Denna digitala version är tillgängliggjord av Stockholms universitetsbibliotek efter avtal med upphovsmannen, eller i förekommande fall då upphovsrätten har upphört. Får användas i enlighet med gällande lagstiftning.

This digital version is provided by the Stockholm University Library in agreement with the author(s) or, when applicable, its copyright has expired.
May be used according to current laws.

Stockholms
universitet

HAVING HERDS

Pastoral Herd Growth and Household Economy

Gudrun Dahl Anders Hjort

HAVING HERDS

Pastoral Herd Growth and Household Economy

Gudrun Dahl Anders Hjort

STOCKHOLM STUDIES IN SOCIAL ANTROPOLOGY · 2

© Gudrun Dahl & Anders Hjort 1976

The picture on the front cover shows a wood carving of two camels manufactured in Wajir, northern Kenya

Illustrations by Gudrun Dahl

Department of Social Anthropology, University of Stockholm

All rights reserved. This book, or parts thereof, may not be reproduced in any form without written permission of the authors.

ISBN 91 85284-02-5

CONTENTS

	Page
PREFACE	13
1. INTRODUCTION	15
2. GROWTH IN CATTLE HERDS	27
2.1 Introduction	28
2.2 A survey of the literature on cattle	28
2.2.1 Sex distribution	28
2.2.2 Fertility and fecundity	33
2.2.3 Death rates	37
2.2.3.1 Calf mortality	37
2.2.3.2 Adult mortality	38
2.2.4 Age distribution	40
2.3 Constructing the base-line model	45
2.4 Simulating variations in cattle herds	49
2.4.1 Introduction	49
2.4.2 Eight model cattle herds	51
2.4.2.1 Example 1. Diminishing herd I: a short calving period with few calves born and many dead	52
2.4.2.2 Example 2. Diminishing herd II: lowering the calf mortality	54
2.4.2.3 Example 3. Increasing the herd I: introducing an improved calving rate	54
2.4.2.4 Example 4. Increasing the herd II: retaining a higher calving rate and fewer dead calves	56
2.4.2.5 Example 5. Increasing the herd III: good calving variables but high mortality for calves	59
2.4.2.6 Examples 6 and 7. Maximum increases	61
2.4.2.7 Example 8. The "normal" case	64
2.4.2.8 Conclusions	66
2.5 Absolute growth opportunities	71

3.	GROWTH IN CAMEL HERDS	77
3.1	A survey of the literature on camels	78
3.1.1	Introduction	78
3.1.2	Sex ratios	78
3.1.3	Fertility	79
3.1.4	Mortality and age distribution	81
3.2	Growth models for camels	82
4.	GROWTH IN FLOCKS OF SHEEP AND GOATS	87
4.1	A survey of the literature on sheep and goats	88
4.1.1	Sex ratios	88
4.1.2	Fertility	89
4.1.3	Mortality and age structure	94
4.1.4	Age distribution	96
4.2	Growth models for flocks of sheep and goats	96
4.2.1	Example 1. Typical growth of sheep flocks	97
4.2.2	Example 2. Typical growth of goat flocks	102
4.2.3	Example 3. Flock growth for animals with longer life expectancies	108
4.2.4	Conclusions	111
5.	LONG TERM EFFECTS OF DISASTER TO PASTORAL HERDS	113
6.	WHAT IS A HERD? PRIMARY AND PRACTICAL CONSIDERATIONS	131
6.1	Counting stock	132
6.2	Management units and property rights	133
7.	HOUSEHOLD PRODUCTION FROM PASTORAL CATTLE HERDS	139
7.1	The herds and the household	140
7.2	Food products from pastoral cattle herds	141
7.2.1	Milk	142
7.2.1.1	Length of lactation for pastoral cattle	142

7.2.1.2	Volume of milk for human consumption	143
7.2.1.3	Seasonal fluctuations in the number of milk-givers	148
7.2.1.4	The nutritional value of milk	153
7.2.1.5	Conclusion: Composition and size of a minimum herd	156
7.2.1.6	Milk storage and the possibility of reductions in the required herd size	159
7.2.2	Beef	161
7.2.2.1	Cultural aspects of beef production	161
7.2.2.2	Weights of pastoral cattle	163
7.2.2.3	Proportion of herd available for slaughter	167
7.2.2.4	Storage of beef	169
7.2.2.5	The nutritional value of beef	169
7.2.3	Blood	171
7.2.4	Total yield of food from pastoral cattle herds	175
8.	HOUSEHOLD PRODUCTION FROM PASTORAL CAMEL HERDS	183
8.1	Milk	184
8.1.1	Milk yields	184
8.1.2	The nutritional value of camel milk and human requirements	188
8.2	Meat	190
8.3	Blood	193
8.4	Composition and size of a subsistence camel herd	194
9.	HOUSEHOLD PRODUCTION FROM PASTORAL SMALL STOCK REARING	199
9.1	Meat from small stock	200
9.1.1	Meat yield from sheep	200
9.1.2	Meat yield from goats	202
9.1.3	The nutritional value of meat from small stock	203
9.1.4	Meat offtake and composition in sheep and goat flocks	206
9.2	Milk	210
9.2.1	Yields of milk from small stock	210

9.2.2	Seasonal fluctuations	212
9.2.3	The nutritional value of milk from small stock and human requirements	215
9.3	Blood	218
9.4	Flock sizes and total yields for small stock	218
10.	HERD DIVERSIFICATION; DIFFERENCES AND COMPLEMENTARITY OF TYPES OF STOCK	223
10.1	The comparative productivity of different livestock types and the use of Standard Livestock Units	224
10.2	The complementarity of growth rates	230
10.3	The seasonal and nutritional complementarity of different types of stock	234
10.4	Ecology and labour; implications for herd diversification	237
10.4.1	Management requirements	238
10.4.1.1	Camels and cattle	238
10.4.1.2	Sheep and goats	249
10.4.2	Practicable combinations and manageable herd sizes	251
11.	SUMMARY	257
APPENDIX I: Some data from the simulated growth in herds and flocks of pastoral domestic animals		275
FOOTNOTES		295
BIBLIOGRAPHY		325

LIST OF TABLES

2.1	Early age distribution of female cattle in three nomadic herds in western Sudan, based on the Hunting Report	41
2.2	Female age distribution among nomadic cattle	42
2.3	Female cattle in percent of total herd	43
2.4	A tentative female age distribution in nomadic cattle herds	44
2.5	Assumed age distribution of baseline herd	48
2.6	The characteristics of the cattle herd models	50
2.7	Age structures in the female cattle herds according to Examples 1-8	68
2.8	The number of years needed for the total female herds and herds of fertile cows to be reduced to half the size or to double	71
2.9	Building up a herd: age distribution of female cattle with a short calving period	74
2.10	Building up a herd: age distribution of female cattle with a normal calving period	74
4.1	Age structure for male and female sheep and goats in western Sudan (both migratory and sedentary flocks)	96
4.2	Age structures for the flocks of sheep in Example 1	98
4.3	Age structures in the flocks of goats in Example 2	103
4.4	Size of female flocks in Example 3	109
4.5	Annual increase in total number of female animals year 8-9 and 18-19 in the flocks of sheep and goats in Example 3	109
4.6	Annual growth rates for the model flocks	111
5.1	Age distribution of the female cattle herd exposed to disaster	116
5.2	Age distribution of the female camel herd exposed to disaster	117
7.1	Estimated average portions of lactating milkgivers in adult female herd, calculated for different lengths of lactation and different calving rates	149
7.2	Total composition of the herd generated by herd growth, Example 8	157
7.3	Cold dressed weights of Boran and Tanzanian shorthorn cattle according to Ledger, 1966	165
7.4	Carcass weights of East African pastoral cattle slaughtered in abattoirs during 1965	166

7.5	Some edible offals, their proportions of the live-weight and nutritional value	170
7.6	Product estimates for a herd of 100 cattle	175
8.1	Nutritive value of camel milk	188
8.2	Composition of the model camel herd	195
8.3	Yearly yield from a camel herd of 100 camels	197
9.1	Total flock composition for sheep and goat flocks based on Examples 1b and 2b, Chapter 4.2	207
9.2	Possible meat off-take from a flock of 100 small stock	209
9.3	Nutrients in goat's and sheep milk	216
9.4	Total yearly yield of calories and protein from a flock of 100 small stock	219
9.5	Minimum flock size needed for the reference family's milk and meat diet	220
10.1a	Various livestock conversion rates	225
10.1b	Conversion rates used by the International Cooperation Administration of Somaliland	226
10.2	Comparison between "livestock unit" measures converted to cattle equivalents	228
10.3	Production estimates from Chapters 7-9 converted to cattle equivalents	229
10.4	Typical annual growth rates	231

APPENDIX

I. 1	The development of a female cattle herd over a period of 30 years according to Example 1	276
I. 2	The development of a female cattle herd over a period of 30 years according to Example 2	277
I. 3	The development of a female cattle herd over a period of 30 years according to Example 3	278
I. 4	The development of a female cattle herd over a period of 30 years according to Example 4	279
I. 5	The development of a female cattle herd over a period of 30 years according to Example 5	280
I. 6	The development of a female cattle herd over a period of 30 years according to Example 6	281
I. 7	The development of a female cattle herd over a period of 30 years according to Example 7	282
I. 8	The development of a female cattle herd over a period of 30 years according to Example 8	283
I. 9	The development of a female camel herd over a period of 40 years according to Example 1	284
I. 10	The development of a female camel herd over a period of 40 years according to Example 2	285
I. 11	The development of a female flock of sheep over a period of 15 years according to Example 1a	286
I. 12	The development of a female flock of sheep over a period of 15 years according to Example 1b	287
I. 13	The development of a female flock of goats over a period of 15 years according to Example 2a	288
I. 14	The development of a female flock of goats over a period of 15 years according to Example 2b	289
I. 15	The development of a female flock of goats over a period of 15 years according to Example 2c	290
I. 16	Long-term effects (two generations) on a herd of female cattle from a two-year drought	291
I. 17	Long-term effects (two generations) on a herd of female cattle from a three-year drought	292
I. 18	Long-term effects (two generations) on a herd of female camels from a two-year drought	293
I. 19	Long-term effects (two generations) on a herd of female camels from a three-year drought	294

LIST OF FIGURES

2.1	Sex distribution according to herd size in Samburu herds, Kenya	30
2.2	The relative probability of an animal surviving yeat another year	47
2.3	The number of surviving animals each year out of 136 calves born	47
2.4	The distribution of relative calving rates within the age intervals used in the eight examples	51
2.5	The development of the model herd according to Example 1. Numbers of female calves, heifers and fertile cows	53
2.6	Total number of female cattle and annual growth rates in Example 1	53
2.7	The development of the model herd according to Example 2. Numbers of female calves, heifers and fertile cows	55
2.8	Total number of female cattle and annual growth rates in Example 2	55
2.9	The development of the model herd according to Example 3. Numbers of female calves, heifers and fertile cows	57
2.10	Total number of female cattle and annual growth rates in Example 3	57
2.11	The development of the model herd according to Example 4. Numbers of female calves, heifers and fertile cows	58
2.12	Total number of female cattle and annual growth rates in Example 4	58
2.13	The development of the model herd according to Example 5. Numbers of female calves, heifers and fertile cows	60
2.14	Total number of female cattle and annual growth rates in Example 5	60
2.15	The development of the model herd according to Example 6. Numbers of female calves, heifers and fertile cows	62
2.16	Total number of female cattle and annual growth rates in Example 6	62
2.17	The development of the model herd according to Example 7. Numbers of female calves, heifers and fertile cows	63
2.18	Total number of female cattle and annual growth rates in Example 7	63

2.19	The development of the model herd according to Example 8. Numbers of female calves, heifers and fertile cows	65
2.20	Total number of female cattle and annual growth rates in Example 8	65
2.21	The annual changes in the total female herds of cattle, Examples 1-8	67
2.22	Building up a herd: number of female cattle	76
3.1	Survival probabilities for female camels according to Examples 1 and 2	83
3.2	The development of the model herd according to Example 1. Numbers of female calves, heifers and fertile camels	85
3.3	Total number of female camels and annual growth rates in Example 1	85
3.4	The development of the model herd according to Example 2. Numbers of female calves, heifers and fertile camels	86
3.5	Total number of female camels and annual growth rates in Example 2	86
4.1	The growth in a flock of sheep aged 0-6, 6-12 and over 12 months, Example 1a	99
4.2	The number of female sheep and six-month growth rates, Example 1a	99
4.3	The growth in a flock of sheep aged 0-6, 6-18 and over 18 months, Example 1b	100
4.4	The number of female sheep and six-month growth rates, Example 1b	100
4.5	The total number of female sheep in Examples 1a and 1b	101
4.6	The growth in a flock of goats aged 0-6, 6-12 and over 12 months, Example 2a	104
4.7	The number of female goats and six-month growth rates, Example 2a	104
4.8	The growth in a flock of goats aged 0-6, 6-18 and over 18 months, Example 1b	105
4.9	The number of female goats and six-month growth rates, Example 2b	105
4.10	The distribution of survival probabilities for the flock of sheep and goats in Example 2c	106
4.11	The growth in a flock of goats aged 0-6, 6-12 and over 12 months, Example 2c	107

4.12	The number of female goats and six-month growth rates, Example 2c	107
4.13	Number of fertile she-animals in the flocks of sheep and goats; Examples 3a and 3b	110
5.1	The time span of a simulated drought and its basic relation to the simulation model used	118
5.2	The effects of a two-year drought on the number of calves, heifers and fertile cows in a herd of cattle	120
5.3	The effects of a two-year drought on the total number of female animals in a herd of cattle and annual growth rates	120
5.4	The effects of a three-year drought on the number of calves, heifers and fertile cows in a herd of cattle	121
5.5	The effect of a three-year drought on the total number of female animals in a herd of cattle and annual growth rates	121
5.6	Total number of females remaining in a herd of cattle after a two-year and a three-year drought	122
5.7	The effects of a two-year drought on the number of calves, heifers and fertile dams in a herd of camels	123
5.8	The effects of a two-year drought on the total number of female animals in a herd of camels and annual growth rates	123
5.9	The effects of a three-year drought on the number of calves, heifers and fertile dams in a herd of camels	124
5.10	The effects of a three-year drought on the total number of female animals in a herd of camels and annual growth rates	124
5.11	Total number of females remaining in a herd of camels after a two-year and a three-year drought	125
7.1	Daily individual yields for human consumption from lactating cows in two pastoral economies	147
7.2	Proportion of milk-givers in the total adult female herd when there is only one main rainy season	150
7.3	Proportion of milk-givers in the total adult female herd when there are two rainy seasons	152
9.1	Hypothetical percentage of milk-giving does among a total adult female herd in a western Sudan flock	214
10.1	The percentage of lactating cattle, sheep and goats in an area with one major rainy season	235
10.2	Effective grazing area for cattle between a settlement and a water point	240
10.3	Schematized description of camel grazing zone	243

PREFACE

Many colleagues have been helpful in discussions about the manuscript of this book. We would especially like to acknowledge the help from Professor Karl-Eric Knutsson. We would also like to mention the generosity of Dr Paul Spencer who provided some unpublished stock census material. Ulf Thellander and Inger Bryngelsson helped with the computer simulation. Martin Percivall read the manuscript correcting language errors also making valuable comments. Christina Ronström typed the final manuscript. Early versions were typed by Kerstin Lagergren.

The publication of the final manuscript has been aided by the Swedish Research Council for the Humanities and Swedish Agency for Research Cooperation with Developing Countries (SAREC).

Stockholm May 1976

Gudrun Dahl and Anders Hjort

1. INTRODUCTION

The anthropological literature on pastoral societies is fairly limited though it has often been of high quality and has made a great impact on its development within the discipline. Anthropologists have taken great pains to explain the rationale behind the social organization and structure of pastoral societies as well as the requirements for raising domestic animals in terms of ecology, labour etc. Dyson-Hudson¹ has summarized some major issues brought forward by identifying four major sets of factors inhibiting social and economical change among the Karamojong in Uganda. These are the value factors (social values expressed in terms of cattle), the ecological factors (the environmental dependence), the institutional factors (social and political organization) and the historical factors (basically the impact of an external administration).

Unfortunately, one of these sets of factors, the value system, has received more attention outside anthropological circles than the rest. Ever since Herskovits' definition of the "East African cattle complex" in 1926 much interest has been focused on the social value of cattle, often without relating it to the consumption requirements of the household. Such a preoccupation with the cosmological aspect of cattle easily leads to a misunderstanding of the rationale for an individual household keeping many cattle (i e to provide sufficient food, to provide security against droughts and disease); the focus is then rather on the prestige aspects of having large herds, beautiful cattle etc. The obvious problems of over-grazing in many areas are then explained in terms of the pastoral value system rather than the need for each individual household to keep large herds of domestic animals.

It can safely be said that a myth has developed outside anthropological circles which centers around this value system but does not take account of the basic precondition clearly stated by social anthropologists that the social value of cattle is supplementary to the productive aspects of the herds;

milk, meat and blood. The myth even today widely believed in states that pastoralists see as their ultimate goal to keep large herds *per se* in order to achieve high social status in their society. This is not true. Certainly, the social value of cattle or camels is important in many ways, for example in defining social relations and (also economic) obligations, in achieving prestige, etc. The tendency that pastoralists try to keep as large herds as possible is not, however, solely a result from the value system. Other factors that are discussed in this book are more important. For example the unreliable rainfall leads to great fluctuations in the availability of water and grazing, both seasonally and over longer periods. For a pastoral household it is necessary to keep a margin against the risk of having part of the herds killed from a drought or an epidemic. The number of animals needed to maintain a longtime continuous production is also much larger than the number of animals immediately utilized at a certain period. It could also be argued that the social value system primarily reflects these economic/ecological aspects.

This book intends to illustrate the economic aspects of having herds. The keeping of large herds is closely linked to the need to protect the household against the effects of drought or epidemics as well as to food requirements during a particular dry period. A sufficient number of animals must survive a disaster in order that the household can exist while the herd is being rebuilt. An understanding of this central feature of traditional nomadic livestock economies is essential both for the comprehension of pastoral land use and for the planning of alternative land uses, such as ranching. For a more detailed discussion of this issue, see Hjort 1976.

The rhetorics of expert and administrative statements on nomadic pastoralism is indeed an interesting topic in itself. The attitudes of national administrations towards pastoralists are, with few exceptions, negative: nomads are generally regarded as "not yet settled". This strange evolutionist point of view can be completely irrational as many of the areas inhabited by pastoralists are only suitable for extensive grazing. The attitude can also be seen as reflecting the political difficulty in dealing with

people who are forced by ecology to disregard political boundaries, and often emphasize their political independence from the central government. In East Africa, many of the traditional pastoral groups have had very decentralized structures of authority, resting on the independence of each local cluster of households. They also reject the thought that land can ultimately belong to a limited group of people. Whether hierarchically organized under a central leader, or situationally joining together according to the segmentary structures of kinship solidarity, nomadic groups throughout the world have often proved well organized from a military point of view. They have also often had the advantage of secure recourse to areas that other people regard as hostile or uninhabitable.

