis
	Gastroenteritis	CCPP (during the rains and after drought)
	Hunger (competition with humans)	Gastroenteritis
	Mange/Fungal infections	Lice and fleas (during dry season)
	Helminthosis	Predation
	Fleas and lice	starvation
	Orf	Orf
	--	Mange/fungal infections
c) Adult deaths		
Causes	30%	20%
	CCPP	CCPP
	Helminthosis	Helminthosis
	Plant poisoning	Predation
	Water poisoning	Water poisoning
d) Reasons for stock disposal		
	Family use	Family use
	Revenue	Revenue
	Chronic illness	Ceremonies
e) Males		
Selection criteria	Growth rate and body colour and dam's milk yield	
Causes of infertility	Scrotal injuries	Trypanosomosis
	Brucellosis	Brucellosis

3. Flock structure ("Selected" farms)		
Total in flock	30-300(200)	20-150(100)
*Kids	15%	24%
Weaners	23%	12%
Male (entire)	4%	2%
Castrates	7%	10%
Females	51%	52%
4. FEED		
Dry season	Fair as acacia pods are ripe then	Mobility ensures adequate feed
Wet season	Ok	No problem
5. WATER		
Dry season	A constraint	A problem
Wet season	No problem	No problem
Remarks	Transhumance	Transhumance

Appendix 3.2 continued.

Eastern Province - Kitui District (n=10).

1. Area parameters		
Location	Kwavonja(5)	Kabati(5)
Rainfall/annum	300-950mm	350-700mm
Altitude		
Average temperatures		
Land tenure	Demarcated	Not fenced
Acreage	20-30 acres	20-50 acres
2. Reproductive performance and wastage		
a) Performance	SEA	SEA
Main kidding season(s)	Oct-Dec	Oct-Dec
Age at 1st kidding	1-1½ years	1-½ year
% Twinning	10%	5%
Kidding to mating interval	4 months	3-5 months
b) Wastage		
% Abortion	5%	10%
Causes of abortion	Pod-Immature Pneumonia Brucellosis	Pods-Immature Brucellosis
% Mastitis cases	< 5%	< 2%
Pre-weaning mortality	20-30%	20-30%
Causes	Gastroenteritis Flea infestation Pneumonia Heartwater	Pneumonia Gastroenteritis Helminthiasis Flea infestation
c) Adult deaths		
Causes	5% Pneumonia/ccpp Helminthosis Heartwater	10% ccpp/Pneumonia Trypanosomosis Plant poisoning
d) Reasons for stock disposal	Home needs Disease + infertility	Ceremonial
e) Males		
Selection criteria	Growth rate and size	
Causes of infertility	Orchitis	Brucellosis
f. Flock structure ("Selected" farms)		
Total in flock	10-35(20)	10-25(15)
*Kids	14%	17%
Weaners	0	0
Male (entire)	11%	13%
Castrates	31%	21%
Females	43%	50%

4. FEED		
Dry season	Scarce except in valleys and on hill side farm by-products and wastes	
Wet season	OK	OK
Remarks		
5. WATER		
Dry season	River and wells	Same
Wet season	OK	OK
Remarks	Serious overgrazing in certain areas	

Appendix 3.2 continued.

North Eastern Province - Mandera District (n = 10) and Garissa District (Questionnaire).

1.Area parameters			
Location	Mandera(5)	Rhamu(5)	Garissa
Rainfall/annum	255mm	635mm	
Altitude	690ft	1905ft	
Average temperatures			
Land tenure	Communal	Communal	Communal
Acreage			
2. Reproductive performance and wastage			
a) Performance	Galla	Galla	Galla
Main kidding season(s)	Dec/Jan	Dec/Jan	Dec/Jan
	July/August	July-August	July-August
Age at 1st kidding	2 years	1½ year	1½ years
% Twinning	< 5%	< 5%	< 5%
Kidding to mating interval			
b) Wastage			
% Abortion	< 10%	< 10%	5%
Causes of abortion	CCPP	Trypanosomosis,	Plant poison
	Plant poison	Plant poison	CCPP
	Trypanosomosis	Brucellosis	Brucellosis
% Mastitis cases	< 2%	< 2%	0
Pre-weaning mortality	10-40%	20-30%	30-50%
	CCPP	CCPP	CCPP
Causes	Gastroenteritis	Trypanosomosis	Pneumonia
	Helminthosis	Mange	
Heartwater			
	Fleas/Lice	Fleas/Lice	
Gastroenteritis			
	Trypanosomosis	Gastroenteritis	
c) Adult deaths			
Causes	10-20%	10-20%	0-5%
	Trypanosomosis	Same	Same
	Helminthosis	Same	Same
	Pneumonia	Pneumonia	Pneumonia
	CCPP	CCPP	CCPP
	Heartwater	Same	Same
d) Reasons for stock disposal		Age	
	Castrates- home use and needs		
	Dowry		
e) Males			
Selection criteria	Size and growth rate		
Causes infertility	Trypanosomosis	same	same
	Besnoitiosis	Besnoitiosis	Besnoitiosis
	Scrotal injury	Scrotal injury	Same

3. Flock structure ("Selected" farms)	Range 100-300(200)	100-400(300)	100-300(200)
Total in flock			
*Kids	8%	30%	30%
Weaners	10%	14%	4%
Male (entire)	2%	6%	4%
Castrates	20%	14%	4%
Females	60%	36%	39%
4. FEED			
Dry season	Scarce except on hilltops + valleys *migration	Scarce except on hilltops and valleys *migration	*migration
Wet season	Plenty	Plenty	Plenty
5. WATER			
Dry season	Scarce	Scarce	Scarce
Wet season	Ok	Ok	Ok

Remarks:
30-40% of the examined animals in all flocks had besnoitiosis which could account for the low fertility and poor body condition despite there being relatively abundant feed.
* Migration = mobility - migration ensures that animals and their owners have adequate feed, water and security.

Appendix 3.2 continued.

Coast Province - Mombasa, Lamu and Kilifi districts (n = 26).

1.Area parameters			
Location	Mombasa(10)	Lamu(6)	Kilifi(10)
Rainfall/annum	1000-1500mm	800-1000mm	600-900mm
Altitude	Sea level < 1000ft	< 1000ft	< 1000ft
Average temperatures			
Land tenure	Individual and demarcated though not fenced		
Acreage	10-20	10-20	10-20
2. Reproductive performance and wastage			
a) Performance	SEA	SEA	SEA
Main kidding season(s)	All year round		
Age at 1st kidding	2-2½ years	1½-2 years	2 years
% Twinning	Low	Low	5%
Kidding to mating interval	4 months	4 months	3½ months
b) Wastage			
% Abortion	10-20%	10%	20%
Causes of abortion	Trypanosomosis CCPP Brucellosis	Brucellosis Trypanosomosis --	Tryps Brucellosis ---
% Mastitis cases	< 5%	10%	10%
Pre-weaning mortality	20-30%	30-40%	30%
Causes	Pneumonia Gastroenteritis Trypanosomosis Heartwater mange/fungal infections	Gastroenteritis "Anaemia" Trypanosomosis CCPP	Same Pneumonia H e a r t - water Baboon attacks Same Mange
c) Adult deaths			
Causes	5-20% Trypanosomiasis CCPP Heartwater Mange/Fungal	10% CCPP Helminthosis Trypanosomosis -	5-15% Heartwater CCPP Tryps Helminthosis
d) Reasons for stock disposal	Home needs Dowry	Age Home needs Dowry	AgeAge Home needs Dowry
e) Males			
Selection criteria	Growth rate	Same	Same
Causes of infertility	Brucellosis Trypanosomosis	Brucellosis Same	Brucellosis Same
f. Flock structure ("Selected" farms)			
Total in flock	15-20(10)	10-30(15)	10-50(20)
*Kids	20%	27%	28%
Weaners	7%	8%	9%
Male (entire)	13%	8%	6%
Castrates	0	19%	6%
Females	60%	38%	51%

4. FEED
Dry season — Fairly good throughout including maize and millet stover
Wet season — " "

5. WATER
Dry season — Fairly good throughout- dam and streams
Wet season — " "

Remarks

Appendix 3.2 continued.

Coast Province - Tana River District (Questionnaire).

1.Area parameters		
Location	Tana River	Garsen
Rainfall/annum	300-700mm	300-1000mm
Altitude	900-1200ft	900-1200ft
Average temperatures		
Land tenure	Communal	Communal
Acreage		
2. Reproductive performance and wastage		
a) Performance	SEAxs	SEAxs
Main kidding season(s)		
Age at 1st kidding	1½-2 years	1½ year
% Twinning	Low (1%)	< 5%
Kidding to mating interval		
b) Wastage		
% Abortion	NOT OBSERVED	NONE
Causes of abortion	-	-
% Mastitis cases		
Pre-weaning mortality	30%	20%
Causes	Inadequate milk due to low plane of nutrition- starvation	
	Helminthosis	Helminthosis
	Pneumonia- especially in the wet season due to poor housing	
	Management- hygiene	
	Mange	Mange/fungal infections
c) Adult deaths		
Causes	15%	20%
	CCPP	Trypanosomiasis
	Trypanosomiasis	Heartwater
	Helminthosis	Helminthosis
	Heartwater	CCPP
	Mange	-
d) Reasons for stock disposal		
	Rustling	Ceremonies
	Pneumonia	Trypanosomosis
	Trypanosomosis	Pneumonia
	Battering/exchange	for goods and services
e) Males		
Selection criteria	Growth rate	
Causes of infertility	Not observed	Not observed
Flock structure ("Selected" farms)		
Total in flock	20-150(80)	50-250(100)
%Kids	8%	10%
Weaners	30%	33%
Male (entire)	5%	10%
Castrates	14%	7%
Females	43%	40%

4. FEED		
Dry season	Scarce	Scarce
Wet season	Sufficient	Adequate
Remarks		
5. WATER		
Dry season	Constraint	Constraint
Wet season	Adequate	Adequate

Appendix 3.2 continued.

Nyanza Province - Siaya District (Questionnaire).

1.Area parameters	Central Sakwa, Bondo Division
Location	Siaya
Rainfall/annum	600-900mm
Altitude	1000-1350ft
Average temperatures	
Land tenure	Individual
Acreage	Not consolidated

2. Reproductive performance and wastage

a) Performance	SEA
Main kidding season(s)	All year round
Age at 1st kidding	11 months
% Twinning	30-40%
Kidding to mating interval	4 months

b) Wastage	
% Abortion	0%
Causes of abortion	-
% Mastitis cases	0%
Pre-weaning mortality	50%
Causes	Pneumonia
	Helminthosis
	Enteritis
	Fungal infection
	Careless handling

c) Adult deaths	
Causes	< 1%
	Helminthiasis
	Pneumonia
	Physical injury

d) Reasons for stock disposal	Age
	Home needs
	Sold to neighbours for breeding
	Drought

e) Males	
Selection criteria	Exotic bucks for upgrading
Causes of infertility	Not noticed

3. Flock structure	
("Selected" farms)	
Total in flock	10-60(20)
*Kids	12%
Weaners	17%
Male (entire)	20%
Castrates	-
Females	51%

4. FEED

Dry season	Readily available
Wet season	Readily available
Remarks	

5. WATER

Dry season	Readily available
Wet season	Readily available
Remarks	

Appendix 3.3.

The major causes of goat mortality, both kids and adults, and the mean % percent mortality between 1987-1990 in Sheep and Goat Multiplication Centres.

DISEASE	NAIVASHA		MARINDAS		NAROK		KIMOSE		KITE.		BUCHUMA		MATUGA		MACALDER		TOTAL	OL/T/F
	NOS	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	%	
Pneumonia	41	27.3	3		19		11	32		65	49	26		18	40	48	37	28	29
Grain overload	2	1.3																	0.2
Enteritis	6	4																	0.7
Coccidiosis													1	0.7					0.1
Sudden death			18		12								1	0.7					2.5
General body Weakness							1	3										14	11 1.9
Metritis			1		0.6													1	0.7 0.2
Diarrhoea	6	4					1	0.6							22	17			3.8
Poisoning (plant)	3	2.0	7		5				7	5			1	1		2	1.5		2.6
Predation			1		3	5	4		27	18					2	1.5			5.0
Snake bites	1	3	1		0.7								8	10	1	0.7			1.4
Physical injury													1	1		5	4		0.7
Premature	2	1.3					5	4											0.9
Unknown			7	20					14	11								——	- 3.0

Appendix 3.3 continued.

DISEAS	NAIVASHA OL/T/F				MARINDAS		NAROK		KIMOSE		KITE.		BUCHUMA		MATUGA	MACALDER		TOTAL		
	NOS	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	%			
Bladder block					1	3														0.2
Starvation	1		3		16		12				30	23	6		2					1.0
Bloat	11		7					2	1.3											1.7
Drowning								6	4				1		3			1	0.7	1.0
Dip poisoning	5		3.3								6	5				6	4			2.2
Dystocia	3		2.0					5	4											1.0
Obstruction					11		7							2	1.3					1.7
Sheep pox					8		50													1.0
Paralysis											2	2								0.2
Impaction		2	1.3																	0.2
Trypanosomosis					2		13				12	8				15	18			4.0
Hair ball								1	0.7											0.1
Tetanus														1	0.6					0.1
Suffocation					14		9							1	0.7		2	1.5		2.2
Photosen-sitization											2	1.5								0.2
Entero-toxaemia	13		9					1	3					7	5					2.7

Other dieases/conditions listed included:- Purulent hepatitis, Pulpy kidney, Otitis media, ketosis, indigestion, losses and paralysis.
Kite = Kitengela

Appendix 3.3 continued.

The major causes of goat mortality, both kids and adults, and the mean % percent mortality between 1987-1990 in Sheep and Goat Multiplication Centres.

DISEASE	NAIVASHA OL/T/F		MARINDAS		NAROK		KIMOSE		KITENGELA		BUCHUMA		MATUGA		MACALDER		TOTAL
	NOS	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	NO	%	%
Helminthosis									1	0.7							0.1
Abscess	1	0.6															0.1
Infection											1	0.7					0.1
Chilliness											1	0.7					0.1
Haemonchosis	3	2.0	1	3	5	4	20	14									3.8
Prolapse		-	1	6													0.1
Necrosis							1	0.6									0.1
Malnutrition	2	1.3															0.2
Inconclusive	57	43															7.5
Old age			3	2.0					1	3							0.5
Stomatitis	1	0.6							8	10							1.1
Fever			2	6			7	5									1.1
E. coli													2	1.5			0.2
Hernia			1	0.7							2	1.5					0.3
Heartwater	6	4	1	6	2	6	2	2	21	14	1	1.1					4.3
Joint ill															1	0.7	01
Myiasis											3	2.0					03

Appendix 3.4a.

Quality of semen collected from bucks donated from the Marimanti and Kiburine Sheep and Goat Multiplication Centres, Tharaka Nithi, suffering from besnoitiosis. The bucks had acute[1], subacute[2] and chronic[3] forms of the disease.