To the difficulty of administration is added another factor contributing to an anti-nomadic predisposition in many administrations of newly independent states. The changes brought about by colonization and involvement in a world-wide political and economic system has turned the traditional power structures upside down. Yesterday's traditional serfs or agricultural clients of the nomads are the overlords of today.

Whatever the reasons for an anti-nomad ideology, it is certainly backed up by a large number of "expert" statements on the pastoral economy. Although these are not always based on reliable research, they tend to support each other. References are, for example, often made to the "unusually high and unpredictable rates of increase and decrease" in herds of cattle or other types of domestic animals. Information on the composition of herds, fertility and mortality rates, actual growth rates etc occur often unsystematically in the literature. This has led many authors to base their arguments on assumptions rather than primary data, in spite of the fact that the question of the demographic characteristics of pastoral herds is central to an understanding both of pastoral strategies and redistribution systems; confusion has led to difficulties for both administrators and the nomads who suffer from the measures taken that are contrary to their way of life.

One example showing how comparisons between different systems of live-stock production are also often biased can be given from Asmarom, quoting information from Fransen et al.²:

"Compared with modern systems of animal production ... /the pastoral ways of exploiting semi-arid regions /... are highly wasteful systems of resource exploitations ... There are vast differences in the efficiency of beef production between advanced and primitive /(sic!)/ economies. It takes 11 head of cattle to produce one metric ton of beef in the United States compared with 10 to 20 head for Australia and Argentina. By contrast, it takes 55-200 to produce the same amount of beef in Africa. The differences are just as dramatic in terms of dairy production. Exotic breeds can produce an average of 5000 litres of milk per year (e g Frizian) whereas the average for African cattle is less than 500 litres."

The calculations in Chapter 7 show that a herd of slightly more than 100 cattle is likely to give such a metric ton yield of meat which is, if not easily marketable to western customers, at least perfectly fit for consumption. But the comparison quoted does not say that this herd then also produces lots of other things like milk and blood, nor does it mention how many persons gain their livelihood from the herd. And last, but not least, it is formulated so that the reader gets the impression that cattle kept under "modern managements" in semi-arid areas would give as much milk as the Frizian. Such comparisons are on the whole totally irrelevant, as they do not entail a realistic appraisal of what is possible in the semi-arid zone; "exotic" stock demand considerably more grazing and are less resistant to disease. The comparisons instead support already prevalent prejudices by undercommunicating certain facts.

By this discussion we do not want to prejudge what the outcome of a fair comparison would really be, but rather emphasize that there is, as far as we know, not yet any data sufficiently detailed to justify such a comparison. As long as such data are lacking, scepticism is the best attitude and also the morally necessary one, because many thousands of nomads are the objects (and victims) of reforms and programmes based on unfounded theories rather than first-hand knowledge.

An excellent review of the trends that can be discerned in the history of the science of understanding pastoral societies has been given by N Dyson-Hudson (1972) in his introduction to "Perspectives on Nomadism". This essay concludes with a request for a systematic study of variations in pastoral societies, based on an identification of "relevant elements" that can be used as analytical concepts "combined and recombined into various constellations".³ The relevant points for the understanding of pastoral societies, are connected with the phenomenon of coincident populations of animals and people. The understanding of the characteristics of each of these populations is essential if one is to construct a "herding model" of pastoral societies.⁴ Dyson-Hudson points out that:

"Obviously, one can hardly hope for an effective analysis of livestock-oriented groups without some sophisticated grasp of their central concern, viz how to achieve sufficient productivity from the manipulation of available livestock within the available environment so that people may be kept alive from one year to the next. Yet it is a topic most inadequately dealt with by anthropologists ... An extensive literature exists on cattle in the tropics, but either does not relate directly to the range conditions most relevant to the anthropologist's interests; or where it is applicable, seems frequently to be ignored by him, or to be unknown to him. Such information as we have about camel characteristics, moreover, comes generally from non-anthropologists ... Yet clearly, until we have such data much of our supposedly ecological and management discussions of pastoral groups must be quite ingenious." ⁵

It should be emphasized that Neville and Rada Dyson-Hudson themselves have made a substantial contribution towards such an understanding and that their work in this direction has a good chance of becoming a classical watershed in the development of the understanding of pastoral societies.

The present book is an attempt to compile the scattered knowledge on domestic herd animals that is available today. It is not an effort to construct a general model of pastoral societies or cultures, but restricts itself to such aspects of the animal population that we feel can provide the basis for a social anthropological understanding. As it presents an over-view ethnic variations are not always accounted for for the sake of making generalizations on some central points.

The intention of this book is accordingly to construct a largely materialistic framework and to disregard ideological and social aspects of a nomadic society so long as they are not related to herd management. This is done in order to stress such aspects of pastoralism that we think are essential and that have been neglected most and is not a general methodological recommendation.

One of our reasons for focussing on these aspects is that many of the prevalent misconceptions concerning pastoral cultures and societies are based on comprehension deficiencies about these material conditions, or on deliberate or unconscious misrepresentations of them in order to rationalize the ideologies and strategies underlying the administration of nomads. We hope that, in addition, some of our conclusions will be of direct practical relevance for planners working with pastoral societies generally or with the effects of droughts and epidemics.

The first four chapters summarize the scarce and scattered empirical facts given in the existing literature, discusses them and sketches a general analysis by suggesting hypothetical herd evolution models, based on these facts. The purpose of these models is to try to delineate maximum and minimum limits for the pastoral economy, and also to illustrate how small differences in mortality or fertility rates may change the picture completely, thus stressing the importance of precise data.

Although other types of animals may be used as "staple stock" in some pastoral societies (viz reindeers, yaks, lamas and horses) we have concentrated on those species that commonly occur as pastoral stock in Africa and the Middle East, i.e. cattle, camels, sheep and goats.

The focus of our interest is the pastoral household and its herd. The definition of "household" is the minimum independent societal unit which contains sufficient personnel and an internal division of labour that enables it to carry out the most important tasks of looking after a herd, that is of sufficient size to supply the household members with their requirements

for meat (occasionally blood) and milk. Thus, the household unit that we refer to in this book may be regarded as the minimum management unit.

Our models are concerned with total herds, and not with individual animals. When analysing herd growth we concentrate on female animals. In order to describe a typical case of herd growth and herd structure, we ascribe a particular mortality and calving-rate to each female age-class and follow the development resulting from these rates over a time-span of a couple of generations.

After this description of the evolution of the female herd, a certain number of males are ascribed to the herd, in proportions based on the typical ages at which bullocks are slaughtered, and the required ratio of studs/fertile cows. When the requirement of a minimum number of males is fulfilled, the number of male stock does not directly influence the growth rate. If there are too many heads of stock in an area in terms of its grazing resources, a large proportion of males will of course be detrimental to the general well-being of the herd and more males will result in slower growth. The relations between carrying capacity and herd composition are important, but outside the scope of this study. Furthermore, the age-structure of the female herd is mainly the product of biological restrictions since milk production is the main interest of the household and the common strategy is to keep a maximum number of cows. The male age-structure on the other hand, is more subject to cultural differences. This is another reason for focussing on females in the models. Factors that influence the slaughter of males are the ritual and symbolic values ascribed to bulls and oxen, the meat consumption pattern, the degree of involvement in a cash economy, etc. When meat production is the main interest, and not herd reproduction and associated milk production, male animals are more relevant than in the present context, but still pose problems of generalization.

There are, of course, great problems involved in predicting the evolution of a particular herd. Our calculations concern theoretical possibilities, and can in most cases only apply to large populations. In reality, as every

anthropologist knows, pastoral societies are characterized by the constant redistribution of wealth in terms of animals, and no individual's herd grows or declines independently of other herds. Gifts are given or received, animals are borrowed or loaned. We touch briefly on these aspects in Chapter 6 by, for example, pointing out the necessity of redistribution mechanisms in connection with a drastic reduction in the number of cattle in a herd, illustrated with the simulation of a disaster and its effects in Chapter 5.

We believe that generalized growth models like the ones presented here are of value in that they help to isolate crucial factors in the search for better explanatory analyses. One example of such an analysis is the one made by Paul Spencer in his book on the Samburu and the Rendille. The differential growth rates of camels and cattle is used as an explanatory factor in the analysis of cultural differences and symbiosis between the two groups. Within cattle populations a wide range of different growth rates are possible, implying different ramifications of inheritance rules, bridewealth transactions etc.

Not only are the demographic characteristics of a herd little known, the conditions of pastoral production, its opportunities and goals are also frequently misunderstood. It is safe to say that whereas many western "experts" take it for granted that meat production is the primary goal of livestock rearing, the primary goal for nomads is to produce milk for subsistence use. As Widstrand⁶ points out "A basic tenet is that the pastoral livestock operation is not a capitalistic undertaking aimed at producing a marketable surplus. Its aims are rather to provide a good, regular supply of food for the family, to enable them to survive physically and socially and to maximize the chances of their surviving prolonged droughts and other risks." It is important to remember that many of the official publications on pastoral nomadism rest upon a foundation of superficial capitalist ideology. Little interest is given to questions such as the opportunities of making a subsistence economy

more efficient - and therefore little information is collected on the productivity of pastoral cattle and sheep, and virtually none exists on camels and meat goats. Chapters 7, 8 and 9 attempt to compile the scarce data that is available in the literature. Like the earlier chapters on herd growth it is our ambition to give estimates rather than final answers: to locate relevant fields of data and to pose questions.

Comparisons between traditional pastoral ways of keeping herds and "modern systems of animal production" are commonly made in terms of efficiency measured as the maximum output of products for the market with the minimum labour input. Rarely do they take into account the positive aspects of labour-intensive undertakings giving both subsistence and meaningful occupation to a number of people comparing the number of job opportunities under the two different systems. When comparisons are made between the output of for example protein under the two systems, one issue that is seldom touched upon is how many people can be sustained from an increased protein production within the modernized sector. Given the present food distribution system of the world, how would the additional protein relate to the actual nutritional needs of ordinary people, whether pastoralists or farmers? The risk is obvious that increased protein production would only benefit the western world and that the nomads, being easy victims of the actions of transnational organizations of different types, would benefit less from increased protein production in the world than the overfed populations of the industrialized countries.

A discussion of the merits of these two modes of economic thought will not be further elaborated in this study, but the authors' acceptance of the advantages of relatively labour-intensive systems of production should be acknowledged and accepted as a frame of reference for the following chapters.

While Chapters 7-9 discuss the minimum herd sizes necessary from a subsistence point of view, where only one breed is concerned, Chapter 10 tries to identify the advantages of a combination of different species, and the ac-

tual possibilities of combining them. Different aspects of herd management present restrictions on the combinations that are practicable or economically viable, on the maximum sizes of herds and flocks of domestic animals and also on the number of herds and flocks belonging to each household. The discussion of maximum herd sizes is kept short, mainly concentrating on management aspects.

The present book does not deal with the carrying capacities of different grazing zones. This is not due to any lack of understanding of the importance of such considerations, but rather to a lack of space and to the fact that we feel that this is dealt with thoroughly in other literature.⁷ A holistic view of nomadism should combine the discussion here with an interest in the ecological potential of the pastoral areas.

2. GROWTH OF CATTLE HERDS

2.1 INTRODUCTION

This chapter is organized in three parts. The first part contains a summary of the most relevant points made in the literature on cattle. This is followed by the construction of a base-line herd model, in order to create an age distribution model of females to be taken as the starting point for further discussion. Finally, changes are simulated in the designed base-line herd by varying its parameters. One of the objects of this is to show typical and extreme changes in cattle herds and to specify critical developments under different conditions, which can be expressed in terms of variations in fecundity, mortality, population size and age distribution.

Some of the results are used in Chapter 5 to answer questions such as: "What demands do people have on their animals in terms of different aspects of production?", "What would be the possible off-take for sale?", "What opportunities are there for herd diversification?", "What qualitative aspects of herd management are decisive, such as the use of domestic animals as an insurance system?", etc.

2.2 A SURVEY OF THE LITERATURE ON CATTLE

This section deals to a large extent with Eastern Africa as most cattle nomads are found there.¹

2.2.1 Sex distribution

The ratio between newborn males and females is approximately one to one. The Hunting Report² for example, calculates a ratio of 1:1.042 based on a cattle survey in western Sudan including 194 newborn calves. Among mature animals the ratio is generally very much biased in favour of females. This ratio has been of considerable interest to administrators and veteri-

nary experts who are interested in the possible off-take from nomadic herds to the beef market.

A small number of virile bulls is needed to ensure maximum calving. Williamson and Payne³ state that one mature bull usually can serve around 50-60 cattle. Among the Nuer, Evans-Pritchard estimates the ratio to be one bull per 30 to 40 cows.⁴ In southern Somalia 2 to 5 bulls are kept for each 100 female cattle.⁵ The proportion of bulls to serviceable female stock in eleven home settlement herds and eleven grazing camp herds of Karamojong ranges from 1:8 to 1:60 according to Dyson-Hudson⁶. The ratio in cattle herds of the Pokot in Kenya is as low as around 1:5 according to Schneider⁷. It can be expected that nomadic pastoralists keep more bulls than the necessary minimum as a security against losses. The remaining bull calves, when not immediately slaughtered, as previously amongst the Hima⁸, are castrated and are either fattened for sale or kept as a living store of meat for use either in ritual ceremonies or in the dry season when milk production is low. They can also provide blood for the nomadic diet during this season. Most pastoralists try to keep as many female cattle as possible, in order to safeguard milk production and to secure reproduction of the herd. The number of male stock is more variable. For each ecological situation and each ethnic group there may be a useful average, but there is no point in trying to estimate an overall average rate.

Even if bulls move freely among the cows some selection is made when deciding what calves shall be bulls. This choice is governed by different considerations. The Toposa and Murle north of Lake Rudolf emphasize the size and fatness of the calf as well as the dam's record of good health, if it has produced a succession of disease-resistant calves and if its milking capability is high⁹. Nilotes in Sudan (Dinka and Nuer) use the dam's milking capability as the prime criterion when selecting bulls for breeding¹⁰. Here a slight negative selection occurs because the best male calves are chosen as "song bulls" intended for ritual purposes, and they are castrated at the age of one to three years. Baker reports that the Karamojong of Uganda kill all young bull calves unless they are of extremely good quality¹¹.

Furthermore there is a correlation between a household's herd size and its sex distribution; having a large herd implies less need to slaughter for household consumption during hard times, causing decreased off-take for consumption purposes both in absolute and relative figures; see 5.2.2.3. P Spencer has recorded the distribution of male to female stock in two grazing schemes in Samburu, Kenya, during 1958 and 1959. The distribution is illustrated in Figure 2.1. This tendency will be disregarded here as we are dealing mainly with average herd sizes.

FIGURE 2.1: Sex distribution according to herd size in Samburu herds, Kenya (based on data from P Spencer; personal communication)

The characteristic traits of the female part of the herd are to a higher extent restricted by purely natural processes; while social, cultural, and economic factors influence the age composition of bulls and oxen in the

herd. These characteristics will vary according to dietary and other consumption preferences among the population.

Considerable variations are to be found in the literature concerning the estimates of sex distribution in average or typical herds. Widstrand¹² estimates for the Pokot of Kenya that mature cows make up 50 % of the total herds. The definition of "mature cows" is not always clear, no information being given as to whether heifers are included or not. Examples of corresponding figures can be obtained from other areas, such as western Sudan, where 67.6 % of the herd are heifers and cows¹³, and the Karamojong of Uganda where the proportions range from 49 % to 85 %¹⁴. Among the Maasai in Kenya and Tanzania the proportions are given as 44-51 % by Widstrand¹⁵ and 53-61 % by Jacobs¹⁶, including both heifers and cows. For the West African Sahel the proportion of female cattle aged one year or more is given as 44 % by Brémaud and Pagot¹⁷.

Spencer¹⁸ gives two figures for the total number of female cattle in the Samburu District of Kenya, 74.6 % in 1959 and 65 % in 1962. These figures also include the female calves. McKay¹⁹ also discusses Samburu cattle. He gives an "average herd" comprising of 224 animals. Based on his figures 61 % of the herd is made up of females (57 % cows and 4 % heifer calves). Demirören²⁰ gives a corresponding estimate of 75 % females as an average for African nomads. This figure can be compared with Leslie Brown's estimate for southern Ethiopia that 50 % or more of the cattle herds consist of adult cows²¹.

Proportions within the adult herd are also given. Widstrand²² estimates the sex ratio males to females to be 1:5 in the Maasai herds, while in the Hunting Report²³ the ratio in western Sudan proves to be 1:7.47 for animals aged over thirty months.

The general category "male animals" includes bullocks as well as bulls. The proportions between these two categories also vary in accordance with cultural-ecological factors, mainly in terms of how many bullocks are left in the herd and not sold. However, both in Sahel²⁴ and among the Karamo-

jong of Uganda²⁵ the proportions are estimated to be around 1:6. Sometimes all uncastrated calves are classified as bulls, as by Gallais²⁶, which results in the Fulani and Tuareg herds being given almost inverse proportions between bulls and bullocks as compared with the figure given by Brémaud and Pagot.

Van Raay²⁷ gives age and sex distribution among cattle herds in northern Nigeria. If one assumes that the sex distribution among calves less than one year old is fifty-fifty, it can be calculated that, on the basis of a census carried out in 1965 and 1966, 68 % of the total female herds are made up of adult cows, 20 % of heifers and 12 % of female calves aged one year or less. About 70 % of the total herds are made up of female cattle. These figures give a larger proportion of adult females and a smaller one of heifers than other sources. Van Raay points out, however, that it can be difficult to differentiate between old heifers and young adult females. In his own surveys from two Nigerian provinces (1968-1970) he arrives at a different age distribution; out of the total female herds 59 % (64 %) would be made up of adult females, 26 % (23 %) of heifers and 15 % (13 %) of female calves. The sex distribution is almost identical in both Van Ray's surveys and the older census data, i e female animals make up about 70 % of the total herds.

Young bulls, 1-3 years old, occur in the same proportions as heifers in all four of the censuses given.

An evaluation of the sizes of pastoral herds is often made on the assumption that "unproductive" animals, i e bullocks, are "hoarded" for conservative and traditional prestige reasons. It is important to note their use as a reserve store for meat and blood, which has been mentioned above. In some cases, as among the Darfur Baggara, bullocks are also used as pack animals²⁸.

Meat is not necessarily taken from animals when they are fattest or have the leanest meat, nor is blood taken when animals have the optimal opportunities for fast recuperation. Rather, these products are used when human

needs are most pressing, i.e. in the dry season when competition is greatest between calves and people. It is worth noting again that a pastoral nomadism is based on cows as producers of milk, rather than on beef production. Bulls and bullocks still have a value for the human nutrition, however, especially during periods of scarcity.

2.2.2 Fertility and fecundity

Fertility and fecundity rates among cattle, as well as the timing of the beginning and end of their fertile period, depend on the nutritional status of their fodder, which is related to rainfall, soil quality etc. One can expect these factors to vary considerably. Judging from the literature on savannah and semi-desert nomads, this is also the case.

The time of the first birth thus ranges from two to four or even five years. Bartha states that Zebu cattle in the Sahel start breeding at the age of 2 - 2 1/2 years²⁹. Scott provides an age for first calving of between three and five years, an estimate similar to the one given by Bartha for the Azaoak-Zebus in the Sahel³⁰. For East Africa Meyn³¹ states that "There is certainly a wide variation and in this instance an average figure does not mean very much". A low figure is given by Spencer³² for the Samburu (northern Kenya) heifers who are of Boran breed. Spencer's informants claim that "a healthy and fertile cow would bear between seven and ten calves at ten-monthly intervals from the age of 30 months". Spencer finds that this data information from the Samburu is consistent with data in Kenya Land Commission Evidence³³, based on a study of herds acquired from Samburu nomads. In comparison with other neighbouring nomads the Samburu have good access to grazing, but it seems that the informants have given the ideal figure rather than an average³⁴. Samburu cattle seem, however, to be unusually productive. McKay³⁵ states that "sexual maturity (among Samburu cattle) occurs at a very early age, and although this age fluctuates, the average is from 12 to 15 months - most heifers calving down at about 24 months old". From the Ugandan Karamojong the Dyson-Hudsons give us an estimate of 3 1/2 - 4 years³⁶. Nandi cattle on ranches

in the Kenya Highlands calve on average at 42.7 months age according to Galukande³⁷.

Joshi et al³⁸ give 3 1/3 years for White Fulani cattle in northern Nigeria, 3 1/2 years for Toposa cattle in Sudan and Kenya, 3 3/4 years for Boran cattle in Kenya and Ethiopia, 3 to 4 years for the cows of the Mauretanian nomads, 4 to 4 1/2 years for the Baggara Arabs and 4 to 5 years for the Ankole cattle of Bahima in Uganda and Zaire. Grunnet³⁹ and Evans-Pritchard⁴⁰ give four years for the Dinka and the Nuer (Sudan) respectively, the corresponding figure given by Joshi et al being 3 - 4 1/2 years. Four years is also given as a general age for Zebu cattle in the Sahel zone by Bartha⁴¹ and used as an overall average by Demiriören⁴².

In the Hunting Report⁴³ comparison is made between migratory herds and sedentary herds in western Sudan. In the migratory herds as many as 65% of the heifers bear calves before they are four years old, being restricted only by the beginning of their natural oestrus cycle. This may be compared with 28.6 % of the sedentary heifers.

Demiriören⁴⁴, in writing about cattle in the savannah belt of Sudan, refers to "all authorities" agreeing on "low fertility (often only one calf every second year), high age at first calving and a high death rate". This is partly contradicted by the findings about western Sudan in the Hunting Report showing normal fertility and age at first calving. However, it is mentioned that in southern Darfur the age of first calving is said to have gone up from 3 to 4 years to 4 to 5 years according to estimates made by the cattle-owners themselves. This decline is supposedly due to deteriorating grazing (ibid).

Finally, the standard handbook on tropical husbandry, written by Williamson and Payne, only gives the advice that dairy heifers in the tropics usually should not calve until three years of age. There is, however, no specified information on migratory cattle who breed without constraints⁴⁵. Sjöberg & Persson⁴⁶ hold that the age of first calving could be so low as two years under favourable conditions. The length of pregnancy for tropical

cows is 9 - 9 1/2 months. After that the "heat", which is the time when they can be served by bulls, reccurs with intervals of 21-24 days, with an "ideal" next conception at the second heat which occurs approximately 50 days after the birth⁴⁷.

Many sources give "calving rates". As there seem to be few age-based calculations of cow fertilities, it is taken for granted that "calving rate" is usually calculated in relation to the total number of adult cows, and defined as the percentage of cows giving birth during one year out of the total number of grown up heifers and cows. A high number of infertile or old cows will lower the rate. Twin births are uncommon with Zebu cattle, with which we are mainly concerned here, and so one birth implies strictly one calf⁴⁸. When they occur in Boran herds, the twins are hidden so that envy and the evil eye will not affect them. McKay estimates twinning among the fertile Samburu cattle to occur maybe once in a thousand calvings⁴⁹.

A low estimate of the average "calving rate" in nomadic cattle is given by Demirören⁵⁰ who states that it is 45 % to 55 %. A similar low figure (50 %) is given by Sjöberg and Persson⁵¹. Slightly higher figures are indicated by Meyn⁵², who cites both "Kenya Range Research Project", giving 45 % fertility, and McKay⁵³, Kenya Ministry of Agriculture⁵⁴ and L H Brown⁵⁵, concluding that fecundity lies around 55 % to 70 % in areas with two rain seasons and 40 % to 60 % in areas with one season of rainfall. In western Sudan⁵⁶ the figure for the fecundity of nomadic cattle is about 65 %. For sedentarized nomadic cattle it is much lower, about 40 %, bringing down the average for the whole of the surveyed area to roughly 59 %. This discrepancy might be due to differences in fodder and health conditions, or to conscious control of breeding and herd growth by the sedentary herd owners. The calving rate given for the cattle of the Bahima in Uganda by Ruthenberg⁵⁷ is 70 %. Williamson and Payne, finally, give 90 % as the desired goal, but say that 50 % to 80 % is normal for traditional pastoralism⁵⁸.

This information about calving "rates" should be compared with the information available on calving intervals. Here again, Spencer's informants seem to have given him the ideal maximum, which is only possible if the cows virtually become pregnant at the first oestrus after the last birth. The Samburu calving given by McKay⁵⁹ is 18 months. Meyn⁶⁰ relying on this figure and those of Brown⁶¹ (op cit), gives the general calving intervals for East African cattle as ranging from 14 to 22 months. Prole estimates that one calf born every 18 months would be normal⁶². Rada and Neville Dyson-Hudson⁶³ state that 443 days (i.e. 14 months and 3 weeks) is the average for Karamojong cows. The corresponding average estimate for Dinka cattle is 18 months according to Grunnet⁶⁴. Intervals of 16-18 months calving are said to be frequent among the Maasai crossbreed of "Masai Grey" and "Boran Zebu" cattle according to Jacobs⁶⁵. Among Nandi cattle in the Kenya Highlands, Galukande et al find a mean calving interval of 362 days⁶⁶. Joshi et al estimate that the fertile Murle cows (north of Lake Rudolf) give birth at twelve month intervals⁶⁷.

In the Hunting Report⁶⁸ a theoretical average interval of 20.35 months is calculated, but it is noted that the calculation includes barren animals and that approximately 25 % of the cows bore calves in successive years. In places like western Sudan and Somalia, climatic factors result in calving occurring mainly at one single peak season, which changes the average interval; see Maris⁶⁹. Joshi et al also report seasonal fluctuations in breeding. Among the cattle of the Arabs in northern Sudan conceptions occur after the rainy season (one per year) so that calves are born during the next rains⁷⁰. A similar tendency is found in Nilotic Sudan though not so marked⁷¹. The Ankole cattle of the Bahima in Uganda and Zaire, where there are two rain seasons, have two seasonal breeding periods⁷². The Hunting Report points out, that individual cows probably calve within intervals of either one or two years for cattle of the temperate type. According to Williamson and Payne⁷³, the percentage of sterile cows is 3-5 % in all ages up to the age of ten years when it rises rapidly. It has not been possible to find figures on the sterility rates of tropical cattle. Therefore,

the assumption of Williamson and Payne (*ibid*) that it drops in much the same way as with European cows, maybe earlier, must still be employed. Demiriören gives the number of calves born per cow as lower or equal to three⁷⁴. Southern Somali cattle who live for ten years at least, produce four to five calves⁷⁵. Grunnet⁷⁶ states that Dinka cattle get four to seven calves. Using the average 5.5 and the calving interval mentioned above, a fertile period for Dinka cattle ranging from four years to just above twelve can be obtained. Evans-Pritchard's⁷⁷ and Spencer's⁷⁸ maximum estimates of 8 calves vs 10 calves would also give us maximum calving ages of around 12 years. One source states that Baggara cows may give birth to even 12 calves⁷⁹. As Schinkel⁸⁰ points out, however, this is exceptional. Occasionally, however, cows do bear calves at fairly high ages. Many nomadic pastoralists, especially those with small herds, are therefore also reluctant to sell or slaughter old cattle.

Finally, Joshi et al estimate that the Murle cattle, who live north of Lake Rudolf, produce on an average eight calves per cow⁸¹. A similar estimate for the nomadic Arabs of northern Sudan is five to twelve calves⁸². The White Fulani cattle of northern Nigeria are said to have an effective breeding life of around ten years⁸³, which would mean ten calves per lifetime, as they are considered to be regular breeders.

2.2.3 Death rates

2.2.3.1 Calf mortality

Mortality is defined as the relative number of deceased animals during one year. The information on mortality, whether among calves or adult cattle, is again scattered.

One can expect the rates to change considerably from year to year, as the climatic conditions for pastoral nomads are often unpredictable. A decrease in the amount of grazing and water has direct influence on milk

production. Out of the season rains may cause chills and other diseases especially in undernourished calves⁸⁴.

The highest calf mortality rate not ascribed to abnormal occurrences is given by Gallais⁸⁵ for the Tuareg and Fulani. Among their calves 20 % and 40 % are said to die during their first year, due to a high degree of internal parasitism. For East Africa, the figure given by Meyn is similar: 20 % to 35 % in normal years⁸⁶. A high first year mortality rate, 20 %, is also given by Ruthenberg for the Bahima of Uganda⁸⁷. Shaw and Colville⁸⁸, who are referred to by Williamson and Payne⁸⁹ show a calf mortality figure of 15 % in their survey of North-Nigerian stock, and they cite 18 % calculated by a Nigerian Province Officer. Demirören⁹⁰, in an attempt to generalize, gives 10-15 % as a common rate. In western Sudan the Hunting Report indicates that 11 % of the calves died within the first six months⁹¹. This figure for nomadic herds should be compared with 40 % for the sedentary herds. Deaths in young animals between 6 and 18 months old are common, but the number is not specified in the report.

Losses of heifer calves tend to be lower than losses of bull calves. This is due to their higher value for the nomadic economy. They get more attention and probably a greater share of milk; see e.g. Meyn⁹². This difference has been noted by Wilson⁹³ among Ankole cattle in Uganda. 21.7 % of the heifer calves died while the number of dead bull calves was more than double.

Williamson and Payne⁹⁴ give very high rates as common, and recommend that 5 % in normal years would be a desired rate of mortality under good management. Further, 10 % is common with intensive husbandry while 15 % should attract serious attention.

2.2.3.2 Adult mortality

Grunnet⁹⁵ gives a figure for the normal life span of Dinka cattle, who die a natural death at nine to fifteen years of age. Prole⁹⁶ shows an almost

identical figure for the Maasai cattle in Kenya and Tanzania with an average life expectancy of around twelve years. This is probably normal for savannah cattle. The maximum age given by Demirören is thirteen⁹⁷. Bartha⁹⁸, however, mentions that the life expectancy of the Azaoak-Zebus in the Sahel can be very high; an age of 17-20 years is not unusual.

Mortality rates for adult animals are difficult to obtain. Meyn states that "losses in older animals are in the order of 10 %"⁹⁹. Demirören¹⁰⁰ estimates the general mortality rates for adult cattle, i.e. those over four years old to be between 5 and 7 %. Statements phrased in this way are of little value at present since they do not indicate the exact age-range and age-distribution of the animals concerned. Apparently they refer to a percentage of the total adult herd rather than of each age class seen separately. Mortality rates for yearly age intervals have generally not been found. One exception is Demirören who estimates mortality among cattle between one, two and three years old to be 7-8 %.

Some rates are given for the herds as a whole, including the calves. Examples of this are the 15.5 % mortality rate in migratory herds in western Sudan in the Hunting Report¹⁰¹, Shaw's and Colville's estimate of 5 % for Nigerian livestock referred to by Williamson and Payne¹⁰². Among Bahima in Uganda the yearly losses in the total herd are 5 % to 10 % according to Ruthenberg¹⁰³. Deshler¹⁰⁴ estimates that the average annual mortality rate among Dodoth cattle in Uganda may go as high as 10 % to 15 % during certain years.

Measuring the mortality rates of nomadic herds involves some problems. It is important to follow up all gifts and transactions of animals that are made between the herds that are being investigated and also to make a clear differentiation between animals that are slaughtered and those that die from natural causes. As the Hunting Report points out, old animals slaughtered for human consumption often belong to the category that would have died anyway, but this cannot be taken for granted. It should at least be clearly stated whether they are included in the mortality rate or not. This criti-

cism of many of the sources is also relevant to the different mortality rates for bull and heifer calves mentioned earlier; bull calves are often slaughtered at an early age. It would be necessary e g for development planning to know if they died of malnutrition or to become a good meal of meat.

2.2.4 Age distribution

As age distribution is dependent to a high degree on death rates the difficulties of obtaining good age distribution figures are not surprising. Age of cattle can be estimated by actual inspection of their teeth. This is, however, only possible with young cattle. For animals over the age of five years it seems to be impossible to get good estimates. For proper information a long-term registration of data on births and deaths would be necessary. The difficulties of even getting reliable knowledge of the number of animals in a certain herd are well-known; to follow the animals through all transactions during number of years would be still harder. In areas where tagging is used in order to identify ownership, ages of young animals could be marked on the tags. As far as we know this has only been done in western Sudan, and applies to a limited number of herds according to the Hunting Report¹⁰⁵.

In this report dentition has been used as a criterion, and the age composition of male and female animals in the nomadic herds are given. In the following table the age distribution for female animals has been calculated on the basis of figures in the Hunting Report:

TABLE 2.1: Early age distribution of female cattle in three nomadic herds in western Sudan, based on the Hunting Report¹⁰⁶

Age interval (years)	Number of female cattle	%
0 ≤ 7/12	22	5.6
7/12 - 2	104	26.5
2 - 2 1/2	14	3.6
2 1/2 - 3 1/2	21	5.3
3 1/2 - 4	33	8.4
> 4	199	50.6
Total	393	100.0

The age intervals used here are irregular, which makes analysis difficult, if extrapolation for more than a few years is involved. This is a result of estimating ages by dentition. Furthermore, the figures contain some anomalies. The high increase in the interval 3 1/2 - 4 years is surprising and may be due to an exceptionally good breeding season when the cattle of this category were born. The low figure for young calves below seven months could be due to methodological causes; the survey was carried out in January 1973, while the major calving season in the area starts some three months later (April - June). The calves of the last calving season were already too old.

Nevil Dyson-Hudson¹⁰⁷ presents one case of a Karamojong family herd composition (Uganda), and refers to eleven other incomplete counts where some of the calves have been systematically omitted. Deshler¹⁰⁸ presents a rough estimate of the number of calves less than one year old in Dodoth, Uganda. Demirören¹⁰⁹ tries to make a general estimate of the number of old cows above nine years.

Jacobs¹¹⁰ presents average compositions for fairly large samples of herds among the Maasai of Kenya and Tanzania, but does not go into detail about

ages. Apart from these authors no one, as far as has been ascertained, provides information on this point. The information given is summarized in the following table:

TABLE 2.2: Female age distribution among nomadic cattle

	A. Karamojong Uganda	B. Western Sudan	C. Dodoth, Uganda	D. General nomadic herds
	Dyson-Hudson 1966 p. 47 (one case of 109 heads)	The Hunting Report 1974 Table I:1 (average of 3 herds)	Deshler 1965 p. 161 (estimated average)	Demiriiren 1974 p. 17 (estimated average)
Calves	All nursing calves; absolute no 25	Female calves under 7 months; absolute no 22	All calves under 1 year; 20-23 % of total herd	
Heifers	Absolute number: 38	Absolute number: 139 in the age 7/12 - 3 1/2 years		
Cows	Milk cows: 25	232 over 3 1/2 years old	20 % of total herd	
Old cows				1/5 of 75 % female cat- tle in total herd

To make these figures comparable, they have been treated in the following ways:

- 1) All absolute numbers have been transformed into percentages of total herd.

- 2) The calf rates of Dyson-Hudson and Deshler have been divided by two in order to estimate the percentage of female calves. Then Deshler's rate has been further reduced with $\frac{0.9 \cdot 5}{12}$ to roughly correspond to the 7 months interval. 0.9 is the correction factor based on the assumption that mortality within this interval is around 10 % and the values are therefore not evenly distributed during the year. Note the low figures for Sudan, commented on above.
- 3) The "heifers" of Dyson-Hudson are taken to be 7 months to 3 1/2 years old. As cited above, the first calving age is 3 1/2 - 4 years old among the Karamojong cattle.
- 4) The "milk cows" of Deshler are taken to be fertile cows over 3 1/2 years old.

TABLE 2.3: Female cattle in percent of total herd

	A. Karamojong, Uganda	B. Western Sudan	C. Dodoth, Uganda	D. General nomadic herds (Demirören)
Calves				
0-7 months	12 %	4 %	6.25 - 7.75 %	
Heifers				
7/12 - 3 1/2 years	35 %	25 %		
Cows $\geq$ 3 1/2 years	23 %	42 %	20 %	
Old cows $\geq$ 9 years				15 %

It is clear that the information given in the table above is not thorough enough to provide us with any definite knowledge of the average age distribution in typical nomadic cattle herds. The single Karamojong case seems to be typical for Karamojong, as the other information given by Dyson-

Hudson shows a much higher proportion of cows than of heifers. In the cattle count that he refers to, the average proportions between heifers and milk cows can be calculated as being 29:71 or 3:7. The proportion of calves in the Karamojong single case compared to the total number of cows and heifers does, however, agree with information from Jacobs for the Maasai¹¹¹. He does not indicate at what age a calf is no longer counted as a calf, nor does he differentiate cows and heifers. However, he gives the average from two counts; 22 (23) % calves - male and female - and 57 (60) % adult cows (cows and heifers). The proportions between female calves and adult cows is thus roughly 1:6, to be compared with 1:5 in the Karamojong case.

The ratio of 1:6 for calves/adult cows (i.e. cows and heifers) given by Jacobs, and the ratio 3:7 for heifers/milk cows given by data in Dyson-Hudson, are based on the largest herd samples. Jacobs' figures for the first count are based on Kenyan District Veterinary Files on a count including one million cattle (but it was not a total sample of all cattle in the area) and in the second count data from 14 family herds counted by Jacobs himself among Tanzanian Maasai. Dyson-Hudson refers to eleven Karamojong cases of herds counted in 1957 by the District Veterinary Officer of Karamoja. Unfortunately the figures for calves are not complete so a corresponding calf/adult cow ratio cannot be obtained. The heifer/milk cow ratio should, however, be considered reliable.

Via the calf/adult cow and heifer/milk cow rates above, an estimate of the average female age distribution can be made.

TABLE 2.4: A tentative female age distribution in nomadic cattle herds

Calves: 0-7 months	13.5 %
Heifers: 7 months - 3 1/2 years	25.5 %
Cows: 3 1/2 years -	<u>61.0 %</u>
	100.0 %

If the old-age rate in Table 2.3 is applied, 52 of the "cow" percentages will be between 3 1/2 and 9 years old, and nine of the "cow" percentages will be nine years old or more.

2.3 CONSTRUCTING THE BASE-LINE HERD

For the herd growth simulations presented later a baseline must be designed, using the empirical information given in Chapter 2.2. The aim is to simulate a cattle herd with a typical age and sex distribution that can be used in the model when various restrictions on growth and changes in the herd are introduced in the following sections. In order to create the base-line herd the mortality rates given in Chapter 2.2 are employed with the tentative age-structure arrived at in Table 2.4 as a check.