	Identity of the buck.			
Semen characteristics	924 Kibu[1]	741 Kibu[1]	10 (6) Kibu[1]	79 Kibu[2]
Volume	3.0	1.5	3.2	2.5
Colour	Yellowish cream	Milky	Milky	Yellowish cream
Density	Creamish	Milky	Milky	Creamish
Concentration	$10x10^5$	$10x10^5$	$10x10^5$	$10x10^6$
Wave motion of swirl	0	0	0	0
Percent motile (individual)	80	60	80	75
Mass motility	60	50	80	80
% Live	80	70	75	
pH	6.6	6.7	6.8	66
Other cells	-	-	-	-

Appendix 3.4b

Quality of semen collected from bucks donated from the Marimanti and Kiburine Sheep and Goat Multiplication Centres, Tharaka Nithi, suffering from besnoitiosis. The bucks had acute[1], subacute[2] and chronic[3] forms of the disease.

Semen characteristics	85 Kibu[1]	Buck 2 Toggenburg[3]	3/mar [1] Galla
Volume	1.8 ml	3.0 ml	1.5
Colour	Milky	Watery	Milky
Density	Milky	Watery	Milky
Concentration	$1x10^5$	$>50x10^3$	$1x10^5$
Wave motion of swirl	-	-	-
Percent of motile (individual)	70	0	80
Mass motility	60	0	80
% Live	85	20	80
pH	6.6	6.8	6.7
Other cell	-	Superficial	-
Defects Primary			
Secondary	3%	80%-100%	50%

Appendix 3.4c

Quality of semen collected from bucks donated from the Marimanti and Kiburine Sheep and Goat Multiplication Centres, Tharaka Nithi suffering from besnoitiosis. The bucks had acute[1], subacute[2] and chronic[3] forms of the disease.

Semen characteristics	1/MAR Toggen Toggenberg 4 yrs old[2]	2/Mar* ToggxGalla $2^1/_2$-3 yrs[3]	Ex-Elkarama* ToggxGalla R testis small	ilkibu Galla Both testis small[3]
Volume (ml)	1.5	1.5	1.5	1.5
Colour	Yellowish Cream	Clear Watery	Milky White	Milky Watery
Density (estimate)	Milk ($500-1x10^3$)	Watery ($20x10^4$)	Milky ($500-1x10^3$)	Watery (10^3)
Concentration (actual count)	$5x10^3$	$10x10^4$	$10x10^4$	$10x10^4$
Wave motion of swirl	0	0	0	0
Percent motile (Individual)	50%	0	50%	80%
Mass motility	40%	0	40%	50%
% Live	45%	0	50%	50%
pH	6.8	6.8	6.8	6.7%
Other cells	Epithelial			
Defects Primary	20%	30%	2%	-
Secondary	10%	20%	4%	-

Key

- * = Firm epididymis on the affected side(s),

Togg = Teggenberg, x = crosses.

Appendix 4.1a.

The effect of type of birth and sex on weight gain, total protein, IgG and E. coli antibody titre in kids born during the on-farm study 1992-1993.

Kid Id	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	TP (mg/ml)	IgG	E.coli A.b titre
1	1	2	1	2.50			
2	1	2	1	3.60			
3	1	2	1	1.80			
4	1	2	1	2.20			
5	1	2	1	1.70			
6a	2	1	1	2.10			
6b	2	1	1	2.00			
7a	2	1	1	1.80			
7b	2	2	1	1.60			
9	1	1	1	3.00			
10	1	1	1	2.40			
11	1	1	1	2.70			
12	1	1	1	2.60			
13	1	1	1				
14	1	1	1	2.60			
15	1	1	1	2.80			
16	1	1	1	2.80			
17	1	1	1	2.90			
18	1	1	1	3.10			
8b	2	2	1	1.80			
8a	2	2	1	1.40			
1	1	2	2	3.50	7.20	56000.00	1/2560
2	1	2	2	4.50	6.00	40000.00	1/5160
3	1	2	2	2.60	5.00	26000.00	1/640
4	1	2	2	3.10	5.20	40000.00	1/640
5	1	2	2				
6a	2	1	2	2.90	5.60	50800.00	1/640
6b	2	1	2	2.80	6.00	30400.00	1/2560
8b	2	2	2	2.40			
9	1	1	2	4.10	6.10	39000.00	1/5160
10	1	1	2	3.10	7.30	32200.00	1/5160
11	1	1	2	3.60	6.80	48400.00	1/640
12	1	1	2	3.30			
13	1	1	2	2.20			
14	1	1	2	3.30	6.30	48400.00	1/2560
15	1	1	2	3.40			
16	1	1	2	3.20			
17	1	1	2	3.40			
18	1	1	2	3.50			
8a	2	2	2	1.90			
1	1	2	3	4.20			
2	1	2	3	5.60			
3	1	2	3	3.30	6.00	56400.00	0
4	1	2	3	3.20			

Appendix 4.1a continued.

Kid Id	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	TP (mg/ml)	IgG	E.coli A.b titre
6a	2	1	3	3.80			
6b	2	1	3	3.60			
9	1	1	3	5.20			
10	1	1	3	3.90			
11	1	1	3	4.50			
12	1	1	3	4.40			
13	1	1	3	2.60			
14	1	1	3	4.40			
15	1	1	3	3.40			
16	1	1	3	3.00			
17	1	1	3	3.80			
18	1	1	3	3.90			
1	1	2	4	5.00	6.20	40000.00	0
2	1	2	4	6.60	6.40	48400.00	0
3	1	2	4	3.60	6.00	56400.00	0
4	1	2	4	3.20	5.60	40000.00	0
6a	2	1	4	4.40	6.00	35000.00	0
6b	2	1	4	3.10	5.40	35000.00	0
9	1	1	4	5.50	6.00	40000.00	0
10	1	1	4	4.60	5.40	30400.00	0
11	1	1	4	5.80	5.40	39000.00	
12	1	1	4	5.10			
13	1	1	4	3.30			
14	1	1	4	5.10	6.30	14640.00	0
15	1	1	4	3.50			
16	1	1	4	2.50			
17	1	1	4	3.10			
1	1	2	5	5.20			
2	1	2	5	8.10			
3	1	2	5	4.50			
4	1	2	5	3.50			
6a	2	1	5	4.70			
6b	2	1	5	3.50			
9	1	1	5	6.00			
10	1	1	5	5.60			
11	1	1	5	6.60			
12	1	1	5	4.70			
13	1	1	5	5.00			
14	1	1	5	5.70			
15	1	1	5	3.80			
1	1	2	6	5.50			
2	1	2	6	9.00			
3	1	2	6	4.80			
4	1	2	6	3.70			

Appendix 4.1a continued.

Kid Id	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	TP (mg/ml)	IgG	E.coli A.b titre
6a	2	1	6	5.00			
6b	2	1	6	4.00			
9	1	1	6	7.20			
10	1	1	6	6.10			
11	1	1	6	6.80			
12	1	1	6	6.50			
13	1	1	6	5.30			
14	1	1	6	6.50			
15	1	1	6	5.10			
1	1	2	7	5.60			
2	1	2	7	9.90			
3	1	2	7	5.10			
4	1	2	7	3.90			
6b	2	1	7	4.40			
6a	2	1	7	6.40			
9	1	1	7	7.40			
10	1	1	7	6.90			
11	1	1	7	7.00			
12	1	1	7	7.40			
13	1	1	7	6.50			
14	1	1	7	7.40			
15	1	1	7	5.70			
1	1	2	8	6.00	7.50	40000.00	1/160
2	1	2	8	10.70	6.60	50800.00	1/160
3	1	2	8	5.50	6.80	39500.00	1/160
4	1	2	8	4.10	8.50	40000.00	1/160
6a	2	1	8	6.60	6.50	40000.00	0
6b	2	1	8	4.70	5.90	26000.00	1/160
9	1	1	8	8.00	6.10	45200.00	0
10	1	1	8	7.20	7.30	35000.00	0
11	1	1	8	7.50	6.30	56400.00	0
12	1	1	8	8.00			
13	1	1	8	7.00			
14	1	1	8	8.00	6.80	50800.00	1/160
15	1	1	8	6.20			
1	1	2	9	6.50			
2	1	2	9	11.30			
3	1	2	9	6.40			
4	1	2	9	4.20			
6a	2	1	9	6.20			
6b	2	1	9	5.00			
9	1	1	9	8.40			
10	1	1	9	7.70			
11	1	1	9	8.00			
12	1	1	9	8.50			

Appendix 4.1a continued.

Kid Id	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	TP (mg/ml)	IgG	E.coli A.b titre
13	1	1	9	7.80			
14	1	1	9	8.50			
15	1	1	9	6.50			
1	1	2	10	7.00			
2	1	2	10	11.40			
3	1	2	10	7.40			
4	1	2	10	4.10			
6a	2	1	10	6.40			
6b	2	1	10	5.50			
9	1	1	10	9.00			
10	1	1	10	8.10			
11	1	1	10	8.10			
12	1	1	10	8.60			
13	1	1	10	8.00			
14	1	1	10	8.60			
15	1	1	10	7.30			
1	1	2	11	7.20			
2	1	2	11	12.50			
3	1	2	11	7.30			
4	1	2	11	4.40			
6a	2	1	11	7.00			
6b	2	1	11	6.00			
9	1	1	11	9.10			
10	1	1	11	8.20			
11	1	1	11	8.60			
12	1	1	11	9.00			
13	1	1	11	8.80			
14	1	1	11	9.00			
15	1	1	11	7.60			
1	1	2	12	7.50	10.00	8460.00	1/320
2	1	2	12	13.00	10.80	14640.00	0
3	1	2	12	7.40	8.90	14640.00	0
4	1	2	12	4.90	9.50	26000.00	1/320
6a	2	1	12	7.40	9.70	14640.00	0
6b	2	1	12	6.40	7.20	14640.00	0
9	1	1	12	9.50	8.10	40000.00	1/160
10	1	1	12	9.00	9.60	14640.00	0
11	1	1	12	9.40	7.00	22000.00	1/320
12	1	1	12	9.20			
13	1	1	12	9.40			
14	1	1	12	9.20	9.60	12040.00	0
15	1	1	12	8.30			
1	1	2	13	7.60			
2	1	2	13	13.60			
3	1	2	13	7.60			

Appendix 4.1a continued.

Kid Id	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	TP (mg/ml)	IgG	E.coli A.b titre
4	1	2	13	5.40			
6a	2	1	13	7.50			
6b	2	1	13	7.00			
9	1	1	13	10.00			
10	1	1	13	9.10			
11	1	1	13	10.10			
12	1	1	13	9.40			
13	1	1	13	10.00			
15	1	1	13	8.70			
1	1	2	14	7.90			
2	1	2	14	14.10			
3	1	2	14	7.70			
4	1	2	14	6.00			
6a	2	1	14	8.00			
6b	2	1	14	7.50			
9	1	1	14	10.50			
10	1	1	14	9.20			
11	1	1	14	10.50			
12	1	1	14	9.80			
13	1	1	14	10.50			
14	1	1	14	9.40			
14	1	1	14	9.80			
15	1	1	14	9.40			
1	1	2	15	8.10			
2	1	2	15	14.10			
3	1	2	15	7.90			
4	1	2	15	6.50			
6a	2	1	15	8.10			
6b	2	1	15	8.00			
9	1	1	15	10.70			
10	1	1	15	9.40			
11	1	1	15	11.00			
12	1	1	15	10.10			
13	1	1	15	10.60			
14	1	1	15	10.10			
15	1	1	15	10.00			
1	1	2	16	8.50	5.90	22000.00	1/160
2	1	2	16	15.00	6.20	12040.00	0
3	1	2	16	8.00	6.40	14640.00	1/160
4	1	2	16	7.00	4.20	22000.00	1/160
6a	2	1	16	8.20	6.40	12040.00	0
6b	2	1	16	8.50	5.80	19660.00	0
9	1	1	16	11.00	6.20	14640.00	0
10	1	1	16	10.10	6.80	22000.00	0
11	1	1	16	11.50	6.00	30400.00	1/160

Appendix 4.1a continued.

Kid Id	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	TP (mg/ml)	IgG	E.coli A.b titre
12	1	1	16	10.50			
13	1	1	16	11.40			
14	1	1	16	10.50	9.70	14640.00	1/160
15	1	1	16	10.50			

Appendix 4.1b.

The influence of dams bodyweight at birth, and at 4 week intervals for 3 months postpartum, on the offsprings daily bodyweight gain and total serum protein in kids observed during the on-farm study in Juja A and B in March - June, 1993.

Dam ID	Week	Dam wt. (kg)	Kid ID	Type of Birth*	Kid sex*	Week	Weight (kg)	TP (mg/ml)
27R	1	30	1	1	2	1	2.50	
27R	4	26	1	1	2	2	3.50	7.20
27R	8	28	1	1	2	3	4.20	
27R	12	29	1	1	2	4	5.00	6.20
27R			1	1	2	5	5.20	
27R			1	1	2	6	5.50	
27R			1	1	2	7	5.60	
27R			1	1	2	8	6.00	7.50
27R			1	1	2	9	6.50	
27R			1	1	2	10	7.00	
27R			1	1	2	11	7.20	
27R			1	1	2	12	7.50	10.00
27R			1	1	2	13	7.60	
27R			1	1	2	14	7.90	
27R			1	1	2	15	8.10	
27R			1	1	2	16	8.50	5.90
28R	1	34	2	1	2	1	3.60	
28R	4	31	2	1	2	2	4.50	6.00
28R	8	33	2	1	2	3	5.60	
28R	12	34	2	1	2	4	6.60	6.40
28R			2	1	2	5	8.10	
28R			2	1	2	6	9.00	
28R			2	1	2	7	9.90	
28R			2	1	2	8	10.70	6.60
28R			2	1	2	9	11.30	
28R			2	1	2	10	11.40	
28R			2	1	2	11	12.50	
28R			2	1	2	12	13.00	10.80
28R			2	1	2	13	13.60	
28R			2	1	2	14	14.10	
28R			2	1	2	15	14.10	
28R			2	1	2	16	15.00	6.20
29R	1	32	3	1	2	1	1.80	
29R	4	32	3	1	2	2	2.60	5.00
29R	8	30	3	1	2	3	3.30	6.00
29R	12	30	3	1	2	4	3.60	6.00
29R			3	1	2	5	4.50	
29R			3	1	2	6	4.80	
29R			3	1	2	7	5.10	
29R			3	1	2	8	5.50	6.80

Appendix 4.1b continued.

Dam ID	Week	Dam wt. (kg)	Kid ID	Type of Birth*	Kid sex*	Week	Weight (kg)	TP (mg/ml)
29R			3	1	2	9	6.40	
29R			3	1	2	10	7.40	
29R			3	1	2	11	7.30	
29R			3	1	2	12	7.40	8.90
29R			3	1	2	13	7.60	
29R			3	1	2	14	7.70	
29R			3	1	2	15	7.90	
29R			3	1	2	16	8.00	6.40
30R	1	30	4	1	2	1	2.20	
30R	4	27	4	1	2	2	3.10	5.20
30R	8	29	4	1	2	3	3.20	
30R	12	29	4	1	2	4	3.20	5.60
30R			4	1	2	5	3.50	
30R			4	1	2	6	3.70	
0R			4	1	2	7	3.90	
30R			4	1	2	8	4.10	8.50
30R			4	1	2	9	4.20	
30R			4	1	2	10	4.10	
30R			4	1	2	11	4.40	
30R			4	1	2	12	4.90	9.50
30R			4	1	2	13	5.40	
30R			4	1	2	14	6.00	
30R			4	1	2	15	6.50	
30R			4	1	2	16	7.00	4.20
37R	1	34	5	1	2	1	1.70	
37R			5	1	2	2		2.00
31R	1	36	6a	2	1	1	2.10	
31R	4	32	6a	2	1	2	2.90	5.60
31R	8	33	6a	2	1	3	3.80	
31R	12	34	6a	2	1	4	4.40	6.00
31R			6a	2	1	5	4.70	
31R			6a	2	1	6	5.00	
31R			6a	2	1	8	6.60	6.50
31R			6a	2	1	9	6.20	
31R			6a	2	1	10	6.40	
31R			6a	2	1	11	7.00	
31R			6a	2	1	12	7.40	9 70
31R			6a	2	1	13	7.50	
31R			6a	2	1	14	8.00	
31R			6a	2	1	15	8.10	
31R			6a	2	1	16	8.20	6.40
31R	1	36	6b	2	1	1	2.00	

Appendix 4.1b continued.

Dam ID	Week	Dam wt. (kg)	Kid ID	Type of Birth*	Kid sex*	Week	Weight (kg)	TP (mg/ml)
31R	4	32	6b	2	1	2	2.80	6.00
31R	8	33	6b	2	1	3	3.60	
31R	12	34	6b	2	1	4	3.10	5.40
31R			6b	2	1	5	3.50	
31R			6b	2	1	6	4.00	
31R			6b	2	1	7	4.40	
31R			6b	2	1	8	4.70	5.90
31R			6b	2	1	9	5.00	
31R			6b	2	1	10	5.50	
31R			6b	2	1	11	6.00	
31R			6b	2	1	12	6.40	7.20
31R			6b	2	1	13	7.00	
31R			6b	2	1	14	7.50	
31R			6b	2	1	15	8.00	
31R			6b	2	1	16	8.50	5.80
34R	1	38	7a	2	1	1	1.80	
34R	4	35	7a	2	1	8	7.00	
34R	8	35	7a	2	1	12	8.00	
34R	12	37	7a	2	1	15	9.00	
34R			7a	2	1	16	8.50	
34R	1	38	7b	2	2	1	1.60	
34R	4	35	7b	2	2	8	6.00	
34R	8	35	7b	2	2	12	7.00	
34R	12	37	7b	2	2	15	8.00	
34R			7b	2	2	16	8.00	
43R	30		8b	2	2	1	1.80	
43R			8b	2	2	2	2.40	2.00
46R	1	31	9	1	1	1	3.00	
46R	4	27	9	1	1	2	4.10	6.10
46R	8	30	9	1	1	3	5.20	
46R	12	30	9	1	1	4	5.50	6.00
46R			9	1	1	5	6.00	
46R			9	1	1	6	7.20	
46R			9	1	1	7	7.40	
46R			9	1	1	8	8.00	6.10
46R			9	1	1	9	8.40	
46R			9	1	1	10	9.00	
46R			9	1	1	11	9.10	
46R			9	1	1	12	9.50	8.10
46R			9	1	1	13	10.00	
46R			9	1	1	14	10.50	
46R			9	1	1	15	10.70	
46R			9	1	1	16	11.00	6.20
54R	1	34	10	1	1	1	2.40	
54R	4	29	10	1	1	2	3.10	7.30

Appendix 4.1b continued.

Dam ID	Week	Dam wt. (kg)	Kid ID	Type of Birth*	Kid sex*	Week	Weight (kg)	TP (mg/ml)
54R	8	32	10	1	1	3	3.90	
54R	12	32	10	1	1	4	4.60	5.40
54R			10	1	1	5	5.60	
54R			10	1	1	6	6.10	
54R			10	1	1	7	6.90	
54R			10	1	1	8	7.20	7.30
54R			10	1	1	9	7.70	
54R			10	1	1	10	8.10	
54R			10	1	1	11	8.20	
54R			10	1	1	12	9.00	9.60
54R			10	1	1	13	9.10	
54R			10	1	1	14	9.20	
54R			10	1	1	15	9.40	
54R			10	1	1	16	10.10	6.80
57R	1	36	11	1	1	1	2.70	
57R	4	32	11	1	1	2	3.60	6.80
57R	8	34	11	1	1	3	4.50	
57R	12	34	11	1	1	4	5.80	5.40
57R			11	1	1	5	6.60	
57R			11	1	1	6	6.80	
57R			11	1	1	7	7.00	
57R			11	1	1	8	7.50	6.30
57R			11	1	1	9	8.00	
57R			11	1	1	10	8.10	
57R			11	1	1	11	8.60	
57R			11	1	1	12	9.40	7.00
57R			11	1	1	13	10.10	
57R			11	1	1	14	10.50	
57R			11	1	1	15	11.00	
57R			11	1	1	16	11.50	6.00
57R			12	1	1	1	2.60	
57R			12	1	1	2	3.30	
57R			12	1	1	3	4.40	
57R			12	1	1	4	5.10	
57R			12	1	1	5	4.70	
57R			12	1	1	6	6.50	
57R			12	1	1	7	7.40	
57R			12	1	1	8	8.00	
57R			12	1	1	9	8.50	
57R			12	1	1	10	8.60	
57R			12	1	1	11	9.00	
57R			12	1	1	12	9.20	
57R			12	1	1	13	9.40	
57R			12	1	1	14	9.80	
57R			12	1	1	15	10.10	

Appendix 4.1b continued.

Dam ID	Week	Dam wt. (kg)	Kid ID	Type of Birth*	Kid sex*	Week	Weight (kg)	TP (mg/ml)
57R			12	1	1	16	10.50	
57R	1	36	13	1	1	1		
57R	4	32	13	1	1	2	2.20	
57R	8	34	13	1	1	3	2.60	
57R	12	34	13	1	1	4	3.30	
57R			13	1	1	5	5.00	
57R			13	1	1	6	5.30	
57R			13	1	1	7	6.50	
57R			13	1	1	8	7.00	
57R			13	1	1	9	7.80	
57R			13	1	1	10	8.00	
57R			13	1	1	11	8.80	
57R			13	1	1	12	9.40	
57R			13	1	1	13	10.00	
57R			13	1	1	14	10.50	
57R			13	1	1	15	10.60	
57R			13	1	1	16	11.40	
60R	1	30	14	1	1	1	2.60	
60R	4	26	14	1	1	2	3.30	6.30
60R	8	30	14	1	1	3	4.40	
60R	12	30	14	1	1	4	5.10	6.30
60R			14	1	1	5	5.70	
60R			14	1	1	6	6.50	
60R			14	1	1	7	7.40	
60R			14	1	1	8	8.00	6.80
60R			14	1	1	9	8.50	
60R			14	1	1	10	8.60	
60R			14	1	1	11	9.00	
60R			14	1	1	12	9.20	9.60
60R			14	1	1	14	9.40	
60R			14	1	1	14	9.80	
60R			14	1	1	15	10.10	
60R			14	1	1	16	10.50	9.70
60R			15	1	1	1	2.80	
60R			15	1	1	2	3.40	
60R			15	1	1	3	3.40	
60R			15	1	1	4	3.50	
60R			15	1	1	5	3.80	
60R			15	1	1	6	5.10	
60R			15	1	1	7	5.70	
60R			15	1	1	8	6.20	
60R			15	1	1	9	6.50	
60R			15	1	1	10	7.30	
60R			15	1	1	11	7.60	
60R			15	1	1	12	8.30	

Appendix 4.1b continued.

Dam ID	Week	Dam wt. (kg)	Kid ID	Type of Birth*	Kid sex*	Week	Weight (kg)	TP (mg/ml)
60R			15	1	1	13	8.70	
60R			15	1	1	14	9.40	
60R			15	1	1	15	10.00	
60R			15	1	1	16	10.50	
60R			16	1	1	1	2.80	
60R			16	1	1	2	3.20	
60R			16	1	1	3	3.00	
60R			16	1	1	4	2.50	2.00
60R			16	1	1	1	2.90	
60R			16	1	1	2	3.40	
60R			16	1	1	3	3.80	
60R			16	1	1	4	3.10	2.00
60R			16	1	1	1	3.10	
60R			16	1	1	2	3.50	
60R			16	1	1	3	3.90	2.00

Appendix 4.2a.

Reproductive performance and wastage on selected Sheep and Goat Multiplication Centres in Kenya, used for comparison with the data obtained from the traditional production systems.

a) KIBURINE SHEEP AND GOAT MULTIPLICATION CENTRE.

Reproductive performance parameters	Years under study					
	1985 Jun/ Aug	1985 Jul/ Sept	1986 Mar Floc I	1986 Mar Floc II	May-June 1	May-June Kibu-rine
1. Females to buck (mated)	258	64	23	96	195	60
2. Abortions	22	7	4	6	5	7
	8%	11%	17%	6%	3%	12%
3. Females Barren	38	3	5	9	49	5
	15%	5%	22%	10%	25%	8%
4. Females Kidded	198	54	14	81	141	48
	77%	84%	61%	84%	72%	80%
5. Number of kids born	228	85	20	101	167	55
6. Stillbirths/48 hrs mortality	5	17	-	1	2	4
	2%	20%	-	1%	1%	70%
7. Kids tagged	223	6	20	100	20	
8. % Kids/females to buck (mated)	88%	133%	87%	105%	86%	92%
9. Number of twins	28	31	6	18tri -plets	26	7
10. % Multiple births	15%	57%	43%	25%	18%	15%
11. Average litter size	1.2	1.6	1.4	1.2		
12. % Mortality				to 120 3% days 3% 120 days		
13. Ratio male: Female (of offspring)	57:43	58:42	50:50	49:51		

14. Other Parameters
    * Age at first heat 12-18 months (nutrition dependent). Mating 24 months (720 days) as policy.
    * Age at first Kidding 27-29 months (810-870 days).
    * Interkidding interval 8 months.
    * V = Viability.

Appendix 4.2a continued.

Reproductive performance and wastage on selected Sheep and Goat Multiplication Centres in Kenya, used for comparison with the data obtained from the traditional production systems.

b) MARIMANTI SHEEP AND GOAT MULTIPLICATION CENTRE.

	March 1987	March April 1987	May June 1987	Dec 1987 Jan 1988	June July 1988	May June 1988	Nov Dec 1988	Jan June 1989	Jan June 1989	Jan June 1989	Nov 1989
1.	136	49	72	223	154	40	223	69	201	55	39
2.	9	9	4	2	4	8	1	4	9	3	1
	23%	7%	8%	3%	2%	5%	2%				1.8%
3.	18	39	36	42	27	19	3	27	22	53	8
	46%	28%	74%	58%	12%	12%	8%				14.5%
4.	12	88	39		192	125	36	192	38	145	45
	31%	65%			86%	81%	90%				82%
5.	18	98	-	30	241	144	46	241	42	181	47
6.	-	-	-	3	10	10		10	1	3	-
			10%	4%	7%	0%					
7.	46%	72%	80%	42	108%	95%	115%				
8.	-	-	6%	-	-	-	-	-	-	-	2
9.											
10.	-	-	-	1.1	1.3	1.1	1.1	1.3	1.2	1.2	1.04
11.	7 (7.9%)		1 (1%)		2						
12.	54:46		54:46		53:47		51:49	48:52		56:44	66:34

Key

1 - Females to buck (mated), 2 - Abortions, 3 - Barren females, 4 - Females Kidded, 5 - Number of kids born, 6 - Stillbirths/48 hrs mortality (parturient deaths), 7 - Kids tagged, 8 - Percent kids/females to buck (mated), 9 - Number of twins, 10 - Percent Multiple births, 11 - Average litter size, 12 - Percent mortality, 13 - Ratio of offspring (male: Female),

Appendix 4.2a continued.

Reproductive performance and wastage on selected Sheep and Goat Multiplication Centres in Kenya, used for comparison with the data obtained from the traditional production systems.

c) KIMOSE SHEEP AND GOAT MULTIPLICATION CENTRE.

Performance and wastage parameters.	Years under study						
	1986	1987	1988	1989	1990	1991	1992
Does to Buck mated	145	170	143	143	215	268	218
Abortions	3	5	5	4	6	13	-
Does barren	20	14	28	74	59	50	67
Does kidded	129	137	112	109	174	183	136
No. of kids born	120	154	203	236	213	229	151
Stillbirths/ 48 hrs mortality	-	-	1	1	0	-	-
Kids tagged	120	154	203	236	213	229	151
% Doe kidding joined to buck	0.9	0.8	0.8	0.8	0.8	0.7	0.6
No of twins	47	66	63	85	58	100	50
% multiple births	22.5	26.1	22.3	19.0	19.8	27.3	11.9
Average litter size	1.2	1.3	1.2	2.2	1.2	1.3	1.1
% mortality (kid)	23.4	11.2	25.6	21.9	29.6	40.2	40.4
Ratio M:F	1:1.6	1:1.1	1:1.1	1:1.1	1:1.3	1:1	1:1
Age at 1st heat	11mo	11mo	11mo	11mo	11mo	11mo	11mo
Age 1st kidding	16mo	16mo	16mo	16mo	16mo	16mo	16mo
Inter-kidding	12mo	12mo	12mo	12mo	12mo	12mo	12mo

Key.

11mo - 11 months or 330 days, 12 mo - 12 months or 365 days and 16 mo - 16 months or 480 days.

Appendix 4.2a continued.

Reproductive performance and wastage on selected Sheep and Goat Multiplication Centres in Kenya, used for comparison with the data obtained from the traditional production systems.

d) OLMAGOGO SHEEP AND GOAT MULTIPLICATION CENTRE.

Performance and wastage parameters	Years under study	
	1988	1989
Does to Buck mated	32	108
Does abortions		
Does barren	24	26
Does kidded	18	82
No. of kids born	21	98
Stillbirths 48 hrs mortality	2	-
Kids tagged	19	98
% kids doe:buck		
No. of twins	6	32
% multiple births	16.7%	19.5%
Average litter size	1.2	1.2
% mortality	1%	1.3%
Ratio M:F	1:16	1:27
Other parameters		
Age at 1st kidding	2yrs	2yrs (720 days)
Interkidding interval	330	330 days.

Appendix 4.2a continued.

Reproductive performance and wastage on selected Sheep and Goat Multiplication Centres in Kenya, used for comparison with the data obtained from the traditional production systems.

e) TOP FARM SHEEP AND GOAT MULTIPLICATION CENTRE.

Performance and wastage parameters	Years under study.						
	1986	1987	1988	1989	1990	1991	1992
Does to Buck mated	148	75	109	106	77	99	71
Does abortions	1	-	1	3	1	5	2
Does barren	51	26	29	44	20	16	23
Does kidded	96	49	79	59	50	78	46
No. of kids born	113	62	94	71	64	101	59
Stillbirths/ 48 hrs mortality	5	2	1	2	4	4	-
Kids tagged	108	60	93	69	58	97	59
% kids to buck							
No of twins	24	22	28	24	16	38	26
% multiple births	17.7	22.4	17.7	20.3	16	24.4	28.3
Average litter size	1.2	1.2	1.2	1.2	1.3	1.3	1.3
% mortality (kid)	11.5	18.7	20.9	21.4	24.2	17	19
Ratio M:F	1:25	1:25	1:22	1:11	1:12	1:14	1:14
Age 1st kidding	2yrs	2yrs	2yrs	2yrs	1½-2	1½-2	1½-2
Inter-kidding	3.5	3.5	3.5	3.5	3.5	3.5	3.5

Appendix 4.2b.