The herd is constructed on the following assumptions:

- a. The number of calves born during each of the last fourteen years are equal each year.
- b. The mortality rates within each age interval are constant from year to year, so that the age structure is only a result of the normal mortality structure and not an aggregated result of fluctuations in births and deaths earlier years. Changes will be introduced later on.
- c. For practical reasons each year of age is regarded as a unit, and the model assumes that all those who die within one year die at the same time, at the end of the year.

When discussing age-classes in the text, we have employed a terminology so that, for example, "the age interval between four and seven years" includes the age-classes 4-5, 5-6 and 6-7 years. In a formalized expression the age, x , of an animal in the age class $(i, i+1)$ can lie in the interval $i \leq x < i+1$.

The first-year calf mortality rate has been chosen to be 20 %. This rate is

in accordance with Gallais', Ruthenberg's and Meyn's estimates, given in 2.2.3.1.

In the normal case, the death rates of young animals should go down considerably the next few years after birth. For this period Demirören presents a rate of 7 % to 8 %. Here, the lower figure of 7 % is used. Demirören's estimate applies to heifer and bull calves equally and may be higher than the rate for heifers as mortality often is higher among young males. The selected rate is applied to each of the intervals 1-2, 2-3 and 3-4 years. Demirören's rate apparently is a general average for the whole interval. Given the assumption of a static herd, these rates may coincide; the percentage of deceased animals out of the total number of animals within the interval will also be 7 %.

One would expect the age interval between four and seven years old to have the lowest mortality. It has been set here at 5 %. The animals are mature and the fertile cows making up the majority of cattle in this interval will be well cared for. Their condition should not yet be declining due to high age. As was pointed out in Chapter 2.2 there are no adequate figures given for each age interval. From those given for the total adult herd, one can expect the rate for each year seen separately to at least not exceed 5 % during a normal year.

For the ages 7 and 8 years the annual death-rates have been increased to 10 %. After the age of nine the cattle in this model are decreasing in number more rapidly in accordance with e.g. Grunnet's statement of 9-15 as the normal life expectancy for cattle, the average 12 years given by Prole, or the maximum 13 years mentioned by Demirören (see 2.2.3.2). For cows aged nine years the model assumes a 20 % mortality rate, those ten years old are given a rate of 33 % and of those eleven years old 49 %. Almost all the remaining cows (90 %) die before the age of 13. The few left die within the next year; no cow in the model reaches the age of 14.

Figure 2.2 shows the relative probability of an animal surviving yet another

FIGURE 2.2: The relative probability of an animal surviving yet another year

FIGURE 2.3: The number of surviving animals each year out of 136 calves born

year, and Figure 2.3 shows the number of surviving animals each year out of 136 calves born at Year 0.

Table 2.5 shows the age distribution which is generated by these mortality rates. This is our baseline model. As a check it can be compared with the tentative distribution based on empirical evidence, Table 2.4.

The baseline model rests on the assumption that a static number of animals have been added to the herd each year. By comparing the calves needed with the proportions of fertile cows, one can decide what rate of fertility would be necessary to fulfil this assumption of stability. If the calving period begins at four years and terminates when the cow enters the 9-10 year age interval, the fertility needed to reach a static situation would be ca 67 % and if the fertile period is increased another year it would be 59 %. Note that the fertility rate also includes male calves, while only the female calves are put into our model.

Both the fertility rates and the age distribution of the baseline model agree fairly well with the rates and estimates given in our survey of the literature. In the next section we will systematically vary death rates, calving rates and fertile ages in order to illustrate the dynamics of a cattle herd.

TABLE 2.5: Assumed age distribution of baseline herd

age	%	% (category)
0-1	13.6	13.6
1-2	10.8	
2-3	10.1	
3-4	9.4	30.3
4-5	8.9	
5-6	8.5	
6-7	8.0	
7-8	7.6	
8-9	6.9	39.9
9-10	6.2	
10-11	4.9	
11-12	3.3	
12-13	1.7	
13-14	0.1	16.2
Total	100.0	100.0

2.4 SIMULATING VARIATIONS IN CATTLE HERDS

2.4.1 Introduction

The base-line herd model can be varied by changing three parameters; calving rates, death rates and calving periods. The range of possible combinations is, naturally, great. Eight different examples are given here, in which the parameters have been ascribed different values. These and other examples are presented graphically in the text. Some more detailed information is presented in the Appendix. Each example has as its starting point the base-line herd. The objective of these studies is to identify the possible extreme effects of changes that may occur in reality. Two "normal" examples are also given (Examples 3 and 8).

In order to calculate the number of female cattle, n , in the age interval $(i, i+1)$ at t years after a change has occurred, the following algorithm has been applied, where d_i is the relative number of individual cattle in the age interval $(i-1)$ that die at this age, and f_i is the relative number of cows in the age interval $(i, i+1)$ who give birth to female calves:

$$\text{For } i = 0, n_{i,t} = \sum_{k=4}^m f_k \cdot n_{k,t-1}$$

$$\text{For } 1 \leq i \leq 13, n_{i,t} = (1 - d_i) \cdot n_{i-1,t-1}$$

The period of calving is ascribed different values. In the first four examples the cows calve between four and nine years of age, i.e. $4 \leq k < 9$ in the algorithm above¹¹². The next three examples are based on a calving period from four to thirteen years ($4 \leq k < 13$) and the last example from four to eleven ($4 \leq k < 11$). These are approximations as in practice all cows do not stop calving at the same time. We assume that the number of calves born by over-aged cows is counterbalanced by the decline in fertility that occurs before the end of the calving life. This makes the abrupt end that in the model is ascribed to the fertile period realistic.

In all examples it is assumed that each birth produces one calf, an approximation that is applicable to the Zebu cattle to which these examples predominantly relate.

Within the calving period, rates are regarded as being constant. In practice, lower fecundity rates are to be expected at the beginning and the end of this period. The distribution of calf births within different age intervals for the eight examples is shown in Figure 2.4.

For the sake of convenience, the basic herd is assumed to contain 1 000 females distributed proportionally as in the base-line herd. This means that it contains 136 newborn calves, with the remainder of the animals spread accordingly.

The eight examples and their variables are summarized in Table 2.6. In addition the calving rates required to produce a static situation in the different examples are also given. Comparison of these rates show that in examples 1 and 2 diminishing herd will result but in all the other cases, there is an increase since the calving rate exceeds the necessary minimum.

TABLE 2.6: The characteristics of the cattle herd models

Model	Calving Rate (%)	Necessary rate to keep herd static	Calving Period (years)	Mortality Rate for Calves 1 Year (%)
Base-line	68.0	68.0	4-9	20
Example 1	45.0	69.4	4-9	20
Example 2	45.0	61.6	4-9	10
Example 3	80.0	69.3	4-9	20
Example 4	80.0	61.6	4-9	10
Example 5	80.0	49.4	4-13	20
Example 6	100.0	49.4	4-13	20
Example 7	100.0	43.9	4-13	10
Example 8	70.0	54.2	4-11	20

FIGURE 2.4: The distribution of relative calving rates within the age intervals used in the eight examples

2.4.2 Eight model cattle herds

The examples that are presented below have been simulated on a computer. However, only the graphs plotted as a result of these tests are described here. Great caution should be exercised when comparing the graphs as the scales vary. A comparison is made in the conclusion, 2.4.2.9.

The different examples are based on a period of thirty years in order to represent the evolution of at least two whole generations.

Initially only female cattle are dealt with as they account for both reproduction and milk production - the major food supply of pastoral peoples. Male cattle are taken into consideration, in connection with meat production, see Chapter 7.

2.4.2.1 Example 1. Diminishing herd I: a short calving period with few calves born and many dead

The first example introduces into the baseline model a definite calving period of between four to nine years of age. As shown in the static baseline herd model, a calving rate of approximately 69 % during this period would result in a static situation (See Table 2.6). The calving rate is therefore set lower, at 45 %, in order to create conditions for very low growth. The rate of female births is half that of the calving rate. Thus f_i in the algorithm will be 0.225.

Examples of such low calving rates have been given by Meyn, quoting the Kenya Range Research Project, and the rate is the lower extreme of the range given by Demirören. It is, however, possible that the estimates given by these authors also include old barren cows, which would further lower the rate; their estimates are not clear on this point.

The effects of the introduction of a low calving rate are given in Figures 2.5 and 2.6. During the first four years the change will only affect the number of calves and heifers; on the fifth year the birth of calves will be seriously affected since the number of fertile cows starts to decline.

The age distribution of the total number of females will change and stabilize at approximately 10 % calves, 26 % heifers, 42 % fertile cows and 22 % old cows; see Figure 2.5. This can be compared to the original distribution of around 14 % calves, 30 % heifers, 40 % fertile cows and 16 % old cows. What has happened is that the relative proportion of old animals has increased.

Figure 2.6 shows the growth rate¹¹³ which is below 1.00. The herd diminishes. The yearly decrease amounts to ca 6 %. After about twelve years the female herd has reached half of its original size, while it takes about fourteen years to achieve the same reduction in the (possible) milk-producing herd, because of changes in the age structure.

FIGURE 2.5: The development of the model herd according to Example 1.
Numbers of female calves, heifers and fertile cows

FIGURE 2.6: Total number of female cattle and annual growth rates in Example 1

2.4.2.2 Example 2. Diminishing herd II: lowering the calf mortality

In example 2 the calving rate (45 %) and calving period (four to eight years) from example 1 are retained but more calves are allowed to survive the critical first year, the calf mortality being set at 10 %.

Few authors would agree that this is a common calf mortality rate for nomadic cattle. The factors affecting calf survival are the same as those affecting fertility. This example is more theoretical in that it presupposes a high calf survival rate coupled to a very low fertility rate within a short age-span. The example is only given in order to show the effect of lowering the calf mortality rate.

The calving rate needed to keep the herd at a constant size with a calf mortality rate of 10 % would be 62 %, see Table 2.6. Lowering the mortality rate to 10 %, in order to counteract the decrease of the herd will not be sufficient if the calving rate is kept at 45 %. The results are shown in Figures 2.7 and 2.8.

The yearly losses amount to -4.5 % when the trend has stabilized, see Figure 2.8. It therefore takes around 17 years, including the time lag, before the herd is reduced to half its original size.

The age distribution shown in Figure 2.7 is similar to that in example 1 with an increase in the relative proportion of old animals.

2.4.2.3 Example 3. Increasing the herd I: introducing an improved calving rate

In the third example the short calving period of the first two examples will be retained, while the calving rate is increased to 80 %, which is above the level necessary to maintain a stable situation, the latter being slightly less than 70 % (see Table 2.6).

80 % is the upper limit of what Williamson and Payne consider a normal calving rate in the tropics; see 2.2.2. No other references quote such a

FIGURE 2.7: The development of the model herd according to Example 2.
Number of female calves, heifers and fertile cows

FIGURE 2.8: Total number of female cattle and annual growth rates,
Example 2

high calving rate as an average for nomads. However, Meyn¹¹⁵ gives 85 % with a variation from 67 % to 93 %, as an average for Boran cattle raised in Kenya under ranching conditions.

In this example the mortality rate is reduced to the "normal" 20 %. As Figures 2.9 and 2.10 indicate, a slow increase now occurs with a shift in the age distribution towards younger animals. The proportion of calves in the total female herd increases from 14 % to 15 %, of heifers from 30 % to 32 %, while cows are reduced from 40 % to 38 % and old cows from 16 % to 15 %.

The yearly increase is 2.1 %; see Figure 2.10, resulting in the original herd doubling within roughly 36 years but not within the thirty year period being studied.

2.4.2.4 Example 4. Increasing the herd II: retaining a higher calving rate and fewer dead calves

In the last example, an increase in the model herd was created by a rather high calving rate, 80 %, during a calving period of between four to eight years. In example 4 a further increase is created by allowing this high calving rate be accompanied by a low calf mortality rate of 10 %. As indicated earlier, in 2.4.2.2, it is reasonable to assume that these factors vary together.

If calving rates are taken as the variable, this example can be compared with example 2 which has a considerably lower calving rate 45 % and yet the same calving period and calf mortality rate. The calving rate needed for a static herd is therefore 62 %; see Table 2.6.

As expected, Figures 2.11 and 2.12 show a more pronounced increase than in example 3. The milk-giving herd doubles in size after 21 years while the total female herd doubles after 19 1/2 years.

The relative number of calves and heifers increase from 10 % to 15 % and from 26 % to 34 % respectively and the categories fertile cows and barren

FIGURE 2.9: The development of the model herd according to Example 3.
Number of female calves, heifers and fertile cows

FIGURE 2.10: Total number of female cattle and annual growth rates in Example 3

FIGURE 2.11: The development of the model herd according to Example 4.
Number of female calves, heifers and fertile cows

FIGURE 2.12: Total number of female cattle and annual growth rates in Example 4

cows show relative decreases; from 42 % to 38 % and from 22 % to 13 % respectively. This means that the age structure shifts towards younger animals.

The annual growth rate for the total female herd in example 4 is almost 4 %.

2.4.2.5 Example 5. Increasing the herd III: good calving variables but high mortality for calves

Until now the calving period has been kept constantly short. In this and the following two examples it is extended to cover the ages group from four to twelve years, in order to agree with the longer fertile period given by Grunnet, Evans-Pritchard and Spencer (see 2.2.2). In this way a theoretical maximum is approached.

Given a 20 % mortality rate and a longer calving period, the calving rate that would produce a static herd, is about 49 %; see Table 2.6. The calving rate of 80 % which has been used in examples 3 and 4 is also used here. When the length of the calving period is increased, the percentage of old and unproductive cows is smaller, and thus the differences diminish between a calving rate based on the fertile age-span and one based on the total herd of female cattle over four years old. Here they almost coincide as very few animals are allowed to live beyond the thirteen years of age in the present model.

The development of the herd in example 5 is given in Figures 2.13 and 2.14. The annual increase in the total female herd is slightly more than 6 % when stable. The herd doubles its size 11 1/2 years after the change is introduced. The fertile, and possibly milk producing, part of the total herd is doubled after sixteen years.

That a change in the age structure towards younger animals can also be seen is reflected in the changes in the relative proportions of calves in the total female herd (from 14 % to 18 %), of heifers (from 30 % to 35 %), and of fertile cows (from 56 % to 47 %).

FIGURE 2.13: The development of the model herd according to Example 5.
Number of female calves, heifers and fertile cows

FIGURE 2.14: Total number of female cattle and annual growth rates in Example 5

2.4.2.6 Examples 6 and 7. Maximum increases

The next two examples can be considered as theoretical calculations of the maximum opportunities for herd growth. A calving rate of 1.0 is assumed, i.e. that there are no sterile cows and that all cows produce one calf per year and that conception predominately takes place at the ideal second oestrus. The fact that twins can occur and the purely theoretical possibility that all cows calve every tenth month is disregarded.

The 1.0 calving rate in the model gives the same result as the 0.98 rate for all cows in the total herd aged above four years old as so few live longer than thirteen years.

The calving period is between four and thirteen years of age. The only difference between these two examples is the calf mortality rate. In example 6 it is 20 % and in example 7 10 % has been chosen to produce absolute maximum growth. The minimum fertility rate to maintain a static herd is 49 % in example 6 and for example 7, with its better calf survival probability, 44 %, see Table 2.6.

The annual growth rates for the total female herd are almost 9 1/2 % for example 6 and slightly above 11 % for example 7.

In example 7, which shows the maximum theoretical possible growth in a herd exhibiting a fairly typical age structure, it can be seen that the total female herd doubles its size within 6 1/2 years of the introduced change. Further it takes somewhat more than ten years before the fertile cows, i.e. the potential milk producers, double their number.

As before the age structure distribution shows a shift towards the younger animals. The relative proportion of calves in the total female herd increases from 14 % to 19 % and for heifers from 30 % to 42 %. Again this is the best increase rate and age distribution that can be achieved under the most favourable growth conditions, assuming a normal age structure to begin with and that no cattle are introduced into the herd from outside. The last condition is, of course, not in accordance with real life situations. This will be discussed further in Chapter 6.

FIGURE 2.15: The development of the model herd according to Example 6. Numbers of female calves, heifers and fertile cows

FIGURE 2.16: Total number of female cattle and annual growth rates in Example 6

FIGURE 2.17: The development of the model herd according to Example 7. Numbers of female calves, heifers and fertile cows

FIGURE 2.18: Total number of female cattle and annual growth rates in Example 7

2.4.2.7 Example 8. The "normal" case

In some of the earlier examples the effects of giving rather extreme values to the variables have been examined. This last example shows what could normally be expected if the data from the survey of nomadic literature and the assumptions based on these are correct. In this example a calving period of four to ten years has been chosen in accordance with the data from Williamson and Payne on the decline of cattle fertility. The calving rate of 70 % corresponds to the upper end of the interval given by Meyn, and to the information from Ruthenberg on the Bahima. It is a little above the 65 % rate for the nomadic cattle in Sudan given in the Hunting Report; see 2.2.2 for these rates. However, as before, it must be remembered that these rates may have included old and barren animals. The calves born by the cows in example 8 correspond to a calving rate of 58 % if all female cattle over four years of age are included.

The results can be seen in Figures 2.19 and 2.20. The annual increase in the total female herd is 3.4 % when the trend has stabilized. The development is slightly better than in example 3 (with a 80 % calving rate, a calf-bearing lifespan restricted to four to eight years and with a 20 % calf mortality rate).

The total female herd doubles its size after 21 1/2 years while the number of fertile cows doubles after 24 years, i.e. a period corresponding to almost two generations.

The age structure shows the normal increase in the relative number of young animals in the total female herd with calves increasing from 14 % to 16 % and heifers from 30 % to 33 %. Fertile and old cows decrease accordingly from 56 % to 51 %. From a milk production point of view the greatest difference between examples 3 and 8 is the length of the fertile periods. This is reflected in the fact that 38 % of the female herd are potential milk producers in example 3 and 47 % in example 8.

FIGURE 2.19: The development of the model herd according to Example 8. Numbers of female calves, heifers and fertile cows

FIGURE 2.20: Total number of female cattle and annual growth rates in Example 8

2.4.2.8 Conclusions

Figure 2.21 illustrates the annual changes in the total herds of female cattle. The age structures in these herds in terms of calves, heifers, fertile and old cows are given in Table 2.7.

Examples 1-4 have been ascribed a calving period of 4-9 years. The low upper age limit is reflected in the large number of old cows in Table 2.7. Treating all female cattle four years old or above together, the table illustrates the obvious fact that with higher reproduction follows a shift in the age structures towards younger animals. It can also be seen, that the proportion of potentially milk-giving cows is 40-45 % of the total number of female cattle.

In example 7, which gives the maximum theoretical growth, the annual growth rate of the female herd is 11 %. As the herd has acquired a constant age structure and as the sex distribution does not vary, the growth rates for the total herds are identical with those for the female herds (this is true for all eight examples). It takes 6 1/2 years for this herd to double its size. More important, however, is that the fertile cows, the milk-producers, double their number within 9 1/2 years. As milk is the crucial product from pastoralists' cattle herds, this figure is the most relevant when discussing growth rates from the point of view of the household.