The average station flock reproductive performance and wastage between 1987-1990.

Performance parameters	Mat.	Bach.	Kit.	Naiv.	Kim.	Mar.	Mac.	Narok
Fertility rate %	73	73	-	72	93	53	-	79
Birth rate % (Flock) p.a	44	34	35	71	60	30	33	45
Birth rate % (Breeding Females) p.a	88	58	67	134	94	50	57	72
Weaning rate %	68	72	-	85	97	57	-	72
Mortality rate % p.a	23	17	13.0	15.4	9.9	14.7	31.0	10.0
Disposal offtake % p.a	15.6	17	16.5	40.2	14	30	9.8	24.4

Key

Mat.- Matuga, Bach.- Bachuma, Kit.- Kitengela, Naiv.- Naivasha, Kim.- Kimose, Mar. - Marindas, Mac.- Macalder and Narok - Narok.

Appendix 4.3a

Histopathological findings of tissues obtained from kids that died on farms selected for the on-farm study (1990-1992).

Sample Number	Pathological diagnosis				
	Myocarditis	Hepatitis	Nephritis	G/enteritis	Pneumonia
1	-	+	-	-	-
2	-	+	+	-	-
3	-	+	-	-	+
4	-	-	-	+	-
5	-	+	+	-	-
6	-	+	-	-	-
7	+	-	-	-	+
8	-	-	+	-	-
9	-	+	-	+	-
10	-	-	+	-	+
11	-	+	-	-	+
12	-	+	+	-	-
13	+	+	-	-	+
14	-	+	+	-	-
15	-	-	+	-	+
16	-	+	-	-	+
17	-	+	-	-	+
18	-	+	-	+	-
19	-	-	+	+	-
20	-	-	-	+	-
21	-	+	+	+	-
22	-	-	-	+	+
23	-	+	-	+	-
24	-	-	-	+	+
25	-	-	-	+	+
26	-	+	+	-	+
27	+	-	-	-	+
28	-	-	-	+	+
29	-	-	-	+(ulcerative)	+
30	-	-	+	-	+
31	-	-	-	+	-
32	+	-	-	-	+
33	-	-	-	-	+
34	+	-	-	-	+
35	-	+	-	-	-
36	-	+	-	-	+
37	-	+	-	-	+
38	-	-	-	-	+

Key

G/enteritis - Gastroenteritis.

Appendix 4.3a continued.

Histopathological findings of tissues obtained from kids that died on farms selected for the on-farm study (1990-1992).

Sample Number	Pathological diagnosis				
	Myocarditis	Hepatitis	Nephritis	G/enteritis	Pneumonia
39	-	-	+	-	-
40	-	+	-	-	-
41	-	-	+	-	+
42	-	-	-	-	+
43	-	-	+	+	-
44	-	-	-	+	+
45	-	-	+	-	-
46	-	+	-	-	-
47	-	+	-	-	+
48	-	-	-	-	+

Appendix 4.3b

Postmortem findings, gross pathology, in fresh kid carcases examined at the post mortem room in Kabete (1992-1993).

Sample Number	Sex	Age	Pathological diagnosis
1	M	1 wk	Omphalitis and peritonitis.
2	F	3 m	Gastroenteritis, pneumonia, heavy flea & tick infestation resulting in anaemia.
3(a)	F	3 m	Haemonchosis, Oesophagotomosis and.
(b)	M	3 m	Pneumonia, coccidiosis.
4	M	24 hrs	Pneumonia and gastroenteritis.
5	F	1 m	Helminthosis, coccidiosis.
6	F	Kid	Starvation.
7	F	1 day	Inconclusive.
8	F	2 m	CCPP Strain F38.
9	M	3 m	CCPP Strain F38.

Key

F - female, M -Male, m - month(s), wk - week (s) and hrs - hrs

Appendix 4.4. Haematological profile of preweaned goat kids with moderate flea infestation on Machakos ranch (on-farm study)

Age months	ID No	PCV %	TP g/l	Hb mmo1	RBC 1x10^12	WBC 1X10^9	MCHC	TN %	ST %	L %	M %	E %	B %
2	5	10	52	2.9	4.45	3700	Too few for differential						
2	6	11	68	4.4	8.9	15500		61	0	36	0	3	0
2.5	8	9	64	3.1	5.95	3300		52	2	39	0	8	0
2	9	16	72	6.7	12.55	7500		18	2	78	0	2	0
2.5	40	17	96	6.9	11.25	12000		53	0	37	1	9	0
2	44	17	78	6.8	11.5	11000		40	1	52	0	7	0

Appendix 4.5.

Total protein (g/l), Immunoglobulin levels (mg/l) and E. coli antibody titre of kids born during the on-farm study in 1991-1993 (Juja A and B)

Goat/ kid ID	Total protein Biuret	Ref.reading	IgG	IgA	E. coli Ab
2 weeks of age.					
1	60	72	56000	+	1/2560
2	60	75	40000	+	1/5160
3	50	74	26000	+	1/640
4	52	70	40000	+	1/640
6a	56	70	50800	+	1/640
6b	60	70	30400	+	1/2560
9	61	60	39000	+	1/5160
10	73	62	32200	+	1/5160
11	68	63	51800	+	1/640
14	63	70	48400	+	1/2560
1 month of age.					
1	62	80	40000	+	-
2	64	71	48400	+	-
3	60	73	56400	+	-
4	56	61	40000	+	-
6a	60	74	35000	+	-
6b	54	70	35000	+	-
7	60	76	40000	+	-
10	54	65	30400	+	-
11	54	74	39000	+	-
14	63	80	14640	+	-
2 months of age.					
1	75	62	40000	+	1/160
2	66	62	50800	+	1/160
3	68	62	39500	+	1/160
4	85	80	40000	+	1/160
6a	65	50	45200	+	-ve
6b	59	60	26400	+	1/160
9	61	60	45200	+	-ve
10	73	62	35000	+	-ve
11	63	70	56400	+	-ve
14	68	63	50800	-	1/160
3 months of age.					
1	100	66	8460	+	1/320
2	108	68	14640	+	-ve
3	89	62	14640	-	-ve
4	95	64	26000	-	1/320
6a	97	62	14640	-	-ve
6b	72	58	14640	+	-ve
9	81	62	40000	-	1/160
10	96	70	14640	+	-ve
11	70	50	22000	+	1/320
14	96	68	12040	+	-ve
4 months of age.					
1	59	60	22000	+	1/160
2	62	54	12040	+	-ve
3	64	56	14640	-	1/160
4	42	30	22000	-	1/160
6a	64	56	12040	+	-ve
6b	58	52	19660	-	-ve
9	62	60	14640	-	-ve
10	68	52	19660	-	-ve
11	60	58	30400	+	1/160
14	97	72	14640	-	1/160

Appendix 4.6.

The effect of birth type (1= single, 2 - twin;), weight (kg) and kid sex (1- male, 2 - female) on growth rate, serum IgG levels (mg/l) and E. coli antibody titre in kids observed from birth to weaning during the on-farm study (1991-1993).

Kid ID	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	IgG	E.coli A.b titre
1	1	2	2	3.50	56000.00	1/2560
1	1	2	4	5.00	40000.00	0
1	1	2	8	6.00	40000.00	1/160
1	1	2	12	7.50	8460.00	1/320
1	1	2	16	8.50	22000.00	1/160
2	1	2	2	4.50	40000.00	1/5160
2	1	2	4	6.60	48400.00	0
2	1	2	8	10.70	50800.00	1/160
2	1	2	12	13.00	14640.00	0
2	1	2	16	15.00	12040.00	0
3	1	2	2	2.60	26000.00	1/640
3	1	2	3	3.30	56400.00	0
3	1	2	4	3.60	56400.00	0
3	1	2	8	5.50	39500.00	1/160
3	1	2	12	7.40	14640.00	0
3	1	2	16	8.00	14640.00	1/160
4	1	2	2	3.10	40000.00	1/640
4	1	2	4	3.20	40000.00	0
4	1	2	8	4.10	40000.00	1/160
4	1	2	12	4.90	26000.00	1/320
4	1	2	16	7.00	22000.00	1/160
6a	2	1	2	2.90	50800.00	1/640
6a	2	1	4	4.40	35000.00	0
6a	2	1	8	6.60	40000.00	0
6a	2	1	12	7.40	14640.00	0
6a	2	1	16	8.20	12040.00	0
6b	2	1	2	2.80	30400.00	1/2560
6b	2	1	4	3.10	35000.00	0
6b	2	1	8	4.70	26000.00	1/160
6b	2	1	12	6.40	14640.00	0
6b	2	1	16	8.50	19660.00	0
9	1	1	2	4.10	39000.00	1/5160
9	1	1	4	5.50	40000.00	0
9	1	1	8	8.00	45200.00	0
9	1	1	12	9.50	40000.00	1/160
9	1	1	16	11.00	14640.00	0

Appendix 4.6. continued.

The effect of birth type (1= single, 2 - twin;), weight (kg) and kid sex (1- male, 2 - female) on growth rate, serum IgG levels (mg/l) and E. coli antibody titre in kids observed from birth to weaning during the on-farm study (1991-1993).

Kid ID	Type of Birth (1/2)	Kid sex (1/2)	Week	Weight (kg)	IgG	E.coli A.b titre
10	1	1	2	3.10	32200.00	1/5160
10	1	1	4	4.60	30400.00	0
10	1	1	8	7.20	35000.00	0
10	1	1	12	9.00	14640.00	0
10	1	1	16	10.10	22000.00	0
11	1	1	2	3.60	48400.00	1/640
11	1	1	4	5.80	39000.00	
11	1	1	8	7.50	56400.00	0
11	1	1	12	9.40	22000.00	1/320
11	1	1	16	11.50	30400.00	1/160
14	1	1	2	3.30	48400.00	1/2560
14	1	1	4	5.10	14640.00	0
14	1	1	8	8.00	50800.00	1/160
14	1	1	12	9.20	12040.00	0
14	1	1	16	10.50	14640.00	1/160

Appendix 4.7.

ECONOMICS OF VETERINARY INTERVENTION.

i. Assumptions used in Path of calculation for traditional goat production (meat and milk).

To calculate the benefits of veterinary intervention realized during the on-farm study the flock performances on the Enkasit farm, Kajiado, attained before (April 1990-91) and after (December, 1992-93) were used. It was assumed that the average flock size was 160 (100 does, 4 bucks, 20 castrates, 36 kids; preweaning mortality before and after intervention was 70% and 5% respectively. the value per litre of goat milk was assumed to be similar to that of the cow. Based on the known production practices in the arid and semi-arid lands it was projected that the producers will sell all castrates at about 1 year of age, will dispose of about 5% of the females due to age or infertility and will hold all but 1 buck in stock or exchange with neighbours and friends.

ii. INCOME

1. Income - sale of 1 year old castrates.

PATH OF CALCULATION

i. Average kidding interval = 12 months = 1.0 kidding per year

ii. Average # of kids born per year per doe = 1.2

iii. a. % of kids raised per year before intervention = 30%

iii. b. % of kids raised per year after intervention = 90%

iv. Price per kg liveweight = 50% the price of goat meat = 140/2 = Ksh. 70

v. Average weight per year per doe = 30kg, per buck = 40kg and 1 year old castrate and young doe = 25kg.

v. a. 1.0 kidding/year x 1.2 kids / kidding = 1.2

therefore one year old castrates available for sale per year/doe = 1.2 x 30% survival rate x 50% of the kids (sex ratio) = 1.2 x .3 x .5 = .18

Returns from sales would be = number available per doe x the number of does x weight of castrate at 1 year x price per kg liveweight (70Ksh) x # in flock = .18 x 100 x 25 x 70 = **Ksh. 31,500**

v. b. 1 0 kidding/year x 1.2 kids/kidding = 1.2

therefore one year old castrates available for sale per year/doe after intervention = 1.2 x 90% survival rate x 50% of the kids (sex ratio) = 1.2 x .9 x .5 = .54

Returns from sales would be = number available per doe x the number of does x weight of castrate at 1 year x price per kg liveweight (70Ksh) x # in flock = .54 x 100 x 25 x 70 = **Ksh. 94,500**

vi. Value of bucks disposed = # of bucks x No. bucks disposed to the market x weight of bucks x Ksh. 70 = 1 x 40 x 70 = **Ksh. 2,800**

2. Sale of old breeding does leaving the flock

PATH CALCULATION

i. Productive life of a breeding doe = 6 years

ii. # of old breeding does leaving the flock per year = 1:6 = .167

iii. Weight of per adult doe leaving the flock = 30 kg

iv. Value per adult doe leaving the flock = 70Ksh x 30 kg = Ksh. 2,100

Therefore the expected income from the sale of does leaving the flock would be = .167 (x100) x 30 x 70 = **Ksh. 35,070**

v. 5% females dying per year = 10 x weight of does x 70Ksh = 10 x 30 x 70 = **a loss of - Ksh. 10,500**

vi. Weight gain by does postpartum as a result of strategic drenching = 3kg/year = 3kg x 100 does x 70Ksh = 3 x 100 x 70 = **Ksh. 21,000**

3. Value of milk

Based on flocks monitored in Baringo/Koibatek and Ganze, Kilifi, it was established that the producers milked an estimated 100-150ml/day per doe for about 3-4 months, with parity 1 and 2 does being milked for shorter periods. Therefore assuming that each doe is milked for at least 3 months and the local value per litre of milk is Ksh 16.00 - then:- for 100 does x 100ml of milk x 90 days x Ksh 16.00/l = **Ksh. 14,400**

Appendix 4.7.

ECONOMICS OF VETERINARY INTERVENTION.

i. Assumptions used in Path of calculation for traditional goat production (meat and milk).

To calculate the benefits of veterinary intervention realized during the on-farm study the flock performances on the Enkasit farm, Kajiado, attained before (April 1990-91) and after (December, 1992-93) were used. It was assumed that the average flock size was 160 (100 does, 4 bucks, 20 castrates, 36 kids; preweaning mortality before and after intervention was 70% and 5% respectively. the value per litre of goat milk was assumed to be similar to that of the cow. Based on the known production practices in the arid and semi-arid lands it was projected that the producers will sell all castrates at about 1 year of age, will dispose of about 5% of the females due to age or infertility and will hold all but 1 buck in stock or exchange with neighbours and friends.