For a typical herd, if example 8 can be regarded as such, the annual growth rate is 3.4 % which means it takes 24 years for the fertile cows to double their number.

It must be emphasized that these figures presuppose a steady growth and balanced age-structures without fluctuations in mortalities. Chapter 6.2 illustrates what happens when mortalities do fluctuate by simulating various drought conditions.

Observations, such as Allan's about Maasai cattle, that they by 1954 had shown a natural increase of 32 % in two years and another 20 % in 1955 mean that the period preceeding the one when the stock census was made

FIGURE 2.21: The annual changes in the total female herds of cattle, Examples 1-8

TABLE 2.7: Age structures in the female cattle herds according to Examples 1-8

	Ex 1	Ex 2	Ex 3	Ex 4	Ex 5	Ex 6	Ex 7	Ex 8
Proportion of calves	10.1	9.9	15.0	14.6	17.7	19.7	18.9	15.8
Proportion of heifers	25.6	27.3	32.2	34.2	35.2	37.1	38.9	33.2
Proportion of fertile cows	42.0	42.0	38.4	38.0	47.0	43.1	42.1	46.8
Proportion of old cows	22.3	20.8	14.4	13.2	0.1	0.1	0.1	4.2
Total number of females after 30 years (1 000 Year 0)	173.49	279.16	1 814.76	2 987.38	6 127.54	14 770.82	23 453.27	2 675.95

must have been untypical, i.e. that the relative proportion of surviving fertile cows was higher than normal. If the stock census is correct, the only possibility is that an anomalous age and sex structure was present during that particular period. Furthermore, through "survival of the fittest", the normal mortality rate should decrease somewhat during the first years of recovery after a large scale reduction brought about by disease or starvation.

Allan gives also growth rates for cattle herds in Zambia¹¹⁷. With 45 % of the herds made up of breeding cows and heifers, with a calf mortality of 33.3 % and an average herd mortality of 8 % the annual growth in the (total) cattle herds is 4 %. These figures correspond well with this analysis.

Spencer¹¹⁸ presents an annual growth rate of 5.6 % in a typical herd for the Samburu in northern Kenya. Demirören quotes "Perspective Studies of Agricultural Development"¹¹⁹ as giving 4 % as the present overall increase in Sudanese nomadic herds. These rates seem in line with the calculations presented here.

Brémaud & Pagot¹²⁰ give a 10 % annual increase allowing for losses to the Sahelian cattle herds. This, on the other hand, seems too high an estimate to be realistic, unless there have been changes in the age structures.

Brown¹²¹ states that a pastoral cattle herd may double in four years if disease is controlled and that, therefore, "theoretically such a herd should be reduced by about 35 % p.a.". Widstrand¹²² too, claims that it is possible for a herd to double its size in five years. However, this is not probable seen purely in terms of biological reproduction under stable conditions: we have seen that the minimum number of years under optimal conditions would be 6 1/2. Similar doubts can be ascribed to Prole's¹²³ estimate that pastoral cattle herds may increase 8-32 % annually depending on the rains, "without counting sales, deaths and internal consumption". Even with due regard to these reductions we find that the higher percentage in this range is somewhat optimistic.

Table 2.8 summarizes the information on how many years it takes for a female herd to double its size. As already mentioned, it takes an equivalent period of time for the corresponding total herds of cattle to double their size. This table has been compiled to facilitate comparisons between the authors referred to. However, from a pastoralist point of view the growth rate of the number of milking animals would be of greater interest. As a result Table 2.8 also includes the number of years necessary for the fertile cows to double their numbers in the different examples.

Growth of individual herds is, of course, the result not only of reproduction within the herds but also of the redistribution of cattle between households. This aspect is outside the scope of the simulation of biological growth and will be referred to later in Chapter 7. It would be very difficult to include redistribution in the present model, as it is related to particular herd sizes, to differences in herd sizes, and to the number of members in household units.

The net biological reproduction of pastoral cattle herds account for the real economic increases within an area; the circulation of cattle results in the redistribution of wealth. Seen in this light, wherever the domestic herds form the means of production, the herds of a whole region may well be regarded as one large reproducing herd. From the individual pastoralist's point of view this is correct so far as that he must have potential access to cattle in his social space (network of contacts) in case his household is struck by disaster; if the total number of heads in a large area diminish there will be no cattle for circulation. When it comes to his own particular herd, or subherds, it cannot be judged as a totally independent unit which grows in isolation from other herds. Redistribution becomes relevant, even if temporary, as having access to a particular domestic animal normally implies the right to its products; see Chapters 5 and 7. Food production from cattle herds in terms of milk, meat and blood will be discussed in Chapter 5.

In the model the sex ratio at birth has been defined as 1:1. In real herds

TABLE 2.8: The number of years needed for the total female herds and the herds of fertile cows to be reduced to half the size (Example 1-2) or to double (Example 3-8)

	EXAMPLE NO							
	1	2	3	4	5	6	7	8
Total female herds	13	17	> 30	19 1/2	11 1/2	8	6 1/2	21 1/2
Fertile cows	14	18 1/2	> 30	21	15	10 1/2	9 1/2	24
Half the size			Double in size					

the male/female proportion among the offspring can sometimes differ from this. A fortunate cattle-owner could have a high proportion of female calves, thus increasing the growth rate and another may be hit by bad luck only getting bull calves. This adds to the necessity of redistribution of wealth between herdowners and increases the social and economic obligations and demands between individual pastoralists. Unusually lucky or skillful owners in terms of high growth increase will not be unnoticed in the local community. One example mentioned by Spencer¹²⁴ is Mr Kalasi, a Sam-buru, famous for the high increase rate of his herd, which was calculated by Spencer to have been 14 % annually.

2.5 ABSOLUTE GROWTH OPPORTUNITIES

So far the simulated examples have been deterministic. We have simulated a herd, it has been ascribed various parameters and its development over two generations has been observed. We shall now present a different approach.

When a boy among the Boran of northern Kenya or southern Ethiopia is born he is given a heifer. A hair-cutting and naming ceremony occurs when he is four years old and he is given yet another heifer. At the age of fifteen, when he is circumcised, he is given one more heifer. This is a system found among several East African pastoral groups. Now, supposing that the boy wants to marry, how many heads of cattle are at his disposal as a result of these three animals?

When the problem is put in this way it is different from the previous examination of herd growth. There we had herds as the productive and reproductive units. Here, we want to present an example of how to build up a herd around a few individual heads of cattle, which can be described as a stochastic process dependent on whether the individual animals survive (which in turn depends on seasons, rains, grazing, management, etc)¹²⁵.

Here the problem is outlined fairly briefly and we assume that each of the three heifers is just about to experience her first heat. The possibility of a disaster is disregarded for the moment.

Using different fertility rates for the cows, two different examples have been constructed. The herd is generated by adopting the following rules:

1. A cow will either produce calves during a 4-9 year interval or a 4-10 year interval. The latter fecundity interval can be considered normal while the former indicates low fertility; see 2.2.2. The possibility of a cow still reproducing after ten years of age is not taken into account.
2. Every fifth female calf is assumed to die within its first year while no other female cattle die until after the end of their fertility period. This is a very rough approximation of existing mortality rates; see 2.2.3. As older cows do not, in our model, contribute to the growth of the herd, their death rates after the fertile period is less relevant. In this case we assume that the principle that no cows give birth after nine or ten years of age equalizes the effect of killing off too few before this age.

3. Each cow produces a female calf every three years and one male calf in between. Every other reproduction starts with the birth of a female calf. In this way the sex ratio between new-born calves remains 1:1. The assumed calving rate corresponds to a fecundity of roughly 75 %.
4. When a male calf is born first, a female is born the consecutive year for 50 % of the cases and one year later for the remainder of the cases. This is to approximate a calving interval of more than one year.
5. The number of males aged one year and over and the number of females of greater age than the fecundity interval are then ascribed to the model in typical proportions according to the discussion under Sections 2.2.1 and 2.2.4. Further, it is assumed that male cattle have been slaughtered so that females make up 60 % of the total herd (see Chapter 7).

Under the conditions assumed in the first example, the boy will own a total herd of 35 heads of cattle when he is 24 years old assuming the cows are fertile during five years. Out of his herd 14 are males and 21 females. The age distribution of the female cattle at different stages of the herd's development may be seen in Table 2.9. 10 cows are potential milk-producers. These fertile adult cows are many enough to cover the nutritional needs of the man and his wife given that half of them actually are in milk at a certain time, and that each produces at least 0.9 kg milk per day. We will go deeper into the question of the relation between cattle products and human nutrition in Chapter 7. Even if the herd can cover the needs of these two persons, it is not necessarily possible to establish an independent household at this stage. The notion of "independence" also has consequences for the minimum family size, as has been pointed out by Stenning¹²⁶. Even if the herd is big enough to cater for the family, the family may not be able to cater for the herd. The management aspects of herds will be discussed in Chapter 8.

TABLE 2.9: Building up a herd: age distribution of female cattle with a short calving period

Age interval (cattle)	Age of the owner (years)					
	4	8	12	16	20	24
0 - 1	0	0	0	2	1	4
1 - 2	0	1	0	1	4	2
2 - 3	1	1	3	1	1	4
3 - 4	1	1	0	2	2	1
4 - 5	0	0	0	1	2	1
5 - 6	0	0	1	0	1	4
6 - 7	1	1	1	3	1	1
7 - 8	0	1	1	0	2	2
8 - 9	0	0	0	0	1	2

If we now turn to the second example where an extended calving period up to ten years of age for the cows has been assumed, the situation changes dramatically. The boy would now own a total of 57 heads, applying the same rules as given previously. Out of these, 34 are females. The age distribution within the female group can be seen from Table 2.10:

TABLE 2.10: Building up a herd: age distribution of female cattle with a normal calving period

Age interval (cattle)	Age of the owner (years)					
	4	8	12	16	20	24
0 - 1	0	0	1	4	5	6
1 - 2	0	1	1	1	4	4
2 - 3	1	1	2	1	1	4
3 - 4	1	1	1	2	2	3
4 - 5	0	0	0	2	4	5
5 - 6	0	0	1	1	1	4
6 - 7	1	1	1	2	1	1
7 - 8	0	1	1	1	2	2
8 - 9	0	0	0	0	2	4
9 - 10	0	0	0	1	1	1

The twentyfourth year, the boy has access to 17 milch cows, and he may even be able to feed three or four persons on the produce from them.

In ethnographic accounts, "normal marriage age" is often referred to. Marriage ages and the time when new households become independent are important aspects of social structure. Anthropologists¹²⁷ have for example related the common polygyny of nomadic societies in East Africa to the delayed marriage age of young men who are needed for specialized defense and cattle-raiding functions. A delayed marriage age for one sex gives rise to unequal proportions of marriageable men and women and creates the opportunity and necessity for polygynic marriages. Other aspects of marriage age have not been considered to the same extent. It is clear that the average rate of resource increase in the form of herd growth, as illustrated in this chapter, must be of great relevance to the study of such topics. The implications of the neglect of these problems may be significant and it appears that this could be a line of inquiry to be pursued further.

From Tables 2.9 and 2.10 one can, finally, also appreciate the time it would take after a disaster, to multiply a herd of say 3 mature female animals and their calves by looking at the development after year 12. To build up a herd from small numbers is especially difficult if human food and animal fodder is scarce as this intensifies the competition for milk between calves and humans thereby raising the calf mortality.

FIGURE 2. 22: Building up a herd: number of female cattle

3. GROWTH IN CAMEL HERDS

3.1 A SURVEY OF THE LITERATURE ON CAMELS

3.1.1 Introduction

While cattle nomads have been observed to a certain extent there is very little information about camel nomads that can be used to estimate the normal rate of herd growth in the same way as for cattle in Chapter 2. The general opinion amongst the authors referred to, is that the growth rates of camel herds is low. Spencer¹, for example, makes a point of this when he contrasts the expansive economy of Samburu cattle nomads and the static society of the Rendille camel breeders in Kenya.

Camels may be used for many different purposes: as draught animals, pack animals, for riding and as milk producers. Here, as earlier, we are concerned with animals in a nomadic economy and in which human diet is primarily based on milk; and this study therefore concentrates on their most important function, that of milk-producers.

3.1.2 Sex ratios

The optimum sex ratio for the herds in a particular area depends upon the uses that camels are put to. In many nomadic groups most male calves are slaughtered.

Female camels provide milk and endure hardships better than male camels². The slaughtering of male calves may also leave more milk over for human consumption³. Asad⁴ estimates for the camels of the Kababish Arabs that one good average male can serve about thirty females. In exceptional cases one bull can serve fifty female camels. However, this rate for mature males is given as normal by Leese⁵ who states that a very well-kept bull camel should be able to serve seventy cows. This rate agrees well with the estimate made by Yasin and Wahid that one bull is needed per 50-80 female camels⁶.

According to Born⁷ the arabic camel nomads of eastern Sudan keep two bull camels per 40-100 females. Lewis⁸ states that each herd of 80-100 camels has at least one male. Asad⁹ indicates that three bulls per 150 female camels should be sufficient, especially since not all cows are on heat within the same period. Spencer¹⁰ is of the opinion that 60 % to 70 % of the total number of animals in the Rendille (Kenya) herds are female.

If male camels are kept for work purposes, they are castrated to improve handling, as for example by Somali camel owners. Female camels are never used by them for work purposes¹¹. The suitable age for the castration of young male camels is said to be between four and six¹².

3.1.3 Fertility

According to Musil¹³ and Spencer¹⁴ the female camel becomes mature in her sixth year. Other authors hold slightly different opinions. Sweet claims that in north Arabia they are used for breeding from when they are five years old.¹⁵ Williamson and Payne¹⁶ estimate that, for the tropics in general, female camels become fertile after four years. This is identical with the first mating age for Pakistani camels¹⁷ while Kalmyk camels raised in the Astrakhan province of the Soviet Union breed at three to four years.¹⁸

Four years is given by Mares¹⁹ as the first calving age for Somali camels. The same low age is claimed by Nicolaisen²⁰ for Tuareg camels.

The camel doe carries her calf in the womb for between 12 and 13 months²¹, the average being 370 days.²² There is not much dissention on this point; only Sweet²³ claims that 11 months is normal for the camels of north Arabia.

This refers to camels of the dromedary type, which are mainly used by pastoral nomads. A Soviet source, Blagoveščenski²⁴, gives the average gestation for dromedaries as 388 days (12.9 months) as compared with 406 days (13.5 months) for the two-humped Bactrian variety.

It would seem from Musil²⁵ that Bedouin female camels remain fertile at least until the age of twenty. After this the camel is old and no longer referred to by the term for middle-aged female camels. Similar information on the fertile lifespan of camels is provided by Williamson and Payne²⁶. Twenty is also regarded as the maximum age for the use of male working camels²⁷. Mares²⁸ relates that Somali camels breed till the age of twenty, being slaughtered afterwards for meat, and Lewis confirms that Somali camels are fertile for about fifteen years²⁹.

Yasin & Wahid³⁰ state that some Pakistani female camels can go on breeding until they are thirty years old. Nicolaisen's³¹ Tuareg informants indicated that the average natural end of the female camel's mating life was at 25 years of age, but recommended that cows older than twenty should be sold or killed.

With regard to calving frequency, most sources agree that camels give birth to one calf every other year"³². Spencer³³ states that Rendille female camels are said to give birth during their life to as many calves as Samburu cattle cows, i.e. between seven to ten. This would mean that they gave birth from the age of six to twenty or twentysix. The average indicated by Mares³⁴ is eight calves.

There is a biennial periodicity in calving due to the fact that male camels normally have one major "rutting" season of two to three months³⁵ each year. The reason for this periodicity is not known but a correlation between humidity and rutting seasons has been noted.³⁶ Other explanations are that rutting may be induced by the lengthening of the day³⁷ or on the availability of fodder³⁸. In some areas the bull camels are said to be unable to impregnate female camels without human help. In general, they become nervous and difficult to handle during the rutting season.

The peculiarities of camel mating make it possible to control breeding even under pastoral conditions. This is practised by, amongst others, Somali herdowners who breed for qualities such as colour or being a fast and easy drinker³⁹.

Regular biennial calving implies of course an annual calving rate of 50 % among the fertile camels. Even among ranched camels it is virtually impossible to achieve a much higher annual calving rate. On some Soviet ranches, however, Bactrian camels have reached a rate of 65 % per annum⁴⁰.

Conception usually taking place in the rainy season, the females will then give birth during the next rainy season, i.e. the mating and calving seasons coincide, but the female cannot be impregnated again until the next season, one year later. The calves normally drink part of their mother's milk during the whole of the next year⁴¹.

3.1.4 Mortality and age distribution

Information on mortality rates is very scarce. As far as can be ascertained, no author gives any estimates of mortality rates or even calf mortality rates. However, Sakuye herdsman in Kenya maintain that camel calves have a higher mortality rate than cattle calves. Williamson and Payne⁴² agree that many newborn camels are slow to acquire strength and that a considerable number of them die before they are three weeks old. Furthermore, the upper age limit is not given explicitly among the references, with the exception of Nicolaisen⁴³, who states that the average life span of Tuareg camels is thirty years according to the nomads themselves, and by Yasin & Wahid⁴⁴ who indicate that 20-30 years is normal but that individual Pakistani camels can live to be forty years old.

In the references cited there is no information on the age distribution of female camels in a herd. As no age based death-rates exists, an estimate would be very hard to make.

3.2 GROWTH MODELS FOR CAMELS

The information presented in Chapter 3.1 will be used here to simulate the growth of a herd of camels. As insufficient details about mortality rates have been found in the literature, two examples are given with differing survival probabilities based on "intelligent guesses".

The methodological assumptions are identical to those presented in Chapter 2.4. The evolution of the two camel herds is simulated over a period of fifty years in order to cover two generations. As with the cattle herd simulation, male camels are disregarded. It is taken for granted that a sufficient (small) number of bulls are available.

The female camels in the herd models start reproducing when they are in the age interval 6-7 years. They produce one calf every two years. Exactly half of these calves are females. According to the assumptions made in the model, a female camel produces her last calf in the age interval 20-21 years. This means that each of the female camels produces eight calves during its lifetime. These values are those given by Mares⁴³, and imply an annual calving rate of 0.25 female calves per fertile camel.

In areas where camels are mainly used for transportation, female camels are sterilized. It is unlikely that sterilization takes place in the herds of people with a milk staple diet. Some female camels may however be naturally sterile but as there is no information on the occurrence of sterility this factor is disregarded.

The survival probabilities assumed in the two examples are given in Figure 3.1. The high calf mortality rate (30 %) is based on the fact that camel calves are very vulnerable during their first year.

Those camels surviving their first year in Example 1 live until the age of 21 years and then die. This is a very rough approximation, in which the differences from the real-world situation are partially compensated by limiting the fertile age set to 21 years; the low upper age limit of fecundity thereby counteracts in part the absence of deaths in lower age-classes.

Though the Tuareg, for example, prefer that their camels do not reproduce after the age of 21; other sources indicate higher fertile ages; see 3.1.

In Example 2 the relatively short fertility period is kept unchanged while more realistic mortality figures are introduced; see Figure 3.1. This means that the annual growth rate is slower in Example 2 than in Example 1; 1.5 % compared with 7.5 %.

FIGURE 3.1: Survival probabilities for female camels according to Examples 1 and 2

Given that the proportion of male and old female camels is constant, and given that the fertile period is 6-21 years for female camels, one conclusion from Example 1 would be that the maximum annual growth rate in a camel herd is around 8 %.

The evolution of the herds given in the two examples is presented in Figures 2.2 - 2.5. The number of fertile, and potentially milkproducing, females doubles in 15 years in Example 1 and in well over 50 years in Example 2. The corresponding figures for the total female herd are 11 years and 51 years respectively.

The growth rates of camel herds have not been subject to as many speculations or careful calculations as those for cattle and the smaller types of livestock. Spencer⁴⁵ quotes the Rendille as saying that the growth in their herds is imperceptible, and hints that the Rendille area is not wholly suitable for camel breeding. A high mortality rate and a low fecundity rate both contribute to this static situation, which, however, need not necessarily be typical. Growth rates for herds in other areas have not been found.

FIGURE 3.2: The development of the model herd according to Example 1.
Numbers of female calves, heifers and fertile cows

FIGURE 3.3: Total number of female camels and annual growth rates in Example 1

FIGURE 3.4: The development of the model herd according to Example 2. Numbers of female calves, heifers and fertile cows

FIGURE 3.5: Total number of female camels and annual growth rates in Example 2

4. GROWTH IN FLOCKS OF SHEEP AND GOATS

4.1 A SURVEY OF THE LITERATURE ON SHEEP AND GOATS

4.1.1 Sex-ratios

The flocks of both sheep and goats are made up of predominantly female stock, as is the case with cattle and camels. The number of each sex at birth is roughly equal¹ with only a very slight tendency for male stock to out-number the females. In its study of sheep, for example, the Hunting Report gives 171 males to 163 females at birth². To take an example for goats, Wijeratne³ found no significant departure from a 1:1 sex ratio at birth for South Indian meat goats. Some polled and partly hornless goat breeds have a considerable proportion of hermaphrodites sometimes up to 10 %, which reduces the proportion of females⁴.

Sheep

The ram lambs are soon outnumbered by ewe lambs since most of the former are slaughtered at an early age. In western Sudan, for example, the Hunting Report (loc cit) states that insufficient grazing keeps lamb mortality in the nomadic flocks at a high level, and if male lambs are slaughtered, the survival chances for ewe lambs are improved. The Yomut of Iran keep a proportion of between 60 % to 90 % reproducing females in their flocks⁵. The Hunting Report estimates the number of female breeding animals as 56.8 % of the total sheep flocks of western Sudan⁶. Williamson and Payne⁷ give 1:60 as the general minimum rate of uncas-trated males to ewes. In the arid zones the ratio is higher, since the fer-tility of the rams is lowered by undernourishment⁸. 1:10 is a usual rate for Africa, and 1:20 is typical for Arabia. For the Basseri of southern Iran, Barth⁹ gives an even higher rate: one ram has to serve only five ewes. The Kababish in Sudan consider eight sires per 200 does as neces-sary (= a ratio of 1:12.5)¹⁰.

Somali sheepbreeders castrate all male lambs at five months of age, 2 % being retained for breeding purposes. A ram breeds until the age of five after which it is castrated and fattened¹¹.

Goats

For flocks in the western Sudan the Hunting Report noted an almost total absence of male goats above fifteen months of age, while almost one quarter of the flocks were made up of male kids¹².

Fertile females made up 49.8 % of the flocks. This early slaughter of male goat kids can be explained by the need to provide increased grazing opportunities when grazing becomes scarce, and also by the fact that young animals provide the best goat meat¹³.

Bucks are considered to have a much higher breeding capacity than rams¹⁴. Reaching sexual maturity at six months of age¹⁵ they can tup up to 100 she-goats per year under favourable circumstances¹⁶. The buck/she-goat ratio reported for the flocks of goats belonging to the Kababish Arabs is 1:30¹⁷. Those not used for breeding are often castrated which results in an increase in the quality of the meat¹⁸. The Yomut Turkmen, for example, are said to castrate the majority of their male flocks of small stock, in order to sell them after they have reached maturity¹⁹. Castration of young buck kids are also made by Somali herdsmen²⁰. However, very little data on the castration of nomadic sheep and goats has been found.

4.1.2 Fertility

Sheep

According to Williamson and Payne the first oestrus should occur for an ewe when it is one year old²¹. Ward²², who over several years has studied one controlled farm flock in Rhodesia (Zimbabwe), calculated on average first lambing age for ewes of 464 ± 90 days. Sacker and Trail²³ in a simi-

lar study of a flock in Uganda gave an average age for first lambing of 531.8 ± 8.1 days. The latter flock were East African Blackheaded sheep while Ward refers to Rhodesian "indigenous ewes". With a gestation period of around 150 days the time for the first oestrus in the Uganda herd would occur at around 380 days of age, which is well in accordance with the approximate general average age according to Williamson and Payne. For nomadic flocks in western Sudan, the Hunting Report shows that many sheep reached sexual maturity in advance of one year's age²⁴ and assumed as a working hypothesis in the study that all ewes older than fifteen months, and half of the animals between six and fifteen months old, were breeding²⁵. Irons²⁶ states that the sheep of the Yomut Turkmen of Iran are mature at two years of age.

For some species, like the fat-tailed variants, breeding may be difficult, and the tupping ram has to be assisted by humans²⁷. High air temperature may influence the successfulness of conception²⁸. When successful, the gestation period will last 140-160 days. This seems to be the general average. Asad, however, states that the length of pregnancy in the flocks of the Kababish Arabs in Sudan is six months for sheep as well as goats²⁹ while Spencer gives four months for the Samburu flocks.³⁰

After lambing, the heat re-occurs normally after forty days and this is then repeated every 15-19th day³¹. The minimum interval between lambings would thus be 140-160 days plus 40 days. Sacker and Trail³² have an over-all mean lambing interval of 255 ± 2.3 days.

Ward³³ gives intervals ranging from 227 days to 288 days. The Hunting Report gives examples of ewes lambing within intervals of on average 275 days. The shortest interval observed by the Hunting Report is 159 days, which seems to be at the lower end of what is actually possible.

Among the sheep of western Sudan, as in other arid areas, conception usually tends to be related to periods of good grazing though it is often not possible to identify a clearly defined lambing season³⁴. In addition drought tends to reduce lambing rates³⁵. Sheep may give birth more than once a

year³⁶, a possibility that sometimes needs to be restricted. In Somalia, for example, where sheep breeding is carefully controlled, extremely good ewes are often kept from lambing more than once a year in order to restrict their mortality³⁷. Where sheep tend to mate seasonally within the same period they either mate twice a year (giving birth at each rainy season) or once a year, in contrast to the more continuous mating of goats.

The annual lambing rate given by the Hunting Report in its study of western Sudan is 1.5³⁸. This can be compared with 0.80 given by Demiriören as the lambing rate for Iranian sheep under extensive husbandry, and with 0.60 - 0.90 noted for Somali sheep³⁹.

The annual lambing rate is not only dependent on the number of births, but also on the incidence of twinning. In the Hunting Report the average litter size is 1.14⁴⁰. However, when grazing is scarce, one of the lambs will most often die soon after birth as few ewes can support two lambs⁴¹. This is illustrated by the results presented by Purser and Young⁴² though, admittedly, for sheep in nontropical conditions. For Welsh Mountain and Blackface breeds mortality rates for twin lambs were shown to be 35-45 % higher than those for lambs born singly.

In the Hunting Report⁴³ the estimated expectancy of lambs per sheep is given as 4.7. This makes the expected limit of the fertile life period identical with the expected time for death at five years of age. Sacker and Trail⁴⁴ in their study of a flock in Uganda calculate that each ewe produces on average seven lambs until it is 5 1/2 years old. Ward⁴⁵ gives similar figures by assuming a five-year old ewe to have produced seven lambs in single births. Somali ewes breed until the age of eight or nine years⁴⁶.

Goats

Female goats can have their first heat at an age of only a few months. Six months is the lower age limit of fertility given by French⁴⁷. Williamson

and Payne⁴⁸ advise that animals should not be allowed to mate before the female goat is nine months old, and that it may even be necessary to wait until an age of up to 18 months depending on the season in which the female goat itself was born. The incidence of sexual maturity depends on nutrition and body growth and varies between different breeds. Many of the female goats in the western Sudan study seem to have conceived at roughly the age of ten months⁴⁹, while the female goats of the Yomut nomads in Iran are said to be mature at the age of two years⁵⁰.

Sacker and Trail⁵¹, in a study of female Mubende goats in East Africa, found that the average age for giving birth to kids was 567 ± 11.6 days. Wijeratne⁵² presents very similar figures (582 ± 13 days) for the south Indian meat goat. Epstein and Herz⁵³ give one year as the normal age for several breeds, but emphasize that poor grazing conditions may delay births until the female goats are two years old.

The gestation period for tropical goats generally lasts five months⁵⁴. However, as was the case with sheep, different figures are given for goats in the Kababish and Samburu flocks: in this case six and four months respectively⁵⁵.

Female goats are on heat for periods of three days at intervals of approximately twenty days⁵⁶. The minimum interval between births is therefore approximately 170 days. According to Sacker and Trail⁵⁷ the mean interval for the East African Mubende goats is 296.7 ± 8.5 days and thus well above the theoretical minimum. Wijeratne⁵⁸ gives an even longer average interval of 328 ± 8.5 days for the South Indian meat goats.

It is common that goats give birth either twice a year or three times in two years⁵⁹. The mating of nomadic goats is seldom restricted by human intervention in the same way as that for sheep. Somali allow their goats to breed freely⁶⁰, while the Tuareg seem to be an exception in that they restrict both animals⁶¹.

As goats are less dependent on grazing, their reproduction is not as sea-

sonal as that for sheep. Spencer, however, states that goats give birth mainly during the dry season, producing milk at a time when cows' milk is scarce⁶². In the western Sudan the Hunting study notes that births take place at all times of the year, with an average of 238 days between births. A graph in the Report clearly shows a drop in the number of births towards the end of the dry season and a rise in births during the wet season and the beginning of the dry period. Strangely enough, the authors of the Report found no significant fluctuations between months when the data was given a chi²-test⁶³.

The kidding rate is more influenced by the number of twin or triple births than is the case with lambs and such births are common to many breeds of goats. Occasionally up to six kids can be born⁶⁴. Mason and Maule⁶⁵ estimate the incidence of multiple births in East Africa to be 5 to 10 %, although higher frequencies (10-15 %) have been recorded in Tanzania. Sacker and Trail⁶⁶ estimate, however, that for Mubende goats 30 % are twin births and 1.7 % births of triplets.

According to Shanmugasundaram⁶⁷, as many as 50 % of the births of Malabar goats in India are twin births while 8 % are births with three or more. The Hunting Report found similar rates in western Sudan, where 52 % were multiple births. The average number of kids per birth was 1.57⁶⁸ and the overall annual kidding rate 208 %⁶⁹. Epstein and Herz⁷⁰ give an overall average number of 1.59 kids per birth for several breeds with a lowest figure of 1.27 (Appenzeller) and a highest of 1.90 (Saanen). For south Indian goats Wijeratne's study⁷¹ shows a litter size of 1.2 which is similar to the minimum figure for the breeds studied by Epstein and Herz.

Williamson and Payne⁷² regard 1.8 as a normal average litter size for tropical breeds, although certain breeds like the Nubian, very rarely give birth to more than one kid per year.

According to the Hunting Report, in the western Sudan the number of kids that can be expected to be born during a female goat's life is 7 to 8 births taking place until death at 5 1/2 to 6 years of age⁷³. Equivalent figures for

the East African Mubende goats studied by Sacker and Trail⁷⁴ are lower; a female is expected to produce six kids during its 0-5.6 years. The figures given by Irons for the fertile lifespan of Yomut flocks (including both sheep and goats) indicate that an increase in the number of kids may be possible on the assumption that kidding intervals are the same. Spencer notes that many Samburu female goats desert their kids in the bush after four births⁷⁵.

4.1.3 Mortality and age structure

The life expectancies of sheep and goats, given in the Hunting Report for western Sudan, have been referred to above in connection with the period when they cease to be fertile. Five years is a common maximum age for sheep and 5 1/2 to 6 for goats. Other sources indicate greater life expectancies.

For example although East African Blackhead sheep can, at least under favourable conditions⁷⁶, attain 5 1/2 - 6 years of age, Somali sheep even reach an age of eight or nine years⁷⁷. Ranches Karakul ewes in South-west Africa are sold and slaughtered at seven years, according to Ruthenberg, while "the traditional practice is to keep ewes as long as they bear lambs, which in effect means until they die of old age"⁷⁸. Williamson and Payne consider ranches arid-area ewes in Australia as old at the age of seven to eight or above⁷⁹. Such old animals are particularly susceptible to drought. In the latter two cases the animals concerned are ewes for wool. The Yomut Turkmen are said to allow their ewes and female goats to breed for a period of seven to nine years after maturity at two years of age⁸⁰ which implies a maximum age of at least nine to eleven years. At the end of this period they are fattened for sale. The information given by Sacker and Trail indicates that goats may live until the age of 5.6 years; see 4.1.2, and French⁸¹ estimates the life expectancy of a goat to 8-10 years. Apart from these figures and the data in the Hunting Report, little specific information is available.

In an FAO-report⁸² the lamb mortality rate is estimated to be 8-60 % under extensive systems, but this figure says very little about normal conditions.

The Hunting Report gives an overall lamb mortality rate of 30.5 % for lambs under six months amongst sedentary and migratory herds in western Sudan. Animals for sale or slaughtered for emergency reasons are not included in this rate. As mentioned previously the rate is higher for twin-born than for single-born animals⁸³. The Sudan data can be compared with Ward's study of indigenous ewes raised in Rhodesia (Zimbabwe) where 17.9 % of the new-born lambs died before the age of four months⁸⁴. French⁸⁵ found that 26.5 % of the lambs died before the age of seven months in a herd consisting of Ugogo, Maasai and Blackheaded Persian Sheep. The first-born lambs in Ward's study showed a higher mortality rate than the remainder (*loc cit*).

As regards goats Sacker and Trail⁸⁶ also differentiate between first-born kids and others, and give considerable variations in mortality rates; 45.3 % and 18.8 % respectively. They also give higher mortality rates for twin births than for single births. The mortality rate for twins from second and subsequent kiddings is 36.1 %. The kid mortality rate during the first six months in western Sudan is 29.54 %⁸⁷. A similar figure is given by Wijeratne⁸⁸ for South Indian meat goats which have a kid mortality rate of 26.8 % (until weaning). Hee, too, gives higher mortality rates for multiple births (*loc cit*). On the basis of Irons⁸⁹ the death rate among Iranian lambs and kids during their first year can be estimated to be 40 % to 70 % assuming that the females mate only once a year, and give birth to only one offspring at a time; under other conditions the figures will be even higher.

Death rates for older animals are lacking and those that are available do not differentiate between animals that are slaughtered and those that die from disease or consistently between lambs or kids and mature animals, between sexes, or between migratory and sedentary herds.

4.1.4 Age distribution

Information about age distribution is also scarce as there are no suitable ways of discerning the ages of sheep and goats after the last teeth have appeared (up to roughly 32 months). This implies that a survey should continue during a whole life-span in order to obtain this information.

In western Sudan the Hunting Report⁹⁰ gives data for the first 15 months which may be summarized as follows:

TABLE 4.1: Age structure for male and female sheep and goats in western Sudan (both migratory and sedentary flocks) (according to the Hunting Report 1974)

age interval	male sheep	female sheep	Total	male goats	female goats	Total
0 - 6 m	8.8	13.4		14.8	18.5	
6 - 15 m	9.2	15.3		7.2	16.1	
> 15 m	4.2	49.1		1.6	41.8	
Total	22.2	77.8	100.0	23.6	76.4	100.0

From the above table it can be seen that 63 % of the ewes were above 15 months and that 55 % of the female goats were above 15 months.

4.2 GROWTH MODELS FOR FLOCKS OF SHEEP AND GOATS

In this section a few growth models for sheep and goats will be presented. The examples will basically match conditions given in the Hunting Report. The same simulation model as for cattle and camels has been used with the following modifications; the age-classes span over six months instead of one year and the fertile periods and upper age limits have been altered to agree with the information available for sheep and goats.

4.2.1 Example 1. Typical growth of sheep flocks

The first example concerns sheep. The time of first birth varies according to which season the animal is born in, whether mating is planned or allowed to occur spontaneously, and how rapidly the animals mature. Even though in practice the physiological age, which is related to the weight of the animal, may be a better indicator of maturity than the biological age, for practical reasons the biological age is used here.

Two different first lambing ages have been used. In Example 1a the ewes are assumed to start breeding fully at the age of 6-12 months, and in Example 1b half a year later, i.e. in the interval 12-18 months. The first births occur in the age intervals 12-18 and 18-24 months respectively.

The upper end of the lambing period is equated with death. It is also assumed that 30 % of the lambs die within the first six months (i.e. at the end of the first interval). This lamb mortality corresponds to the one found in the flocks studied in the Hunting Report. It is regarded as an average figure and applied to all lambs. In this way no differentiation is made between first-born lambs and those born by ewes who have given birth previously in spite of the fact that mortality is lower for the latter category; see 4.1.3.

All remaining sheep live until their fifth birthday whereupon they die. As no information has been found on the mortality rates for higher ages, a proper estimate of the original age structure has not been made. Instead, the flock starts with 14.3 lambs and 90 animals of older ages, distributed evenly between the different adult age-classes. This causes some temporary disturbances at the beginning of the development of the model flocks until the age distribution has stabilised.

The lambing rate is 1.5 lambs per breeding ewe and year. The half-year rate is approximated to 0.75, of which half are female lambs, i.e. there is a female lambing rate of 0.375. At this rate, each ewe will produce 5.3 to 6 lambs during its lifetime. This is higher than the number of lambs per

ewe according to the Hunting Report, which is 4.7, but lower than the figure of 7 lambs per ewe given by Sacker and Trail, see 4.1.2.

The growth in the total number of female sheep is given in Figure 4.5. As the only difference between Examples 1a and 1b is the time of the first birth it can be immediately concluded that this is very important for flock growth.

Figures 4.1 and 4.3 show the growth in the flocks over a period of fifteen years for female lambs, with young ewes having not yet given birth and fertile ewes having already given birth. The stabilized age structures after the initial variations are given in Table 4.2:

TABLE 4.2: Age structures for the flocks of sheep in Example 1

Category	Example 1a	Example 1b
Female lambs	13 %	20 %
Young ewes not yet having given birth	22 %	24 %
Ewes having given birth	65 %	56 %

The growth of the total female flocks and the half-yearly growth rates are given in Figures 4.2 and 4.4. Example 1a with the lower first birth age shows an annual growth rate of 26 % after growth has stabilized and for Example 1b the annual growth rate is 18 %⁹¹. These growth rates are also valid for the total flock of sheep, males included, if the proportion males/females is kept equal over time.