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ii. Average # of kids born per year per doe = 1.2

iii. a. % of kids raised per year before intervention = 30%

iii. b. % of kids raised per year after intervention = 90%

iv. Price per kg liveweight = 50% the price of goat meat = 140/2 = Ksh. 70

v. Average weight per year per doe = 30kg, per buck = 40kg and 1 year old castrate and young doe = 25kg.

v. a. 1.0 kidding/year x 1.2 kids / kidding = 1.2

therefore one year old castrates available for sale per year/doe = 1.2 x 30% survival rate x 50% of the kids (sex ratio) = 1.2 x .3 x .5 = .18

Returns from sales would be = number available per doe x the number of does x weight of castrate at 1 year x price per kg liveweight (70Ksh) x # in flock = .18 x 100 x 25 x 70 = **Ksh. 31,500**

v. b. 1.0 kidding/year x 1.2 kids/kidding = 1.2

therefore one year old castrates available for sale per year/doe after intervention = 1.2 x 90% survival rate x 50% of the kids (sex ratio) = 1.2 x .9 x .5 = .54

Returns from sales would be = number available per doe x the number of does x weight of castrate at 1 year x price per kg liveweight (70Ksh) x # in flock = .54 x 100 x 25 x 70 = **Ksh. 94,500**

vi. Value of bucks disposed = # of bucks x No. bucks disposed to the market x weight of bucks x Ksh. 70 = 1 x 40 x 70 = **Ksh. 2,800**

2. Sale of old breeding does leaving the flock

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iii. Weight of per adult doe leaving the flock = 30 kg

iv. Value per adult doe leaving the flock = 70Ksh x 30 kg = Ksh. 2,100

Therefore the expected income from the sale of does leaving the flock would be = .167 (x100) x 30 x 70 = **Ksh. 35,070**

v. 5% females dying per year = 10 x weight of does x 70Ksh = 10 x 30 x 70 = **a loss of - Ksh. 10,500**

vi. Weight gain by does postpartum as a result of strategic drenching = 3kg/year = 3kg x 100 does x 70Ksh = 3 x 100 x 70 = **Ksh. 21,000**

3. Value of milk

Based on flocks monitored in Baringo/Koibatek and Ganze, Kilifi, it was established that the producers milked an estimated 100-150ml/day per doe for about 3-4 months, with parity 1 and 2 does being milked for shorter periods. Therefore assuming that each doe is milked for at least 3 months and the local value per litre of milk is Ksh 16.00 - then:- for 100 does x 100ml of milk x 90 days x Ksh 16.00/l = **Ksh. 14,400**

4. Value of manure

PATH OF CALCULATION

i. Average weight of doe = 30 kg

With an average kidding interval of 12 months and 1.0 kidding per year. This gives - an average # of kids born per year per doe to 1.2. Of which 30% and 90% survived to reach puberty before and after intervention respectively.

ii. Average weight of the 1.2 kids = 1.2 x average weight of doe x 70%
= 1.2 x 30 x .7 = 25.2kg

iii. Average weight of doe and kids = 30 + 25.2 = 55.2kg

iii. Percentage of dry matter feed intake relative to body weight of the goat = 3%

iv. Percentage of not digestible organic matter in feed = 40%

v. Percentage of manure actually available for collection = 75%

vi. Percentage of Nitrogen content in dry matter manure = 1.57%

vii. Average cost of 1 kg N-fertilizer = Ksh. 16; while the price per 5 tons of manure = Ksh. 4,500 = Ksh. 900 per ton.

viii. Dry matter manure produced per year/doe and kids assuming 100% survival = 55.2kg x 3% of dry matter x 40% x 365 days per year = 241.8kg

At 70% and 10% preweaning mortality before and after weaning this give rise to 30 kg + (25.2 x.3) x 3% of dry matter x 40% x 365 days per year = 164.5kg and 30 kg + (25.2 x.9) x 3% of dry matter x 40% x 365 days per year = 230.74kg.

For the 100 doe flock this would give rise to 16,450kg and 23,740kg of manure annually.

ix. Based on the field survey results goats are out browsing for a maximum of eight hours a day and therefore may deposit at least 10hrs/24hrs (41%) of their manure in the field.

Therefore recoverable manure under the arid and semi-arid production system = 16,450kg x 58% - Percentage of manure dropped in the night and day enclosure x 75% - Percentage of manure dropped that is in the enclosure that is actually available for collection = 75% = 7,155.8kg / 1,000kg x Ksh. 900 = **Ksh. 6,300** per year.

and 23,740kg x 58% x Percentage of manure actually available for collection = 75% = 10,326.9kg / 1,000kg x Ksh. 900 = **Ksh. 9,000** per year.

ii. COSTS OF REALIZING THE ABOVE INCOME

1. Replacement of old breeding does with pubertal does

PATH CALCULATION

i. Productive life of a breeding doe = 6 years

ii. Young does needed to replace the old does = 1:6 = 0.167

Therefore 0.167 goats per year x weight of female goats at 1 year (25kg) x Ksh. 70/kg x 16.7 culled does per year = **Ksh. 4,880.60**

2. Risk of mortality of adult breeding does

PATH CALCULATION

i. Value of young breeding doe = 25kg x Ksh. 70/kg = Ksh. 1,750

ii.Value of old breeding doe = 30kg x Ksh. 70/kg = Ksh. 2,100

iii. Average value of a doe = Ksh. 1,750 + Ksh. 2,100 / 2 = Ksh. 1,925.

Therefore the risk of mortality of adult breeding does based on adult doe mortality observed during the field study = Ksh. 1,925 x the observed adult mortality (10%) = 1925 x .1 = **Ksh. 192.5 or Ksh. 19,250** per year for 100 doe flock.

3. Concentrates

PATH CALCULATION

Under the studied production systems no concentrates were provided for the goats. The few producers who bought salts did it so occasionally that the costs were negligible.

4. Veterinary drugs and chemicals

PATH CALCULATION

i. # of deworming standard (STD) doses/year = 4. Therefore doses per year for the flock = 400 at Ksh. 24 each = **Ksh. 9,600**

Average kidding interval = 12 months = 1.0 kidding per year

ii. Average # of kids born per year per doe = 1.2

iii. a. % of kids raised per year before intervention = 30% (100 does x 1.2 x .3=

36 kids)
iii. b. % of kids raised per year before intervention = 90% (100 does x 1.2 x .3= 108 kids)
Each kid receives 2 x .5 STD doses + 2 x 1 STD doses = 3 STD doses at Ksh. 24 each. Cost before intervention would be zero or a maximum of 24 x 36 x 3 = **Ksh. 2,592**, while the cost of intervention = Ksh. 24 x 108 x 3 = **Ksh. 7,776**
The cost of other drugs including those for the control of external and internal parasites and treatment of sick kids up to weaning, during the on-farm trial, was about Ksh. 100 per kid = 108 kids x Ksh. 100 = **Ksh. 10,800**

5. Minerals
PATH CALCULATION
Under the production systems in use in the arid and semi-arid areas surveyed goats were given naturally occurring salts and hence the cost of providing the minerals was internalized into the costs of labour.
6. Cost of leasing breeding bucks
PATH CALCULATION
In the areas surveyed all producers at one time or the other required the use of services of bucks borrowed or leased from friends and neighbours - the cost of leasing bucks therefore evened out eventually. Most of the producers often exchange bucks for use for a season and therefore there are no in-built costs.
7. Marketing and transport
PATH CALCULATION
i. Though marketing and transport costs were not easily definable as there were other social benefits and activities that were performed at the same time as the transporting and marketing of goats, they were budgeted at Ksh. 20 per goat
There were 16.7 culled does, 1 buck and 18 castrates for sale before the intervention and 16.7 culled does, 1 buck and 54 castrates for sale after intervention. This would cost **Ksh. 720** and **Ksh. 1,440** respectively.
8. Tools
PATH CALCULATION
The cost of tools used to maintain the flock including watering containers, panga (Machetes), ropes, syringes and needles, were not easily quantified as their use was not exclusively reserved for goats. These tools were budgeted at Ksh. 10.0 per goat. At this rate the flock cost **Ksh. 1,400** before intervention and **Ksh. 2,120** after intervention.
9. Cost of day and night enclosure
PATH CALCULATION
i. The cost of construction and maintenance of the day and night enclosure was not easily quantified as the construction materials were harvested from the nearby bushes. The value of the enclosure was therefore based on the number of days it would take 1 labourer to put up the enclosure and the state controlled value of that labour - currently at Ksh. 1,500 per month. The cost of maintenance was, however, more difficult to estimate as no specific time was set aside for the maintenance of the perimeter fencing. It was established that the enclosures had a lifespan of about three years if no maintenance was undertaken.
iv. INCOME FOR INVESTED CAPITAL - NOT CONSIDERED AS COST ITEMS UNDER ii.
1. Interest on boma (day and night enclosure) capital
PATH CALCULATION
i. Value of new enclosure, with a life of three years = 30 labour days = 1,500.00
ii. Value of shed after three years = Ksh. 500
iii. Average value of shed during its lifetime = 1,500 + 500 / 2 = Ksh. 1,000
At 26% interest = **Ksh. 260/year/100 does or Ksh. 2.60 per doe**
2. Interest for circulating capital
PATH CALCULATION
i. Cash expenditure under cost items B 3, 4, 5 and 6 = Ksh. 28,176
ii. Period between cash expenditures and goat sales = 6 months
iii. Annual interest rate = 26%
Therefore 26% x 28,176 x 6/12 = **Ksh. 3,662.80** per year

3. Interest for animal capital

PATH CALCULATION

i. Value of young breeding doe = 25kg **x** Ksh. 70/kg = Ksh. 1,750.

ii.Value of old breeding doe = 30kg **x** Ksh. 70/kg = Ksh. 2,100.

iii. Average value of a doe = Ksh. 1,750 + Ksh. 2,100 / 2 = Ksh. 1,925.

iv. At an annual interest rate of 26% = **Ksh. 500.50** per year

Appendix 4.7. Continued.

ECONOMICS OF VETERINARY INTERVENTION

i. Assumptions used in Path of calculation for traditional goat production (meat and milk).

An alternative formula to establish the value of a goat is currently in use by the Integrated Small Livestock Project, in Central Province and Embu. This formula is based on the meat value, appearance, management, dams milk production and breeding value. The meat value is given per kg liveweight such as Ksh. 120/kg, then the other values are derived from, this value.
Appearance (phenotypic value) - 0-10% of the meat value plus
Condition (management) - 0-10% of the meat value plus
Mother's performance (milk) - 0-10% of the meat value plus
Breeder performance (performance of other goats in flock) -0-10% of the meat value plus Breeding value - does the dam and the off-spring have dairy characteristics ?.

PRICE CALCULATION FOR BREEDING DAIRY GOATS - Proposal by the Integrated Small Livestock Project (ISLP) - NYERI (1995).

Calculation Criteria

	Example for a goat with 15kg liveweight	
	Minimum points	with Max. points
1. Liveweight (LW) LW in Kg x Ksh./kg	15kg x 60 = 900	15kg x 60 = 900
2. Appearance - plus up to 10% phenotypic factors	0% = -	+ 10% = 90
3. Condition - plus up to 10% - management factor	0% = -	+ 10% = 90
4. Mother bonus - plus up to 10% - performance of mother etc.	0% = -	+ 10% = 90
5. Breeder bonus - plus 10% - higher points for registered dairy goat breeders	0% = -	+ 10% = 90
6. Breeding Value - for class E - plus 60% - for class C - plus 40%	60% = 540.00	+ 60 = 540
	Ksh. 1440.00	Ksh. = 1800

Key
Liveweight = Weight of the life animal.

Appendix 4.8a.

Survival of kids following veterinary intervention and the cost of the intervention package on selected farms during the on-farm study.

i. Suswa -Elasit.

Survival rate of kids following intervention in the 1991 -1992 season.

Suswa - Elasit.

Total of kids - 22 Number dead before treatment - 30 in the 1991 -1992 season.

Drug	Volume(ml)	Cost/ml (Ksh)	Total (Ksh)
Antibiotics			
Tetracyclines	66	1.75	115.50
PenStrep$_R$	66	2.20	145.20
Rintal$_R$	66	0.50	33.00
Spasmolyte$_R$	8	6.0	48.00
Alugan$_R$ (1 sachet)	106.00	106.00	441.00

Cost of treatment per kid to weaning was 22.10Ksh.

ii. Juja - Kiambu.

Juja (both farms) - total number of kids 39; Number dead before treatment - 0.

Drug	Volume(ml)	Cost/ml (Ksh)	Total (Ksh)
Antibiotics			
Tetracyclines	117	1.75	91.00
PenStrep	117	2.20	114.40
Rintal	156	0.50	78.00
Spasmolyte	10	6.0	60.00
Alugan	1 sachet	106.0	106.00
S-Dime$_R$	20 tabs	5.00	100.00
		549.40	

Cost of treatment per kid to weaning was 14.10Ksh.

iii. Enkasit, Kajiado.

Total of kids - 82 Number dead before treatment - 0.

Drug	Volume(ml)	Cost/ml (Ksh)	Total (Ksh)
Antibiotics			
Tetracyclines	328	1.75	560.00
PenStrep	328	2.20	721.60
Rintal	328	0.50	164.00
Alugan	2 sachets	106.00	212.00
SDime	60 tabs	50.00	300.00
Defungit$_R$	1 sachet	102	102.00
		2059.00	

Cost of treatment per kid to weaning was 25.10Ksh.

Appendix 4.8b.

Survival rate of kids on farms selected for the on-farm study following "assisted" intervention and the cost of the intervention in the 1992 -1993 season.

i. Juja Farm A.

Total number of kids, 11. Number that died before intervention 3.

Drug	Volume	Cost/ml (Ksh)	Total (Ksh.)
Tetracyclines	44.0	2.50	110.00
Pen-Strep$_R$	33.0	2.50	82.50
Trimoxyl$_R$	-	-	-
Rintal$_R$	33.0	0.50	16.50
Fleapowdwer$_R$	1 tin	79.00	79.00
Alugan$_R$	1 Sachet	106.00	106.00
Pectolit$_R$	5 Sachets	Donation	-
		394.00	

The cost of treatment per kid for the season (to weaning) was Ksh.35.80.

ii. Juja Farm B.

Total number of kids, 8. Number that died before intervention 5.

Drug	Volume	Cost/ml Ksh	Total ksh.
Tetracyclines	48.0	2.50	120.00
Pen-Strep	-	-	-
Trimoxyl	24.0	3.0	72.00
Rintal	24.0	0.50	12.00
Fleapowdwer	1 tin	79.00	79.00
Alugan	1 Sachet	106.00	106.00
Pectolit	5 Sachets	Donation	--
		389.00	

The cost of treatment per kid for the season (to weaning) was Ksh.48.65.

iii. Enkasit, Kajiado A.

Total number of kids, 23. Number that died before intervention 0.

Drug	Volume	Cost/ml Ksh	Total Ksh.
Tetracyclines	69.0	2.50	172.50
Pen-Strep	69.0	2.50	172.50
Trimoxyl	-	-	-
Rintal	69.0	0.50	34.50
Fleapowder	1 tin	79.00	79.00
Alugan 1 Sachet	106.00	106.00	
Pectolit	5 Sachets	Donation	-
	564.50		

The cost of treatment per kid for the season (to weaning) was Ksh.24.55.

Appendix 4.8b continued.

Survival rate of kids on farms selected for the on-farm study following "assisted" intervention and the cost of the intervention in the 1992 -1993 season.

iv. Enkasit - Kajiado B.

Total number of kids, 26. Number that died before intervention 0.

Drug	Volume	Cost/ml Ksh	Total ksh.
Tetracyclines	-	-	-
Pen-Strep	78.0	2.50	195.00
Trimoxyl	78.0	3.00	234.00
Rintal	78.0	0.50	39.00
Fleapowder	1 tin	79.00	79.00
Alugan	1 Sachet	106.00	106.00
Pectolit	5 Sachets	Donation	-
			653.00

The cost of treatment per kid for the season (to weaning) was Ksh.25.10.

v. Suswa, Narok.

Total number of kids, 69. Number that died before intervention 65.