For Example 1a a two fold increase in the number of breeding ewes is achieved after 4.5 years, doubling again after 3 years. For Example 1b, with the higher first lambing age the number of fertile ewes doubles after 5 years and then doubles again in 4.5 years. If one looks instead at the growth of the total flocks, Example 1a doubles after three years and again after another three years. The corresponding number of years for Example 1b are 4 and 4.5 years.

FIGURE 4.1: The growth of a flock of sheep aged 0-6, 6-12 and over 12 months, Example 1a

FIGURE 4.2: The number of female sheep and six-month growth rates, Example 1a

FIGURE 4.3: The growth of a flock of sheep aged 0-6, 6-18 and over 18 months, Example 1b

FIGURE 4.4: The number of female sheep and six-month growth rates, Example 1b

FIGURE 4.5: The total number of females in Example 1a and 1b

4.2.2 Example 2. Typical growth of goat flocks

Example 2 can be regarded as being concerned with goats in, for example, western Sudan. The characteristics that are here considered typical for goats may, however, also apply to sheep of other breeds or under different ecological conditions than those of western Sudan who provide the basis for our sheep calculations. The characteristics of goats or sheep vary much between different breeds.

Examples 2a and 2b have the same differences as the two examples in 4.2.1 above; that is, in Example 2a the female goats are assumed to be breeding in the age interval 6-12 months, while in Example 2b first breeding occurs half a year later. This means that first births appear in the age interval 12-18 months for Example 2a and 18-24 months for Example 2b. The total birth rate compared with Example 1 has been increased to 2.0 kids per year and female goat, giving 0.5 female kids born per female goat per half-year. This high rate is intended to compensate for multiple births; see 4.1.2. The lifespan of goats in Example 2 has also been extended by one year compared with the sheep in Example 1. This means that each female goat is expected to give birth to between nine to ten kids during its life-time and die when she reaches her sixth birthday. The number of kids per female goat is thus higher than that given in the Hunting Report (seven to eight kids), and the number given in Sacker and Trail (six kids), see 4.1.2. The reason for the large number of kids per female goat is that the goats in the model are given a long fertile lifespan as a result of the low adult mortality assumed in both examples, and the early maturity of the female goats assumed in Example 2a.

It may well be that Examples 2a and 2b approach the maximum practical level of reproduction efficiency for animals under pastoral conditions. The theoretical maximum should also take into account the possibility of two multiple births per annum but the resulting rates would only be of very limited relevance for pastoral nomadism, even assuming the most favourable conditions.

In the model 30 % of the kids die during their first half-year. As in 4.2.1 this is treated as an average kid mortality rate thereby disregarding variations depending on whether a kid is first-born or not. The goats that survive the first six months are considered to live until they die of six years of age.

Figures 4.6 and 4.8 show for the two examples the growth over a fifteen year period in the number of female kids, female goats that have not yet given birth and female goats that have given birth. The stabilized age structures after the initial variations, are given in Table 4.3:

TABLE 4.3: Age structures in the flocks of goats in Example 2

Category	Example 2a	Example 2b	Example 2c
Female kids	15 %	23 %	15 %
Female goats not yet having given birth	25 %	25 %	26 %
Female goats having given birth	60 %	52 %	59 %

Figures 4.7 and 4.9 present the growth of the total flocks of female goats over a fifteen year period and with six-month growth rates. The annual growth rate in Example 2a is 41 % and in Example 2b 33 %⁹².

In Example 2a the fertile flock increases to double the size after somewhat less than three years, then again after two years. In Example 2b it takes 3 1/2 years to double the size of the flock and two years to double it in size again.

Note that the growth rates can also be taken as the probable growth rate of the total herd, if the proportion of males/females is kept equal over time.

All goats that survive six months live until the age of six years. This is also the maximum age given in the Hunting Report.

FIGURE 4.6: The growth of a flock of goats aged 0-6, 6-12 and over 12 months, Example 2a

FIGURE 4.7: The number of female goats and six-month growth rates, Example 2a

FIGURE 4.8: The growth of a flock of goats aged 0-6, 6-18 and over 18 months, Example 2b

FIGURE 4.9: The number of female goats and six-month growth rates, Example 2b

To give an example of the effects that changes to mortality rates will have, Example 2c introduces an assumed mortality structure (see Figure 4.10) and begins with the same number of goats as in Example 2a. The age-based mortality rates that are introduced correspond in the long run to a yearly overall flock mortality of 25 %. The same fertility rates as in Example 2a have been used and the period of births starts at the same early age.

The results of this mortality rate on the growth of a flock of goats is shown in Figures 2.11 and 2.12. Growth, of course, becomes slower, with an annual growth rate of 31 %, to be compared with 41 % in Example 2a.

This mortality rate for mature goats results in the growth rate becoming similar to that of Example 2b. The age structure, however, remains similar to Example 2a with a higher degree of mature female goats. This is due to the shift in fertile age-classes between the examples.

The number of milk-producing female goats doubles after four years and then again after somewhat more than two years, and the total female flock doubles after three years and again after 2 1/4 years.

FIGURE 4.10: The distribution of survival probabilities for the flocks of sheep and goats in Example 2c

FIGURE 4.11: The growth of a flock of goats aged 0-6, 6-12 and over 6 months, Example 2c

FIGURE 4.12: The number of female goats and six-month growth rates, Example 2c

4.2.3 Example 3. Flock growth of animals with longer life expectancies

The last example is of a slightly different nature than Examples 1 and 2. It is wholly based on Irons' data for the Yomut of Iran. As seen in Sections 4.1.2 and 4.1.3 above, this data varies considerably from what is stated elsewhere about goats and sheep in pastoral economies. The two kinds of animals are here treated together. Firstly, we know neither their birth-rates, nor the exact kid and lamb mortality rates. Secondly, the surviving number of young yearling animals is stated to be 30 % to 60 % of the total number of fertile females⁹³. Irons states that "the proportions of fertile females in a herd which can be expected to reproduce in a particular year varies from 60 % to 90 %". This is not a proper kid birth rate as we do not know the number of births per ewe and year, nor the incidence of twinning. It can, though, be compared to the figure given by Demirüren. If Demirüren's⁹⁴ information, that the lambing rate of Iranian sheep is 80 %, can be applied to all Iranian sheep and goats, Irons' statement would imply a lamb and kid mortality rate ranging from 25 % to 62 %. Demirüren's figure for lambing rates in Iran deals only with sheep. The Yomut flocks, however, also include goats which most probably show a higher birth rate than 80 %. The total birth rate for kids and lambs in a mixed flock would then also be higher than 80 %. This would raise the mortality rates even higher in order to make the number of yearlings agree with the data from Irons. Assuming that the birth rate is 60 % the possible mortality rate ranges from 0 % to 50 %.

The yearling survival rates makes it possible to calculate growth rates for the female herd, even though the birth rates for lambs and kids as well as the mortality rates for newborn animals are not known. It must be noted, however, that we do not know the number of lambs or sheep born nor the possible offtake at this age for meat to be sold in the market or eaten at home.

The percentages mentioned above are used in two examples, 3a with 30 %

surviving female yearlings and 3b with 0.15 surviving female yearlings per adult female animal and year. The absolute death limit is ten years; and all animals are assumed to survive until this age.

The results are given in Tables 4.4 and 4.5 and in Figure 4.6, where it is assumed that newborn lambs and kids always form the same proportion of the female herd.

TABLE 4.4: Size of the female flocks in Example 3

Example	Year 0	Year 4	Year 9	Year 14	Year 19
3a	90.0 (1+x)	132.0 (1+x)	270.1 (1+x)	551.5 (1+x)	1151.1 (1+x)
3b	90.0 (1+y)	96.0 (1+y)	110.6 (1+y)	130.2 (1+y)	152.1 (1+y)

TABLE 4.5: Annual increase in total number of female animals year 8-9 and 18-19 in the flocks of sheep and goats in Example 3

Example	Year 8	Year 9	Year 18	Year 19
3a	231.1 (1+x)	270.1 (1+x)	980.0 (1+x)	1131.1 (1+x)
	+16.8 %		+15.4 %	
3b	107.0 (1+y)	110.6 (1+y)	148.0 (1+y)	152.1 (1+y)
	+3.6 %		+4.1 %	

The factors x and y in both tables refer to the unknown number of new-born female animals.

Allowing for losses, the yearly annual increase in the female flock is thus 15.4 % or 4.1 % in the two examples. Irons states that "this - i.e. the 30 % to 60 % yearling percentages - allows an annual increase in the female proportion of the herd ranging between 15 % and 30 %". Obviously, the author

FIGURE 4.13: Number of fertile females in the flocks of sheep and goats, Examples 3a and 3b

has arrived at this increase rate by just dividing the "survival yearlings"-rate by 2, assuming an equal number of surviving males and females. Such a fifty-fifty sex ratio one year after birth is unlikely (see 4.1.1), as all evidence from other parts of the world indicates a very clear dominance of female animals.

The longlived sheep and goats of the Yomut could have a very high rate of increase in their flocks if the birth rates for lambs and kids were the same as in Example 1 or 2. If the increase is that large, the information is not, however, consistent.

In the model flock in Example 3, the mortality rate is very low as no animals except the newborn die before they are ten years old. This is probably an over-estimation of the real lifespan. If we lower the mortality rate to a more realistic one, the rate of increase given by Irons will be even more unlikely. Furthermore, the figure arrived at, which Irons calls

"increase", is actually the yearly input in the flock, losses of animals not being accounted for. By not calculating the net increase his claims for a very large potential for increase of the Yomut flocks is based on false assumptions.

4.2.4 Conclusions

The literature gives few indications of the rate of growth amongst sheep and goats, although it is generally agreed that it is much higher than the growth rate for cattle. Spencer, for example, states that the sheep and goats of the Samburu have a growth rate that is four times that of cattle⁹⁵. There are many ethnographic examples of people regarding small stock as "small change" that can be disposed of rather easily, carrying much less ritual and social value than cattle.

Brémaud and Pagot give a growth rate of 28 % to 35 % for Sahelian sheep flocks⁹⁶. This estimate of annual growth is higher than that arrived at in Example 1 (26 % and 18 %). It should, however, be remembered that the figures in our examples represent favourable growth conditions. If lower survival rates are used, a reduced growth rate similar to the simulated growth of a flock of goats in Example 2c may be obtained. The annual growth rates for the different cases are summarized in Table 4.6:

TABLE 4.6: Annual growth rates for the model flocks

Characteristics	Example 1 (sheep)	Example 2 (goats)
Early first heat (a)	26 %	41 %
Late first heat (b)	18 %	33 %
Early first heat and assumed mortality rates for mature animals (c)	-	31 %

Goats reproduce faster than sheep but it is unlikely that they would reproduce faster than 40 % per year, at least under East African conditions, as can be seen from Examples 2a and 2c.

The time of first birth influences the percentage of adult and milk-producing animals in the flocks. From Table 4.3 can be seen that the difference can be around 8 % of the total female flock. Such a difference is of direct relevance for a pastoral economy as milk production from sheep and goats often is important as well; see Chapter 7.

The last example, 3, was introduced not to illustrate another possible growth rate but to show how important it is that rates are clearly defined if they are to be of any value at all. Few societies are so limited in their forms by ecology as nomadic societies and for the understanding of growth and expansion, as well as for the understanding of the mechanisms behind impoverishment and social change, it is certainly important to know such issues as those discussed presently.

5. LONG TERM EFFECTS OF DISASTER TO PASTORAL HERDS

The domestic herds of nomadic peoples can be hit by droughts or epidemics. Precautions against such risks are taken by spreading the animals into different areas and ecological zones, by customs of coherding and by the sharing of risks through systems of gifts and exchanges. The present discussion will concern the opportunities for a herd (or a cluster of herds) to recover from a drastic reduction in numbers independently from other herds. The purpose of this discussion is to make a general statement about the long-term effects of such a reduction in the herds, as well as to make a rough estimate of the effects of actual droughts.

The method presented here is intended to be of practical use when analysing the long time effects of such disasters, when pastoralists' redistribution systems prove inadequate for the survival of individual household economies.

When analysing the long term effect of a disaster in a pastoral herd, we shall concentrate our attention on cattle. Small stock are kept mostly as a supplementary source of meat and milk and are of secondary importance in the present analysis¹. The empirical data on camels is so scarce at present that a disaster to camel herds can only be simulated as a matter of illustration.

Chapter 2.2 has extensively discussed the demographic data necessary for the analysis of herd growth. The analysis in Chapter 2.3 describes growth under normal as well as extremely good and extremely poor conditions. When a major disaster occurs, however, the methods of gathering stock census data prove completely insufficient. One is often left with rough overall estimates of death rates but no information on changes in the age structure or the calving rates.

This lack of information has also been noted by R and N Dyson-Hudson in connection with the Sahel drought: "There has been a very large reduction

in livestock numbers, and the herds must be rebuilt, if the grazing resources of the Sahelian region are to be used. However, we had only limited knowledge of the structure of those herds and the numbers and distribution before the calamity came, and while reports emphasize the tremendous loss in numbers of livestock, we have no accurate information about the structure of the Sahelian herds that remain. We know neither the point we are starting from in attempting to build up livestock resources, nor the point that must be reached to re-establish herds sufficient for the survival of the people depending on these herds." ²

A distinction must be made between local and regional disasters. In a local and limited disaster, a household's required subsistence incomes can be maintained by means of the redistribution of cattle between the household's own herds spread over different localities, the activation of stock friendship links or through cattle raiding. In a major, regional, disaster all households may be hit, so that the total social space of a family (consisting of related or acquainted households) is emptied of milk cattle, and no redistribution can occur. The following analysis concerns just such a major disaster.

The drought in northern Kenya 1973-1974 caused predominantly calves and old cattle to die. A similar observation was made by Prole among the Maasai in 1960-1961³. He also noted that as soon as the rains came, the surviving cows produced a calf quickly so that nearly 100 % had calved a year later⁴.

In serious catastrophies like this drought or the Sahel disaster around 1970-1973, a majority of the cattle die. In the case of the Maasai drought, it has been estimated that as many as 80 % died⁵, and there is every reason to assume similar figures for the great Sahel drought. In an official Ethiopian report on the drought in the southern part of the country, which culminated around 1973, 88 % of the preceeding year's cattle herds and 69 % of the camel herds are said to have died⁶. Bondestam⁷ gives a vivid example of the effects of the Ethiopian drought, by quoting a desperate

man in Gashamu town, Ogaden: "Before I had 50 cows, 100 camels and 400 sheep and goats. Now I have only 18 cows and three-fourths of my camels, sheep and goats have died. Next week I will have only 5 cows. Before I was fairly well off. In two or three weeks time I will own nothing but my house and clothes."

Also sheep and goat populations are subject to heavy reductions under drought conditions. Droughts reducing the sheep and goat population to half its size are likely to occur at least once every decade in the Near East⁸. Dumont⁹ refers to the drought of 1920 in Algeria, when more than half of the small stock died.

Epidemics can also kill off a large percentage of the animals. McKay mentions from his time as Veterinary Officer in Charge at Garissa in northern Kenya that rinderpest one year killed 60 % of the Somali cattle¹⁰. Peck reported a severe outbreak of rinderpest in Somalia in 1924, where 73 % out of 1 200 quarantined head died¹¹.

To illustrate the general demographic effect of a large-scale drought, a disaster has been simulated on the most typical of the cases presented in Chapter 2.4, i.e. Example 8, after thirty years of development, when the female cattle are distributed according to the age classes in Table 5.1:

TABLE 5.1: Age distribution of the female cattle herd exposed to disaster

Age interval	% of total female herd
0 - 1	16
1 - 4	33
4 - 11	47
11 - 14	4
	100

The catastrophe is simulated by ascribing very high mortality rates during

a limited period and by varying the calving rates. The disaster is primarily imagined as a drought but most conclusions would also be valid for the effect of a major epidemic. The mortality rates are set to 90% for calves, 40% for heifers and 60% for adult cows until the age of eight years. 90% mortality is ascribed to cows above the age of eight years, i.e. also to some cows that are still fertile as the fertility interval reaches eleven years; see Chapter 2.4.2.7. This is equivalent to an average total mortality among the female herd of about 65%.

Calving rates are set to zero during the disaster in accordance with e.g. Prole's¹² observations 1960-1961 during the drought among the Maasai in Kenya and Tanzania. When the rains come, the surviving cows rapidly become pregnant¹³ and in our model the calving rate is set high for a year, 90%. After one year the calving rate returns to normal where it remains.

As the model employed ascribes calving rates and mortalities to one-year age classes at a time when the animals pass on to the following age class, the beginning and end of the induced drought in relation to the time axis of the model is important; see Figure 5.1.

Two examples are given, one for a short drought of two years and one for a three-year period. The droughts begin half a year before year 0 in the simulation and end between the years 1 and 2 in the first example and a year later in the second, see Figure 5.1. The growth of cattle herds over longer period of time are given in Figures 5.2 - 5.6.

Similar conditions are introduced to the simulated camel herd in Chapter 3.2, Example 2, after a fifty year growth period. The age distribution is given in Table 5.2:

TABLE 5.2: Age distribution of the female camel herd exposed to disaster

Age interval	% of total female herd
0 - 1	13
1 - 6	33
6 - 26	54
	100

FIGURE 5.1: The time span of a simulated drought and its basic relation to the simulation model used

It is assumed that 90 % of the female camel calves die, 40 % of the animals of 1-6 years of age and 80 % of the camel dams and old animals. This is equivalent to an average total mortality of about 60 % among the female herd. The proportions accord with the scarce material available on the over-all mortality rates. The high percentage for calves takes into account that new-born camels are very vulnerable.

A preliminary attempt to describe the long term development of the camel herds under these conditions is given in Figures 5.7 - 5.11.

Two effects of the disasters on cattle herds deserve attention. First, of course, the great reduction in number of heads and the slow regrowth. The more severe drought has the effect that not until ten years after the beginning of the drought does the growth rate for the total female herd catch up with the normal growth rate. This long term effect is supplemented by a second long-term effect expressed in fluctuations in the number of animals and in the yearly growth rates. These fluctuations, can be of considerable magnitude and are referred to in the mathematics of demography as the law of Eilert Sundt.

In Figure 5.2 the number of calves drops to zero at years 1 and 2 due to the drought. The first year after the end of the drought they show a large increase because of high calving rates among the surviving fertile cattle (year 3).

The number of heifers decreases during the drought due to high mortalities, the absence of newborn calves (to be recruited as heifers one year after birth) and the fact that old surviving heifers move into the category of fertile cows at the age of four years. They reach a minimum at year 3, i.e. one year after the end of the drought. In year 4 the heifers pick up in number as new calves were born in year 3.

The number of fertile cows drops at year 1 due to high mortalities during the drought. The following two years they increase again as surviving heifers gradually become fertile cows. The absence of new-born calves during

FIGURE 5.2: The effects of a two-year drought on the number of calves, heifers and fertile cows in a herd of cattle

FIGURE 5.3: The effects of a two-year drought on the total number of female animals in a herd of cattle and annual growth rates

FIGURE 5.4: The effects of a three-year drought on the number of calves, heifers and fertile cows in a herd of cattle

FIGURE 5.5: The effects of a three-year drought on the total number of female animals in a herd of cattle and annual growth rates

FIGURE 5. 6: Total number of females remaining in a herd of cattle after a two-year and a three-year drought

FIGURE 5.7: The effects of a two-year drought on the number of calves, heifers and fertile dams in a herd of camels

FIGURE 5.8: The effects of a two-year drought on the total number of female animals in a herd of camels and annual growth rates

FIGURE 5.9: The effects of a three-year drought on the number of calves, heifers and fertile dams in a herd of camels

FIGURE 5.10: The effects of a three-year drought on the total number of female animals in a herd of camels and annual growth rate

FIGURE 5.11: Total number of females remaining in a herd of camels after a two-year and a three-year drought

the first two years is then reflected in a decrease in the number of heifers in years 1, 2 and 3, and the number of mature cows decreases in years 4, 5 and 6.