Drug	Volume	Cost/ml Ksh	Total Ksh.
Tetracyclines	207.0	2.50	517.50
Pen-Strep	207.0	2.50	517.50
Trimoxyl	207.0	3.00	621.00
Rintal	207.0	0.50	103.50
Fleapowder	1 tin	79.00	79.00
Alugan	-	-	-
Pectolit	10 Sachets	Donation	-
			1759.50

The cost of treatment per kid for the season (to weaning) was Ksh.439.90.

Appendix 4.9.

The mean total protein (g/l), Immunoglobulin levels (mg/l) and E. coli antibody titre of kids born during the on-farm study (Juja A and B)

Goat/ kid ID	Total protein Biuret	Ref.reading	IgG	IgA	E. coli Ab
2 weeks of age.					
1	6	7.2	56000	+	1/2560
2	6	7.5	40000	+	1/5160
3	5	7.4	26000	+	1/640
4	5.2	7.0	40000	+	1/640
6a	5.6	7.0	50800	+	1/640
6b	6	7.0	30400	+	1/2560
9	6.1	6.0	39000	+	1/5160
10	7.3	6.2	32200	+	1/5160
11	6.8	6.3	51800	+	1/640
14	6.3	7.0	48400	+	1/2560
1 month of age.					
1	6.2	8.0	40000	+	-
2	6.4	7.1	48400	+	-
3	6.0	7.3	56400	+	-
4	5.6	6.1	40000	+	-
6a	6.0	7.4	35000	+	-
6b	5.4	7.0	35000	+	-
7	6.0	7.6	40000	+	-
10	5.4	6.5	30400	+	-
11	5.4	7.4	39000	+	-
14	6.3	8.0	14640	+	-
2 months of age					
1	7.5	6.2	40000	+	1/160
2	6.6	6.2	50800	+	1/160
3	6.8	6.2	39500	+	1/160
4	8.5	8.0	40000	+	1/160
6a	6.5	5.0	45200	+	-ve
6b	5.9	6.0	26400	+	1/160
9	6.1	6.0	45200	+	-ve
10	7.3	6.2	35000	+	-ve
11	6.3	7.0	56400	+	-ve
14	6.8	6.3	50800	-	1/160

Appendix 4.8. Continued.

Goat/ kid ID	Total protein Biuret	Ref.reading	IgG	IgA	E. coli Ab
3 months of age.					
1	10.0	6.6	8460	+	1/320
2	10.8	6.8	14640	+	-ve
3	8.9	6.2	14640	-	-ve
4	9.5	6.4	26000	-	1/320
6a	9.7	6.2	14640	-	-ve
6b	7.2	5.8	14640	+	-ve
9	8.1	6.2	40000	-	1/160
10	9.6	7.0	14640	+	-ve
11	7.0	5.0	22000	+	1/320
14	9.6	6.8	12040	+	-ve
4 months of age.					
1	5.9	6.0	22000	+	1/160
2	6.2	5.4	12040	+	-ve
3	6.4	5.6	14640	-	1/160
4	4.2	3.0	22000	-	1/160
6a	6.4	5.6	12040	+	-ve
6b	5.8	5.2	19660	-	-ve
9	6.2	6.0	14640	-	-ve
10	6.8	5.2	19660	-	-ve
11	6.0	5.8	30400	+	1/160
14	9.7	7.2	14640	-	1/160

Appendix 5.1a.

Changes in bodyweight of does during the experimental period.

Goat ID	Vacc status	19/10 1992	21/12 1992	25/01 1992	5/02 1993	4/03 1993	1/04 1993	1/05 1993
Non vaccinated								
1B	N	32.5	25	23	21	-	-	-
26G	N	24.7	19	18	19.5	19	20	17
6B	N	29	27	25	26	26	26	24
34G	N	29	21	-	-	-	-	-
28G	N	25	26	23	25	23	-	-
25B	N	23	21	20	21	20	21	20
35G	N	30.9	21	19	21	20	20.5	19.5
Vaccinated								
7R	Y	28.6	22.0	-	-	-	-	-
22B	Y	29.7	22.0	17.0	18.0	17.0	17.0	15.5
29G	Y	30.0	23.0	-	-	-	-	-
12B	Y	15.9	11.0	15.0	18.0	17.0	17.0	16.0
27B	Y	12	16	18.5	17	17	17	16
20R	Y	26	21	-	-	-	-	-
9B	Y	22	21	17	19	18	-	-
31G	Y	25	23	21	22.5	23	24	22
32G	Y	32.4	24	22	25.5	25	25	22
30G	Y	28.6	23	21	22	22	23.5	21
15R	Y	22.8	19	16	18.5	19	20	19.5
3R	Y	26.4	23	21	22	18	23	21
10B	Y	24.6	18	17	19	17	23	21
8B	Y	22.2	19	18	19	18	17	16
11B	Y	14	17	15	16	15	15	14.5
40G	Y	25	21	19	21	20	19	18.5
27G	Y	22	20	19	20	19	19.5	18
33G	Y	27	20	18	20	20	20	19.5
24B	Y	22.5	20	18	19.5	19	21	20
13B	Y	25	22	-	-	-	-	-
3B	Y	19	16	15	18	15	15	14
14B	Y	26	23	22	22	23	23	22
2R	Y	24	21	19	-	-	-	-

Key

- indicates that the doe died, Vacc - Vaccinated and non vacc - not vaccinated.

Appendix 5.1b.

The mean changes in bodyweight and total protein (±se) of vaccinated and non vaccinated does during the experimental period.

Week	Weight (Vac)	SE (Vac)	Weight (Non-Vac)	SE (Non-Vac)	TP (Vac)	SE (Vac)
1	23.32	1.14	27.52	1.56	83.0	4.40
4	21.53	0.93	24.83	1.11	77.2	3.00
9	19.42	0.85	23.17	1.33	74.0	4.60
13	18.33	0.54	21.33	1.12	58.5*	4.50
15	19.78	0.57	22.25	1.06	57.8*	6.40
17	19.03	0.66	21.60	1.29	57.2*	4.90
19	20.00	0.81				
21			22.00	1.35	74.0	9.90
24	18.81	0.73	20.63	1.52	69.0	2.00
26	18.75	0.73	20.25	-	-	-
28	18.44	0.68	20.00	2.08	72.7	10.20
32	18.91	0.70	20.83	2.32	71.0	11.90
35	19.15	0.68	20.83	1.92	68.3	1.80

* - Total protein levels below the expected range - (64-70.0g/l ± 4.8).

Appendix 5.1c.

The mean changes in total protein and E. coli antibody titre (±se) in serum obtained from vaccinated and non vaccinated does during the experimental period.

Week	TP (Not-Vac)	SE (Not-Vac)	Titre (NonVac)	SE (NonVac)	Titre (Vac)	SE (Vac)
1	84.3	3.40	0.00	0.00	0.00	0.00
4	77.7	1.50	586.67	239.70	6115.56	796.91
9	77.1	2.40	0.00	0.00	0.00	0.00
13	67.0	2.10	693.33	391.19	3760.00	854.42
15	64.4	2.60	1152.00	999.71	3350.59	393.95
17	53.3	1.50	0.00	0.00	0.00	0.00
19	68.3	3.20			3697.78	708.60
21			280.00	136.63		
24	76.8	3.10	960.00	320.00	3415.56	737.05
26			0.00	0.00		
28	82.1	4.10	6826.67	1706.67	6360.00	1689.72
32	75.3	2.90	0.00	0.00	0.00	0.00
35	63.4	2.90	3413.33	3413.33	8530.67	1613.36

Appendix 5.2. Haematological profile of experimental does before and after vaccination with E. coli strain 0126 K71

Doe ID	Week	PCV %	TP g/l	HB mmol	RBC 1x10^12	WBC 1x10^9	MCV fl	TN %	ST %	L %	M %	E %	B %	MICRO HOT
26G	1	24	72	7.3	10.3	16100	19	31	0	65	0	4	0	
	3		70	5.7	9.3	7300		30	5	62	0	3	0	16
	5	23	72	7.4	15	15500		37	0	62	0	1	0	
	9	30	72	9.7	17.4	12000		42	0	55	0	3	0	
6B	1	20	90	7.3	8.9	6300	23	30	0	69	0	1	0	
	3	9	90	7.2	10.4	12500		46	0	51	2	1	0	20
	5	22	88	7.3	11.5	9700		31	0	67	0	2	0	
	9	24	66	8.3	14.05	12400		37	0	56	0	7	0	
35G	1	25	78	8.2	10.3	11000	23	29	0	69	0	2	0	
	3		100	9.1	12.5	14900		49	0	51	0	0	0	21
	5	30	80	10.8	18	7800		45	2	52	0	3	0	
	9	29	70	9.3	15.6	18500		49	0	45	0	6	0	
32G	1	33	76	6	8.5	9400	21	36	0	64	0	0	0	23
	3		78	7	11	20100		73	0	27	0	0	0	
	5	15	70	5.7	10	6600		57	0	40	0	3	0	
	9	27	66	7.6	16.15	15200		25	0	70	0	5	0	
24B	1	18	70	10.7	14.5	8000	20	30	0	61	0	9	0	
	3		74	7	8.9	19000		41	0	59	0	0	0	20
	5	23	80	8.8	14	18100		20	0	80	0	0	0	
12B	1	21	82	7.1	9.4	9300	20	28	0	72	0	0	0	
	3		90	6.6	7.8	17000		41	0	55	0	4	0	20
	5	23	82	8	10	13100		45	0	49	0	5	1	
	9	24	74	7.9	17	12700		44	0	50	0	6	0	
8B	1	25	80	8.5	14.1	11500	18	28	0	65	0	7	0	
	3	21	70	7.5	13.5	14900		44	0	54	0	2	0	
	5	26	86	10.5	18	24500		46	0	48	0	4	2	
	9	42	70	10.4	18.55	12100		36	0	50	0	4	0	
5B	1	18	70	10.7	14.5	8000	20	30	0	61	0	9	0	
	3		80	9.2	12.2	21000		54	0	46	0	0	0	26
	5	23	80	8.8	14	18100		24	0	76	0	0	0	
	9	31	72	9.1	17.25	15500		42	0	55	0	3	0	
11B	1	26	66	10.5	7.15	12600		42	0	55	0	3	0	
	3	22	62	8.5	6.45	14500		27	0	69	0	4	0	
	5	24	72	7.3	10.3	16100		31	0	65	0	4	0	
	9	25	78	8.2	10	12000		29	0	69	0	2	0	
28G	1	28	74	11.6	8.15	11100		48	0	43	0	9	0	
	3	28	74	11	8.5	11600		28	0	68	0	4	0	
	5	26	76	9.7	9.62	9400		30	0	70	0			
	9	27	68	10.7	6.15	13600		31	0	60	0	9	0	

Appendix 5.3.

Changes in bodyweight, total protein (mg/l) and E. coli antibody titre following vaccination with sonicated E. coli vaccine (1) and a placeable (physiological saline - 2) during the on-station research.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	E. coli Ab
Vaccinated does				
1	2B (22B)	29.70	9.1 (7)	NR
1	8B (18B)	22.20	8.3 (7)	NR
1	40G	25.00		NR
1	15R	22.80	8.9 (7)	NR
1	5B(24=34B)	22.50	7.2 (8)	NR
1	32G	32.40	11.1 (7)	NR
1	3R	26.40	6.8 (5.4)	NR
1	3B	19.00	7.5 (7)	NR
1	11B	14.00	7.7 (6)	NR
1	2R	24.00	7.7 (6.1)	NR
1	28G	25.00	8.6 (7)	NR
1	12B	15.90	10 (8)	NR
1	33G (43G)	27.00	7 (6)	NR
1	14B	26.00	7.5 (7.2)	NR
1	30G	28.60	11.9 (7.4)	NR
1	31G	25.00	8.2 (7)	NR
1	27G	22.00	7.3 (7)	NR
1	10B (20B)	24.60	7.2 (6)	NR
1	9B	22.00	9.6 (7)	NR
1	7B (27B)	14.00	8.8 (6.4)	NR
4	2B (22B)	24.00	7 (5.4)	1/640
4	8B (18B)	21.00	8.1 (6.6)	1/10240
4	40G	23.00	7.3 (6)	1/10240
4	15R	21.00	7.3 (6)	1/5120
4	5B(24=34B)	21.00	7.3 (6)	1/10240
4	32G	30.00	7.5 (6)	1/5120
4	3R	24.00	9.2 (7.6)	1/5120
4	3B	18.00	8.2 (6.2)	1/5120
4	11B	17.00	7.6 (5.4)	1/10240
4	2R	21.00	7.3 (6)	1/5120
4	28G	24.00	8 (7)	1/1280
4	12B	13.00	8.4 (7.2)	1/10240
4	33G (43G)	24.00	7.5 (6)	1/10240
4	14B	24.00		
4	30G	25.00	9 (7.4)	1/5120
4	31G	23.00	8.2 (7)	1/1280
4	27G	21.00	7.6 (6)	1/5120
4	10B (20B)	24.00	7.1 (6.2)	1/5120
4	9B	22.00	8.1 (6.4)	1/640
4	7B (27B)	13.00	7.2 (6)	1/5120

Appendix 5.3 continued.

Changes in bodyweight, total protein (mg/l) and E. coli antibody titre following vaccination with sonicated E. coli vaccine (1) and a placeable (physiological saline - 2) during the on-station research.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	E. coli Ab
9	2B (22B)	22.00	8.3	
9	8B (18B)	19.00	8.3	
9	40G	21.00	5.5	
9	15R	19.00		
9	5B(24=34B)	20.00	7.6	
9	32G	24.00	7.6	
9	3B	16.00	7.6	
9	11B	15.00	6.5	
9	2R	19.00		
9	28G	26.00	8.4	
9	12B	11.00	8.5	
9	33G (43G)	20.00	7.3	
9	14B	23.00	8.2	
9	30G	23.00	9	
9	31G	23.00	7	
9	27G	20.00	8.3	
9	10B (20B)	18.00	7.5	
9	9B	21.00	6.8	
9	7B (27B)	12.00	7.3	
13	2B (22B)	17.00	5.6	NR
13	8B (18B)	18.00	7.1	1/81920
13	40G	19.00	6.1	1/5120
13	15R	16.00	7.2	1/5120
13	5B(24=34B)	18.00	7.3	NR
13	32G	22.00	5.9	1/1280
13	3R	21.00	7.8	1/5120
13	3B	15.00		
13	11B	16.00	5.3	1/2560
13	2R		DIED	
13	28G	23.00	5	1/320
13	12B	15.00	7.9	1/10240
13	3.3G(43)	18.00	6	1/5120
13	14B	22.00	7.8	1/10240
13	30G	21.00	7.5	1/5120
13	31G	21.00	6.6	1/5120

Appendix 5.3 continued.

Changes in bodyweight, total protein (mg/l) and E. coli antibody titre following vaccination with sonicated E. coli vaccine (1) and a placeable (physiological saline - 2) during the on-station research.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	E. coli Ab
13	15R	16.00		
13	1B	23.00	6.2	NR
13	27G	19.00	6.9	1/5120
13	31G	21.00	8	1/5120
13	10B	17.00	7.4	NR
13	9B	17.00	5.9	NR
13	7B (27B)	18.00	5.6	NR
15	2B (22B)	18.00	5.3	1/2560
15	8B (18B)	19.00	6.7	1/2560
15	40G	21.00	6.7	1/2560
15	15R	18.50	7.7	1/5120
15	5B(24=34B)	19.50	7.8	1/1280
15	32G	25.50	6.7	1/1280
15	3R	22.00	4.8	1/5120
15	3B	18.00	5.2	1/2560
15	11B	15.00		1/5120
15	2R		DIED	
15	28G	25.00	4.7	NR
15	12B	18.00	6	1/5120
15	33G (43G)	20.00	6.9	1/5120
15	14B	22.00	6.2	1/5120
15	30G	22.00	6	1/2560
15	31G	22.50	8	1/5120
15	15R	18.50	7.7	1/5120
15	1B	21.00	DIED	
15	27G	20.00	6.1	1/2560
15	31G	22.50	5.1	1/5120
15	10B (20B)	19.00		NR
15	9B	19.00		1/640
15	7B (27B)	17.00		1/2560
17	2B (22B)	17.00	5.9	
17	8B (18B)	18.00	5.3	
17	40G	20.00	4.8	
17	15R	19.00	5.8	
17	5B(24=34B)	19.00	5.8	
17	32G	25.00	6.7	
17	3R	18.00	5.3	
17	3B	15.00	5.3	
17	11B	15.00	4.7	

Appendix 5.3 continued.

Changes in bodyweight, total protein (mg/l) and E. coli antibody titre following vaccination with sonicated E. coli vaccine (1) and a placeable (physiological saline - 2) during the on-station research.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	E. coli Ab
17	2R		DIED	
17	28G	23.00	5.3	
17	12B	17.00	4.9	
17	33G (43G)	20.00	4.7	
17	14B	23.00	5.4	
17	30G	22.00	4	
17	31G	23.50	5.1	
17	15R	19.00	5.8	
17	1B		DIED	
17	27G	19.00	5.4	
17	31G	23.00	5.7	
17	10B (20B)	17.00	5.2	
17	9B	18.00	6.4	
17	7B (27B)	17.00	5.2	
19	2B (22B)	17.00	6.7	1/5120
19	8B (18B)	17.00	9.8	1/5120
19	40G	19.00	6	1/2560
19	15R	20.00	7.9	1/5120
19	5B(24=34B)	21.00	7.9	1/10240
19	32G	25.00	6.7	1/1280
19	3R	23.00	7.6	1/2560
19	3B	15.00	8.9	1/2560
19	11B	15.00	6.8	1/1280
19	28G		DIED	
19	12B	17.00	7.5	1/1280
19	33G (43G)	20.00	4.2	NR
19	14B	23.00	6	1/5120
19	30G	23.50	6.9	1/5120
19	31G	24.00	7.5	1/5120
19	15R	20.00	7.9	1/5120
19	27G	19.50	6.1	1/2560
19	31G	24.00	7.5	1/5120
19	10B (20B)	18.00	5.3	NR
19	9B	26.00	5.7	1/1280
19	7B (27B)	17.00	5.5	1/10240
24	2B (22B)	15.50	9.2	1/2560
24	8B (18B)	16.00	7.3	1/5120
24	40G	18.50	6.8	1/2560

Appendix 5.3 continued.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	E. coli Ab
24	15R	19.50	7.1	1/5120
24	5B(24=34B)	20.00	8.9	1/320
24	32G	22.00	7.6	1/320
24	3R	21.00	8.6	1/2560
24	3B	14.00	8.1	1/1280
24	11B	14.50	6.4	1/2560
24	28G		DIED	
24	12B	16.00	8	1/640
24	33G (43G)	19.50	8.4	NR
24	14B	22.00	6.8	1/5120
24	30G	21.00	9.5	1/5160
24	31G	22.00	9	1/5120
24	15R	19.50	7.1	1/5120
24	27G	18.00	6.2	1/10240
24	31G	22.00	9	1/5120
24	10B (20B)	19.00	5	NR
24	9B	25.00		1/10240
24	7B (27B)	15.00		1/2560
26	2B (22B)	15.50		
26	8B (18B)	16.00		
26	40G	18.50		
26	15R	19.50		
26	5B(24=34B)	20.00		
26	32G	22.00		
26	3R	21.00		
26	3B	14.00		
26	11B	14.50		
26	28G		DIED	
26	12B	16.00		
26	33G (43G)	20.00		
26	14B	22.50		
26	30G	21.00		
26	31G	22.50		
26	15R	19.50		
26	27G	18.50		
26	31G	22.00		
26	10B (20B)	16.00		
26	9B	24.00		
26	7B (27B)	16.00		
28	2B	15.50		
28	8B	16.00	9	NR
28	40G	18.50	8.5	1/10240
28	15R	19.50	7.2	1/2560
28	5B	20.50	8.3	1/5120

Appendix 5.3 continued.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	B. coli Ab
28	32G	22.00	7	1/640
28	3R	21.00	9	1/20480
28	3B	14.00	7.7	1/1280
28	11B	14.50	5.9	NR
28	28G		DIED	
28	12B	16.00	12.8	1/10240
28	33G	19.00	9	NR
28	14B	22.00	8.5	1/10240
28	30G	21.00	7.3	1/10240
28	31G	22.00	7.9	1/20480
28	15R	19.50	7.2	1/2560
28	27G	18.00	6.7	1/2560
28	31G	22.00	7.9	1/20480
28	10B	19.00	6.6	1/5120
28	9B		DIED	
28	7B (27B)	15.00	10	1/2560
32	2B	16.50	5.9	
32	8B	17.00	9.1	
32	40G	19.00	5.8	
32	15R	19.00	6.2	
32	5B	21.00	8.2	
32	32G	23.00	9.1	
32	3R	21.00	8.5	
32	3B	14.00	8.4	
32	11B	14.50	5.9	
32	28G		DIED	
32	12B	16.00	7.7	
32	33G	21.00		
32	14B	20.50	7.8	
32	30G	21.00	6.9	
32	31G	24.00	7.5	
32	15R	19.00	6.2	
32	27G	20.00	8.8	
32	31G	24.00	7.5	
32	10B	18.00	6.8	
32	9B		DIED	
32	7B (27B)	16.00	7.8	
35	2B	16.50	5.5	NR
35	8B	17.00	5.1	1/2520
35	40G	18.50	6.1	1/20480
35	15R	19.50	6.4	1/10240
35	5B	20.50	7.4	1/5120
35	32G	22.00	7.9	1/10240

Appendix 5.3 continued.

Week	Goat ID	Weight (kg)	Total Prot (mg/ml)	E. coli Ab
35	3R	22.00	6.1	1/10240
35	3B	14.50	5.1	1/40960
35	11B	15.00	6.4	1/10240
35	28G		DIED	
35	12B	16.50	6.5	NR
35	33G	20.50	5.9	1/2560
35	14B	21.00	4.4	1/10240
35	30G	22.00	7.3	1/40960
35	31G	24.00	7.9	1/20480
35	15R	19.50	6.4	1/10240
35	27G	20.50	8.1	1/10240
35	31G	24.50	7.9	1/20480
35	10B	19.50	7.2	1/5120
35	9B		DIED	
35	7B (27B)	16.00	4.4	1/10240
Non vaccinated does				
0	35G (45G)	30.90	9.4 (7)	NR
0	4B (25B)	23.00	7.3 (6)	NR
0	6B (16B)	29.00	8.3 (6.4)	NR
0	28G	25.00	8.6 (7)	NR
0	26G	24.70	6.8 (5.4)	NR
0	1B	32.50	9.4 (7)	NR
0	34G	29.00	-	NR
4	35G (45G)	28.00	6.8 (4.8)	1/640
4	4B (25B)	22.00	7.9 (6.2)	NR
4	6B (16B)	28.00	7.1 (6)	1/1280
4	28G	25.00	7.1 (6)	1/1280
4	26G	22.00	8.9 (6)	NR
4	1B	25.00	7.6 (6.4)	1/320
4	34G	21.00	-	
9	35G (45G)	21.00	8.1	
9	4B (25B)	21.00	5.7	
9	6B (16B)	27.00	8.5	
9	28G	26.00	8.4	
9	26G	19.00	7.1	
9	1B	25.00	6.6	
9	34G	21.00	-	
13	35G (45G)	19.00	7	1/2560
13	4B (25B)	20.00	6.8	NR
13	6B	25.00	4.1	1/640
13	28G	23.00	7.6	1/320
13	26G	18.00	6	1/640
15	35G (45G)	21.00	8	NR
15	4B (25B)	21.00	6.2	1/5120
15	6B	26.00	5.6	NR

Appendix 5.3 continued.

Week	Goat ID	Weight	Total Prot mg/ml)	E. coli Ab(
15	28G	25.00	4.7	NR
15	26G	19.50	4.4	1/640
17	35G (45G)	20.00	5	
17	4B (25B)	20.00	7.6	
17	6B	26.00	5	
17	28G	23.00	5.3	
17	26G	19.00	5.7	
21	35G (45G)	21.00	9.6	1/640
21	4B (25B)	21.00	7.6	NR
21	6B	26.00	4.8	1/160
21	28G		DIED	
21	26G	20.00	7.6	1/320
24	35G (45G)	19.50	7.3	1/1280
24	4B (25B)	22.00		NR
24	6B	24.00	6.7	1/320
24	28G		DIED	
24	26G	17.00	6.7	1/1280
26	35G (45G)		20	
26	4B (25B)		20	
26	6B		24	
26	28G		DIED	
26	26G	17.00		
28	35G (45G)	19.00	6.3	1/5120
28	4B		DIED	
28	6B (16B)	24.00	6.2	1/10240
28	28B		DIED	
28	26G	17.00	9.3	1/5120
32	35G (45G)	20.50	5.4	
32	6B (16B)	25.00	9.4	
32	28B		DIED	
32	26G	17.00	6.5	
35	35G (45G)	20.00	6.5	NR
35	4B		DIED	
35	6B (16B)	24.50	6.9	NR
35	28B		DIED	
35	26G	18.00	7.1	1/10240

Appendix 5.4a.

Colostral and serum IgG (mg/l), doe's weight at kidding and litter size in vaccinated (1) and non vaccinated (2) does during the on-station trial.

DOE No.	Treatment 1/2	Days P/partum	IgG mg/l Col.	Serum	Wt.(kg) at kidding	Sex	Litter size
Non vaccinated does.							
6B	2	1.00	30000.00	18160.00	27	1	1
		2.00	30400.00	14640.00			
26G	2	1.00	62600.00	22000.00	20	1	1
		2.00	22800.00	22000.00			
		3.00	8460.00				
28G	2	0.25	58800.00	22000.00	24	1	1
		1.00	58800.00				
		2.00	22800.00	8460.00			
		3.00	8460.00				
1B	2	1.00	30000.00	22000.00	25	2	1
35G	2	1.00	62600.00	22000.00	21	1	1
4B(25)	2	0.25	58800.00	22000.00	21	2	1
34G	2	0.25	58800.00	22000.00	21	1	1
Vaccinated does.							
12B	1	1.00	53000.00	22000.00	16	2	1
		2.00	19660.00	22000.00			
		3.00	6820.00				
31G	1	1.00	53000.00	22000.00	21	1	1
		2.00	20400.00				
		3.00	6820.00				
		4.00					
14B	1	1.00	58800.00	14640.00	17	1	*
		2.00	22800.00	12040.00			
		3.00	5280.00				
		4.00					
33G	1	-	-	-	20	1	1
27G	1	-	-		20	2	1
8B	1	-	-	-	18	2	1
30G	1	-	-	-	21	1	1
2B	1	1.00	61400.00	22000.00	21	*	2
		2.00	14640.00	22000.00			
		3.00	3840.00	-			
2R	1	1.00	61400.00	22000.00	20	*	1
11B	1	1.00	40000.00	12040.00	17	*	1
		2.00	30400.00	18160.00			
		3.00	3840.00				

Appendix 5.4b.

The righting reflex, total protein (mg/l), serum IgG (mg/l), HB (mg/l) and E.coli antibody titre in kids, born of vaccinated (1) and non vaccinated (2) does, at varying intervals postpartum during the on-station trial.

DOB Id.	Kid Id	Kid age (days)	Righting reflex	Kid Wt.(kg)	TP(B) mg/l	TP(R) mg/l	IgG mg/l	B.coli Ab titre	PCV %100 MC	Hb mmol/l
6B	72	0.50	1	2.60	59.0	72.0	14640	1/160	31	
		2.00			38.0	20.0	5780	1/160		
		14.00			66.0	62.0	14640	1/160	31	10.40
		54.00				68.0	11400		31	11.40
26G	74	1.00	1	2.40	-	-	-			
		2.00			90.0	6.40	30400	1/160	39	13.10
28G	75	0.25	1	2.60	36.0	2.00	<3380	-ve	39	12.40
		1.00			61.0	4.00	22000	-ve		
		2.00			62.0	4.10	14640	1/160		
		3.00			67.0	4.80	22000	1/160		
1B	71	0	3	2.4						
35G	70	0	4	2.8						
4B(25)	80	0	3	2.4						
34G	81	0	4	2.2						
					69.0	5.40	18160	-ve		
12B	12	0.25		2.10	45.0			-ve		
		1.00			92.0		30400	1/160	29	11.90
		3.00			90.0		40000	1/160		
		4.00			62.0		22000	1/160		
31G	76	0.25	2	1.80	47.0	3.00		-ve	41	
		2.00							39	
14B	77	0.25	1	2.9		46	0	-ve	30	10.00
		0.50				70	14640	1/640	28	11.00
		1.00				62	22000		25	10.00
		2.00				68	18160		24	9.10
		3.00				70	18160	1/640	23	
		4.00				72	11400	1/640	24	
						66	11400	1/160	31	11.40
2B	39	0.50	1	2.20		64		-ve	34	11.40
		1.00				74		1/160	36	12.20
		2.00				74		1/640	35	11.80
	38	0.5	3	1.60						

Appendix 5.4b continued

DOE Id.	Kid Id	Kid age (days)	Righting reflex	Kid Wt.(kg)	TP(B) mg/l	TP(R) mg/l	IgG mg/l	B.coli Ab titre	PCV %100 MC	Hb mmol/l
2R	73	0.25	1	2.10	43.0	30	0			
		0.5			53.0	40	14640			
		1.00			46.0	34	31400	1/320	39	13.10
		2.00			59.0	46	35000			
		10.00							35	
11B	11	0.25		2.40	57.0	40	3380	-ve		13.70
		1.00			83.0	80	18160	1/160		
		2.00			101.0	78	40000	1/320		

Key

1 - male, 2 - female, Righting reflex (ability to stand, search and attempt to suckle) - 1 = < 30 minutes, 2 - 30-45 minutes, 3 - 45-60 minutes and 4 assisted to stand after one hour.

Appendix 5.5.

Colostral E. coli antibodies, birth type and weight at birth, sex and righting of kids born of vaccinated (1) and non vaccinated (2) does during the on-station study.

Doe Id	Treatment 1/2	B.coli Ab at kidding colostral	Birth type 1/2/3/4	Kid ID	Sex 1/2	Birth wt. (kg)	Righting Reflex
Non vaccinated does.							
6B	2	1/1280	4	72	1	2.60	1
26G	2	1/320	4	74	1	2.40	1*
28G	2	1/1280	4	75	1	2.60	2*
4B	2	1/320	3	80	2	2.40	3
1B	2	1/320	4	71	2	2.40	1
35G	2	1/640	3	70	1	2.80	4
34G	2	1/320	2	81	1		3
Vaccinated does.							
2B	1	1/640	3	38	2	1.90	3
2B	1	-	4	39	1	2.20	2
27G	1	1/5120	3		2	1.80	4
8B	1	1/10240	3		1	2.90	4
33G	1	1/10240	3		2	1.70	3
15R	1	1/5120	3		2	2.70	4
31G	1	1/1280	4	76	1	1.80	3
11B	1	1/10240	4	11	2	2.40	2
32G	1	1/5120	3		2	2.40	4
2R	1	1/2560	4	73	2	2.10	3
30G	1	1/5120	3		2	2.60	
14B	1	1/5120	4	77	1	2.90	2
35G	1	1/640	3		1	2.50	
12B	1	1/10240	4	12	2	2.10	3

Key.

* The kid had to be cross suckled as the dam was agalactic. The birth type was categorised as 1-abortion, 2-stillbirth, 3-parturient and 4-survived. Righting reflex was defined as the ability of the kid to get on sternal recumbency, attempt to stand and suckle. This was classified into 1 -<30 minutes, 2 - <30-45 minutes, 3 - 45-60 minutes and 4 - weak and not viable though assisted to stand, Sex - 1 - male and 2 - Female.

Appendix 5.6.

Frequency of bacterial isolates from vaginal swabs obtained from does (n= 31) 1-5 weeks postpartum (abortion, stillbirth or normal birth) and the concomitant vaginal cytology results (- or +).

Goat ID	Isolates from swabs obtained and the cytology results. 2rd week	3rd week	5th week
Non vaccinated does.			
34G	E. coli	S. aureus and S. aureus (+)	NSG(-)
26G	A. pyogenes and S. aureus	Streptococcus sp.(+)	NSG(+)
35G	Streptococcus sp.	S. aureus(+)	Streptococcus sp. (-)
28G	S. aureus and Streptococcus sp.	Streptococcus sp. (-)	NSG(-)
1B	E. coli and Streptococcus sp.	E. coli.S. aureus Streptococcus sp. (+)	NSG(-)
6B	Streptococcus sp.	ND	ND
4B	A. pyogenes	S. aureus(+)	S. aureus(-)
Vaccinated does.			
27G	Streptococcus sp.	S. aureus(+)	NSG(-)
30G	Streptococcus sp. and S. aureus	S. aureus(+)	E. coli(+)
40G	Streptococcus sp	S. aureus(-)	NSG(-)
31G	Streptococcus sp.	Streptococcus sp. and S. aureus(+)	E. coli(+)
32G	S. aureus	Streptococcus sp.(+)	NSG(-)
29G	S. aureus	Streptococcus sp.(+)	Streptococcus sp.(-)
15R	Streptococcus sp.	Streptococcus sp.(+)	NSG(-)
12R	E. coli and Streptococcus sp.	Streptococcus sp.(-)	NSG(-)

Appendix 5.6 continued.

Frequency of bacterial isolates from vaginal swabs obtained from does (n= 31) 1-5 weeks postpartum (abortion, stillbirth or normal birth) and the concomitant vaginal cytology results (- or +).

15B	*S. aureus* and *Streptococcus* sp. *Streptococcus* sp.	(-)	NSG(-)	
8B	*S. aureus* and *Streptococcus* sp. *Streptococcus* sp.	(+)	NSG(-)	
10B	*Streptococcus* sp. *Streptococcus* sp.		*E. coli* and (+)	ND
13B	*A. pyogenes* *E. coli*	*Streptococcus* sp. and *S. aureus*(+)	NSG(-)	
11B	*E. coli*	*Streptococcus* sp. (+)	*E. coli*(-)	
4B	*S. aureus* *Streptococcus* sp.	NSG (-)	*S. aureus*(+)	
2R	*S. aureus* and *Streptococcus* sp.	NSG (-)	NSG(-)	
3R	*Streptococcus* sp.		NSG (-)	NSG(-)
14B	*Streptococcus* sp. *S. aureus*		NSG (-)	NSG(-)
9B	*Streptococcus* sp. *Streptococcus* sp. (+)		*S. aureus* and	NSG(-)
12B	*E.coli* and *S. aureus*	*Streptococcus* sp. and *S. aureus*(+)	*E. coli*(-)	
3B	*S. aureus*	*S. zooepidemicus*(+)	NSG(-)	
33G	*Streptococcus* sp. and *S.aureus*		*Streptococcus* sp. (+)	NSG(-)
2B	NSG *S. aureus* and *Streptococcus* sp. (+)		NSG(-)	
5B	NSG *S. aureus*(+)		NSG (-)	
7B	NSG *Streptococcus* sp. (+)		NSG(-)	
20R and 7R		ND		

Key
ND - Not done.

Appendix 5.7.

Changes in blood glucose levels in controls and kids challenged with an entero-pathogenic strain of E. coli (0126 K76 B) orally. The blood samples were obtained at 0, 24, 48, 72 and 96 hours after challenge and the kids were re-assessed at 10 days post challenge.

STATUS	Kid ID	0 Hours	24 Hours	48 Hours	72 Hours	96 Hours
CHALLENGE	1	9.80	11.40	8.50	11.40	10.20
CHALLENGE	2	11.40	6.60	6.10	10.20	10.10
CHALLENGE	3	11.20	11.20	8.10	11.20	11.10
CHALLENGE	4	8.50	10.50	7.50	9.20	10.80
CHALLENGE	5	6.50	11.20	4.80	8.90	7.80
CHALLENGE	6	11.50	10.80	8.40	10.20	10.80
CHALLENGE	7	10.10	9.60	6.50	10.60	11.20
CONTROL	8	11.40	11.40	4.70	6.20	8.90
CONTROL	9	9.70	10.20	8.30	7.40	10.70
CONTROL	10	8.60	8.60	6.70	5.60	8.90
CONTROL	11	10.70	10.40	6.90	10.60	10.20
CONTROL	12	8.90	9.60	6.60	7.60	7.20
CONTROL	13	6.60	8.60	6.40	5.90	9.90
CONTROL	14	11.40	10.40	5.90	10.60	11.40

Appendix 5.8.

Changes in blood glucose levels in controls and kids challenged with an entero-pathogenic strain of *E. coli* (0126 K76 B) orally. The blood samples were obtained at 0, 24, 48, 72 and 96 hours after challenge and the kids were re-assessed at 10 days post challenge.

Status	Kid ID	WBC (0 Hours)	WBC (24 Hours)	WBC (48 Hours)	WBC (72 Hours)	WBC (96 Hours)
Challenge	1	9900	15400	11200	13400	9500
Challenge	2	8500	17000	9400	9800	9900
Challenge	3	9800	9000	9100	9100	9400
Challenge	4	-	16300	13000	10300	-
Challenge	5	-	15800	15700	14000	-
Challenge	6	12400	13800	12500	13500	9800
Challenge	7	9500	16300	16700	16900	8500
Control	8	11300	20000	15000	5300	11600
Control	9	10500	12000	15600	14800	8600
Control	10	11600	10000	12300	14000	10500
Control	11	8600	10000	14100	15400	-
Control	12	10500	11600	15300	12100	11400
Control	13	11400	11300	13300	-	15500
Control	14	-	-	15500	13300	11300

NB. The expected range of WBC - 4,000-13,000 cells/ul (9,000)

(Schalm *et al.*, 1975).

Appendix 5.9.

Changes in blood parameters including total protein (g/l), packed cell volume (PCV-%), haemoglobin (mmol/l), red blood cell and white blood cell count (/ul) and body temperature in controls and kids challenged with an entero-pathogenic strain of E. coli (0126 K76 B) orally. The blood samples were obtained at 0, 24, 48, 72 and 96 hours after challenge and the kids were re-assessed at 10 days post challenge.

Day	Challenge Status 1/2	Kid No.	PCV %100	TP g/l	HB mmol/	RBC 1x10^{-12}	WBC 1x10^{-9}	MCV fl	TN %	ST %	L %	M %	E %	B %	MICRO HOT	Glucose T^{o}C
1	1	1		64.0	5.40	4.95	9900		38	0	59	0	3	0	14	9.80
38.00																
2	1	1		80.0	10.00	6.70	17000		56	0	41	0	3	0	25	6.60
38.80																
3	1	1		66.0	4.30	4.80	11200	51	32	0	67	0	0	0	14	6.10
38.40																
4	1	1	12	86.0	6.90	7.00	13400		39	0	56	0	5	0		11.40
38.50																
10																
38 50																
1	1	2		90.0	9.50	6.75	8500		54	0	44	0	2	0	26	11.4
38.10																
2	1	2		70.0	8.50	4.95	15400		37	0	62	0	1	0		11.4
38.80																
3	1	2		70.0	9.30	6.10	9400	73	46	0	54	0	0	0	28	6.1
38.40																
4	1	2	26	86.0	9.80	12.00	9800		36	0	56	0	8	0		10.2
38.10																
10																
38 50																
1	1	3		72.0	8.50	7.95	9800		47	0	44	0	9	0	25	11.2
38.10																
2	1	3		78.0	9.00	9.55	9000		43	0	45	0	12	0	22	11.3
39.00																
3	1	3		70.0	8.60	8.30	9100	61	34	0	56	0	10	0	25	8.1
38.40																
4	1	3	24	74.0	8.90	11.00	9100		26	0	74	0	0	0		11.
38.30																
10																
38.60																
1	1	4														8.
38.40																
2	1	4		64.0	9.90	11.25	16300		32	0	65	0	3	0	23	10.
38.60																
3	1	4		60.0	8.30	7.80	13000	52	31	0	69	0	0	0	26	7
38.30																
4	1	4	27	66.0	9.10	15.50	10300		68	0	32	0	0	0		9
38.40																
10																
38.50																

1	1	5					6.50	38.30										
2	1	5		72.0	9.80	8.90	10000		58	0	53	0	6	2	24	10.40		
38.40																		
3	1	5		60.0	8.10	7.50	15700	59	48	0	44	0	8	0	25	4.80		
38.10																		
4	1	5	18	72.0	10.40	8.00	14000		34	0	34	0	2	1		10.90		
38.20																		
10																		
38.40																		
1	1	6		60.0	9.90	11.10	12400		46	0	50	0	2	2	30	11.40		
38.10																		
2	1	6		68.0	10.00	12.15	13000		41	1	56	0	3	0	25	10.80		
38.90																		
3	1	6		66.0	10.30	12.50	12500	42	37	0	60	0	3	0	31	8.40		
38.50																		

1	1	5					6.50	38.30								
2	1	5		72.0	9.80	8.90	10000		58	0	63	0	6	2	24	10.40
38.40																
3	1	5		60.0	8.10	7.50	15700	59	48	0	44	0	8	0	25	4.80
38.10																
4	1	5	18	72.0	10.40	8.00	14000		34	0	34	0	2	1		10.90
38.20																
10																
38.40																
1	1	6		60.0	9.90	11.10	12400		46	0	50	0	2	2	30	11.40
38.10																
2	1	6		68.0	10.00	12.15	13000		41	1	56	0	3	0	25	10.80
38.90																
3	1	6		66.0	10.30	12.50	12500	42	37	0	60	0	3	0	31	8.40
38.50																

Appendix 5.9 continued.

Day Challenge Glucose $T^{o}C$ Status 1/2	Kid No.	PCV %100	TP mg/l	HB mmol/	RBC $1x10^{-12}$	WBC $1x10^{-9}$	MCV fl	TN %	ST %	L %	M %	E %	B %	MICRO HOT
4 1 38.10	6	30	70.0	11.70	11.00	13500		29	0	71	0	0	0	10.20
10 38.50														
1 1 38.00	7		64.0	5.00	7.40	9500		46	0	50	0	2	2	30 10.10
2 1 39.20	7		62.0	8.90	7.60	16300		46	0	54	0	0	0	25 9.60
3 1 38.30	7		64.0	9.00	11.00	16700	59	37	0	63	0	0	0	26 6.50
4 1 38.20	7	28	62.0	10.40	12.00	16900		41	0	58	0	1	0	10.60
10 38.40														
1 2 38.00	8		84.0	6.00	8.05	11300		39	0	58	0	2	1	22 11.40
2 2 39.00	8		68.0	8.80	8.15	20900		51	0	46	0	2	1	24 11.40
3 2 38.20	8		70.0	9.20	9.00	15000	53	42	0	51	0	7	0	27 4.70
4 2 38.50	8	23	72.0	10.50	12.00	5300		35	0	61	0	4	0	8.20
10 38.40														
1 2 38.10	9		84.0	8.80	10.10	10500		41	0	55	0	4	0	25 9.70
2 2 38.40	9		73.0	8.50	11.10	12000		43	0	56	0	0	1	26 10.20
3 2 38.10	9		66.0	8.90	10.50	15600	42	33	0	63	0	4	0	27 8.30
4 2 38.20	9	28	72.0	13.30	18.00	14800		38		55	0	4	3	9.40
10 38.50														
1 2 38.30	10		80.0	9.30	8.95	11600		47	0	49	0	4	0	26 8.60
2 2 38.80	10		64.0	9.50	10.25	10000		41	0	56	0	4	0	24 8.60
3 2 38.30	10		66.0	9.20	9.90	12300	50	54	0	41	0	5	0	28 6.70
4 2 38.30	10	28	68.0	9.40	16.00	14000		45	0	52	0	3	0	9.60
10 38.50														
1 2 38.50	11		60.0	10.00	9.50	8600		31	0	63	0	6	0	23 10.70
2 2 39.70	11		70.0	10.00	9.45	15800		35	0	57	0	7	1	27 11.20
3 2 38.50	11		72.0	8.90	9.00	14100	49	58	0	77	0	5	0	26 6.90
4 2 38.30	11	29	76.0	12.30	15.50	15400		40	0	57	0	3	0	10.60
10 38.50														
1 2 38.10	12		68.0	8.80	10.35	10500		41	0	55	0	4	0	30 8.90
2 2 38.40	12		70.0	8.90	10.40	11600		59	0	33	0	8	0	26 9.60
3 2 38.50	12		68.0	9.10	11.50	15300	45	51	0	47	0	2	0	28 6.60
4 2 38.50	12	27	70.0	13.30	15.00	12100		26	0	71	0	3	0	7.60
10 38.40														
1	13		68.0	7.60	8.60	11400		33	0	65	0	2	0	26 6.60

38.10															
2	13		72.0	6.00	8.05	11300		39	0	58	0	2	1	22	8.60
38.00															
3	13		60.0	8.40	8.80	13300	48	45	0	54	0	1	0	25	9.40
38.40															
4	13														8.90
38.10															
10						38.60									
1	14														11.40
38.10															
2	14														10.40
38.00															
3	14		87.0	5.20	5.90	15500	47	43	0	57	0	0		25	8.90
38.40															
4	14	19	84.0	5.70	10.00	13300		24	0	72	0	4	0		10.60
38.30															
10						38.6									

Key - PCV -Packed cell volume, TP - Total protein, HB - Haemoglobin, RBC - Red blood cells, WBC - White blood cells, MCV - Mean capsular volume, TN -Total neutrophils, Glucose - mmol/l.