Afterwards calves produced after the drought, and which are reflected in the increase in the number of heifers in years 4, 5 and 6, give rise to an increase in the number of fertile cows during years 7, 8 and 9.

The increase in the number of fertile cows in years 1-3, which is about 40 % during this period, influences the reproduction of calves in years 3 and 4 (no calves were born in year 2 as the drought was still in force). The drop experienced in the number of new-born calves is due to the high calving rate immediately after the drought (90 %) returning to normal (70 %). The continued decrease in the number of calves in years 5, 6 and 7 is due to the number of fertile cows decreasing during years 4, 5 and 6, which has been accounted for above.

The accumulated relative decrease in the number of new-born calves has an effect on the number of heifers (female cattle aged 1-3 years), which decreases again until the increasing number of new-born calves from year 8 gradually causes the heifers to increase again.

This detailed discussion can be continued through the whole development of the herd. The important issue is that the drought causes oscillations in the herds that have effect many years after the end of the disaster. That these effects also show in the total herds can be seen in Figures 5.3 and 5.5.

The effect of a two-year drought being prolonged by one year is clearly shown in Figure 5.6. Even if a household could rebuild a herd after a two year drought, this would be very difficult with a three year drought. In the latter case the herd is struck considerably harder and recovers weakly.

In the initial phase, when the total reduction in the herds is greatest, the fluctuations are most marked. When the age-classes where no calves were born, because of the drought, pass the fertile years, the effect of their ab-

sence only works indirectly through their lack of off-spring. As the herd picks up in total numbers over the years, the oscillations also become less significant.

For both cases the variations in the number of fertile cows, which are the potential milk producers for the household, are significant even twenty years after the beginning of the disaster. This underlines the necessity of redistribution systems. It must be of immediate interest for a pastoral household not only to keep a sufficient level in terms of number of cattle, but also to counter oscillations in the herds.

In the case of an epidemic, development may lapse differently as some calves may survive the disaster (where now no calves are born). This would cause less intensive oscillations, though they would still be significant. The proportion of surviving old animals may also be greater. Brémaud and Pagot¹⁴ state that the nomads of the Sahel deliberately keep old cows as they often are resistant to diseases having survived earlier epidemics. Thus they can provide a small base for rebuilding the herd.

Developments in the herds of camels show similar traits to those of cattle herds. The difference between a two-year and a three-year drought is illustrated in Figure 5.11. Here, too, the effects, especially of a prolonged drought, must be considered disastrous.

The analysis given here involves only one disaster. Some authors hold that there is a tendency for droughts to occur at intervals. Morgan suggests a frequency of ten to twelve years¹⁵. For the Near East, cycles of six to eight years have been suggested, with each drought lasting three to four years¹⁶. Curasson suggests that rinderpest also seems to appear cyclically, among the Fulani in West Africa with a period of 25-30 years¹⁷. He also provides other examples. Such phenomena would mean that new fluctuations need to be introduced into the herds, superimposed on the earlier development.

It has also been suggested, that certain diseases may occur in regular

waves, both among people and among animals. The regularity is then determined by the time it takes for the resistance acquired by the stock to become ineffective.

Ideally, estimates of "minimi herd sizes" should take such fluctuations into account to the extent that the time-scale of a recurrent drought or disease can be calculated, and its probable scope estimated. Even without an increase in population, a certain increase in herd size would be necessary to counter the effects of such recurring events.

When a cattle herd grows with a "normal" growth-rate like that of Example 8 (3.4 % annually), its increase over a period of ten years will be almost 40 %, the original herd size being approximately 72 % of the size the tenth year. This means that in order to produce the same amount of food as was produced during the first year, the herd must not be reduced by more than 28 %, excluding the normal mortality which is already included in the growth model. If larger reductions than that occur within this ten year interval, the growth rate is insufficient.

The individual pastoralist does not calculate probabilities in this way, of course, nor is he likely to see the demographical regularities expressed in the cyclical fluctuations. The same applies to the field researcher who observes the herds during a limited time period. These mechanisms are hard to discover except by demographic methods, but none the less their consequences may be harshly felt, and certain kinds of knowledge about them are likely to be incorporated into the general cultural heritage of a pastoral people and expressed amongst other things in the ambition to increase herd sizes. The question of individual rationality versus the functional aspects of a cultural institution or tradition is a complex one, and we do not want to venture too deeply into it here, but rather to indicate that even if not all that the nomad does and thinks is rational, a large part of his cultural traditions are formed by experience that members of his culture have accumulated in a dialogue with the ecology. Culture is to a certain extent a code system conveying this experience, symbolically ex-

pressing the less visible interaction of economy, demography and ecology. Thus, there is likely to exist rather definite opinions on what is a beneficial rate of growth, what culling practices can be followed without harming the future productivity of the herd, and so on.

The individual herd owner is aware of the risks of a pastoral economy and he can take precautions against some of them. We will in the next chapter discuss some of the ways that risks are minimized or shared communally. Despite all such precautions, however, one major way to evade the negative consequences of disasters is to try to keep the size of the herd as big as possible, given a particular environment and a particular number of persons to look after the herd. From a total environmental point of view such behaviour may not be beneficial, but it is certainly rational from the point of view of the individual to strive for a maximal herd growth rate.

6. WHAT IS A HERD? PRIMARY AND PRACTICAL CONSIDERATIONS

6.1 COUNTING STOCK

The major draw-back for really effective herd growth analysis is the scarcity of information on age and sex distributions in pastoral herds. Stock surveys, if carried out at all, are often unreliable. Because these surveys, for historical and other reasons, are associated with taxation, surveyors have often found it difficult to acquire the confidence of the pastoralists. On the contrary, the latter often try to deceive the surveyors, a fact that one is reminded of in the source literature where many unrealistic calculations exist.

Another major drawback, when carrying out a stock survey, is that the act of counting domestic animals is often a cultural offence. The Turkana, for example, never count their cattle. Instead, they have a personal relation to each head or, if needed, have a bunch of sticks where each stick corresponds to one specific animal. At night-time, one stick is thrown away per head (without counting!). To count stock would be to challenge Fate. If any sticks are left, the herd-boy will know what animals are missing and go out in search for them. If an outsider counts the number of heads in a herd, this is considered to bring bad luck and the person is suspected of trying to cast an evil eye on the animals, from which nothing good will follow.

It is also physically demanding for a surveyor to move around in areas that are frequently hot and dry. As a result, a technique of aerial surveying has been evolved whereby sections of a pastoral area can be sampled and photographed from the air. From the photographs the sizes of the livestock can be measured, and with knowledge of local breeds and ecological conditions, the ages can be estimated. Needless to say errors easily become large even if the sampling method is carefully carried out in terms of such local factors as seasonal migrations.

In the Hunting study on western Sudan (Darfur), aerial surveys were avoided (though the techniques have since then improved) and a veterinary specialist spent over a year among the people trying to collect reliable data. Even then great difficulties occurred with recording age structures, as it proved impossible to make sufficiently reliable age estimates for grown-up cattle on the basis of their physical condition without pulling out teeth or cutting horns.

The method involving aerial surveying was used in the late 1950s and early 1960s in Kenya; first in wild-life counts and later in stock counts of Maa-sai cattle in Kaputiei Division and in the Samburu District and North-Eastern Province (predominantly Borana and Somali cattle). The Report¹ does not provide sufficiently elaborate material to be used in the present analysis. A major drawback in the most detailed information, that on Kaputiei Division, is that no information is given on sex distribution; the report deals solely with sizes of total herds, though differentiated according to age-classes. As a result female cattle herds cannot be distinguished.

Since then, the methods have been improved, by using a combination of aerial surveys and sample counts of herds on the ground to increase the accuracy of photographic analysis. We have not yet seen any of the results of this latest method.

In the long run the only way to gather accurate data is by the systematic collection of cattle demographic data over several generations.

6.2 MANAGEMENT UNITS AND PROPERTY RIGHTS

Different practices of risk minimization by circulating domestic stock add principal difficulties to defining what "a herd" really is in a stock survey. Cattle and camels are generally circulated in the social space available to a head of a household. He might at one particular point in time have borrowed a heifer from a friend in need of one or simply done it as a token of their friendship. This means that he will not have access to this heifer's

milk when it produces its first calf. If a crisis occurs, however, he is able to ask this friend for help in terms of one or two heads, according to whatever his friend's household considers it can abstain from. If they cannot, he contacts another friend or relative until he finds someone from whom he can borrow.

This is the fundamental way a stock friendship system works. Such exchanges occur generally though the forms may vary. Each head of a household acquires a set of debts and requests that have developed over a period of time. The effects on the particular herd or herds administered by an individual household is that it is made up of animals that represent various social restrictions and demands. For a good example from the Moyale and Marsabit Boran of Kenya, see Baxter 1966. Some animals may belong to the wives of the household, who have the right to deny their husband to give any of them away to his stockfriends², and who may have the sole right to the produce from the animals but no decision as to where the animals shall graze. Other animals might be set aside for a future marriage. Still other animals may belong to a brother who temporarily has no opportunity of looking after them; and so on.

The list can be made very long. It might even be said that each individual animal has its own unique social significance. As an illustration Hedlund³ estimates that 30-40 % of the cattle that belong to a Maasai man (Kenya and Tanzania) may be dispersed among friends.

The point to be made is that ownership is a relative issue and, whatever it may be, it differs from a household's particular access to stock. Taking into account that the major economic utility for a household is milk production, it is clear that the actual herds managed by a particular household make up the economic base for the household survival rather than the animals that could be regarded as owned by the household. This stock aggregate should be the proper "herd unit" at least for an analysis of subsistence economy.

This is, however, not the complete picture. Grazing availability puts a limit on the number of animals that it is possible to keep near a settlement, and these should be animals providing milk resulting in greater demands on grazing qualities. Bulls, dry cows and a couple of milkgivers are often kept further away from the settlement in reserve herds, so that the best grazing is left for the milkgivers. If the dry cows are impregnated they will be brought into the subsistence herd of a household.

Thus the total herd belonging to a particular household is often split into one subsistence herd and one or several reserve herds. The concept "fallow herd" should be more relevant to signify the quality of reserve herds. Other authors have labelled them "reserve herds" or even "surplus herds"⁴. However, the term "reserve herd" may have a connotation of a non-exploited reserve, which would be misleading. The term "surplus herd" definitely has this connotation. We therefore consider it inappropriate. The issue is that all animals are involved in a productive cycle. No agriculturalist would consider "fallow" as "surplus". In a similar way no pastoralist would regard his fallow herd as a surplus. The analogy is then relevant to visualise the quality of the fallow herds as supplementary to a subsistence herd in a pastoral economy. We shall return to this distinction in Chapter 7.

Female stock are normally circulated between these various herds, thereby reducing ecological risks. However, this is not always necessary. Elam gives an example from Bahima where all the household's cattle are kept together. This is possible because of evenly distributed rainfall and good grazing.⁵

From the point of view of the household the availability of milkproducing cows can be divided into three groups. Female stock grazing near the settlement are obviously directly available. Female stock in reserve herds will potentially become available when they become pregnant. Finally, demands on stock-friends and other relatives result in a third form of availability should the household decide to press these.

Seen from the point of view of the individual household's labour input, the subsistence herd can only be managed by those members of the household that are there. Decisions on where to graze, when to water, etc, are made by the heads of the households. The household's fallow herds may be grazing so far away that there can be no contact with them for weeks. Those responsible for the herds are often older teenage members of the household who join agemates herding together making day to day decisions, although it is the heads of the households who have decided in which general area grazing should take place.

It is often more practical to allow several fallow herds to be herded together so that young people from several households can co-operate in the somewhat difficult task of looking after the fallow herd. This work differs from that of looking after the subsistence animals since frequent movements are necessary and because of the difficulties of protecting them from wild animals and from raiding parties.

From a household point of view a correlation exists between availability for milkproduction and labour input since milch cows require most attention.

Herding activities are a response to the household's necessity of adapting food production to the ecological limitations of marginal dry lands. The system of social and spatial redistribution can be compared to a banking system where surplus is invested and to an insurance system if households are victims of economic fluctuations. That the young men meet outside the household circles and outside the restrictions of "normal" daily community life, is often a matter of great significance for the social system at large⁶.

The overriding importance of the circulation of stock is that risks are minimized. For reasons of herd management the stock of a particular household may be redistributed if the growth of a herd exceeds the manpower available within the household (i.e. if its herds become so large that they are difficult to handle while there is not enough people to take care of yet another subherd). This redistribution entails future possible demands

on the friends who are given the surplus animals for herding. These demands may be activated if the original herd diminishes so that it is now feasible or even necessary to add more animals to the subherds, or if the number of members in the household increases so that sufficient manpower is now available to look after more animals, larger herds or yet another subherd. The latter also involves a greater number of consumers who are dependent on the produce from the herds. For a discussion of the insurance aspect of redistribution, see A Hjort⁷.

One conclusion that can be drawn from the above is that the availability of manpower in a household sets a limit on both the number of subherds and on the number of stock within each herd. As a result, "threshold situations" can develop whereby each subherd can become so large that it is difficult to look after while not enough labour is available to establish yet another subherd. This varies considerably between different kinds of stock and has a bearing on the discussion in Chapter 8.4.

The distribution of surplus stock via a stock friendship system means, in terms of labour input, a flow of animals to where manpower is available. Each household's resources of manpower must be considered at the time of the transaction, in the same way that they must be taken into consideration when the individual herds of a household are to be split up into subherds.

The circulation of livestock does not, in itself, create any problems for this analysis of herd sizes and production. The most important aspect of a herd of cattle or camels is its ability to produce milk for a household irrespective of who is the owner of a particular herd. Not until an animal is slaughtered can ownership create difficulties and even here the problems are often easily overcome, since in an economy focused on milk production the animals that are slaughtered are usually those least likely to produce milk.

7. HOUSEHOLD PRODUCTION FROM PASTORAL CATTLE HERDS

7.1 THE HERDS AND THE HOUSEHOLD

The following three chapters deal primarily with the minimum herd-sizes necessary to provide food for the household. The main theme is the productivity of the herd in terms of milk, meat and blood as related to human nutritional needs, in particular energy and protein. Other material products such as hides and skins that are either sold or used for utensils etc are not discussed here.

As the purpose is to discuss household consumption, the "herd" referred to here is the unit under the authority of one herd manager or household head. The concept of "herd" is in itself problematical, as a herd may be a management unit or a property unit or both. These problems have been discussed in Chapter 6.

If a herd for the present purpose consists of those cattle managed by one household head or available to the family irrespective of ownership, what is then a household? There is of course no "average" pastoral family that can be used as a common denominator for the discussion of households under different cultural systems and in varying ecologies. Because of this, we have taken the liberty to construct a family which will serve as a "reference family" throughout the present chapter.

All calculations on nutritional needs are based on selected data from "Recommended Dietary Allowances"¹ as compiled in Wikberg². The reader who wants to go deeper into the relationships of age, sex and human nutritional needs is referred to any of these two sources.

Nutritional studies often refer to "the reference man and woman". Convenient units as they are, they will be used also in this study. The man, aged 22, is thought to have a body weight of 70 kg, to require daily 2800 kcal and 65 g of protein. The woman, of the same age, weighs only 58 kg and need 55 g of protein and 2000 kcal per day.

The "reference family" adopted for the purpose of this study, consists of a father, around 30, a pregnant mother of 25, two children of 3 and 8 and with one girl of 15 and one boy of 18 attached to the household. Together they would need approximately 318 g protein per day and 13 800 kcal. There are of course other combinations of household members that would give both higher and lower values, but any choice of household composition must of necessity be somewhat arbitrary, given the poor quality of demographic data, variations in life careers and the great cultural differences involved. The "reference family" assumed here corresponds to 4.9 adult equivalents. Others have assumed a larger family size as normal for pastoral groups: Van Rensburg and Brown, for instance, regarded 6.5 adult equivalents as normal³. In addition by using the Recommended Dietary Allowances we may also have relied too heavily on European standards. Brown⁴ states, for example, that "a pastoralist can be described as an active individual doing no heavy work" and thus ascribes a daily need of only 2 300 kcal to a standard male pastoralist, adding that "even this may be too high, for pastoralists are often very slim light people who may not eat as much as a standard European subject". The easiness of pastoral life is, however, debatable, and displays great variations between different pastoral settings. Among the Boran of Kenya, for example, there is a lot of hard work for young people to do, such as carrying heavy loads of water and firewood to the camps or bringing water up from the bottom of the wells to the water-furrows where it can be drunk by the cattle. Even travelling by foot is more laborious than in Europe, as many prefer to move during the hottest period of the day when elephants and lions are asleep.

7.2 FOOD PRODUCTS FROM PASTORAL CATTLE HERDS

The different subsistence products, milk, meat and blood, produced by cattle herds are discussed here. Milk is by far the most important source of food for pastoral nomads, and is referred to first. Blood is important in that it can be used to alleviate hardship during the seasons when milk

production is low. This is also true of meat, but the latter, however, important it is socially and ceremonially, is of varying importance from a nutritional point of view. It is more likely that a cash market for meat exists than for milk and blood. Thus for pastoral people involved in a cash economy, meat resources can to a large extent be converted into local agricultural produce, edible import items or non-food products.

This section also includes calculations on minimum herd sizes. Sections 7.2.1.5 and 7.2.1.6 assume that the total diet is solely based on milk. Section 7.2.4 also takes account of meat and blood consumption. No separate calculation is given for a diet wholly based on blood or meat as this would deviate too much from what occurs in reality.

7.2.1 Milk

In order to ascertain the milk yield from a cattle herd, it is necessary to consider the length of normal lactation and the average amount of milk produced. It is also necessary to investigate the seasonal changes in milk production.

7.2.1.1 Length of lactation for pastoral cattle

The average length of lactation, i.e. the period of time during which a cow gives milk, generally seems to vary between seven and nine months in marginal drylands, although even shorter periods are mentioned by some sources. McKay⁵ found a shorter average time in his study of cattle in northern Kenya. The mean length there was 139 days and the maximum 241 days. Grunnet⁶ states that the average for Dinka cattle in Sudan is one year; in the worst cases lactation only lasts three to four months. Sweet⁷ states for North Arabia that cows there only give milk during the moist season, which lasts for around five months. Brown⁸ generalizing for the pastoral areas of Ethiopia noted that lactation is usually short; less than six months.

Other sources fall more consistently within the interval mentioned. For example seven months (210 days) is given by Evans-Pritchard⁹ for the Nuer cattle in Sudan. The same figure is also given by Klima¹⁰ for Baraibaig dams in Tanzania, and by Brémaud and Pagot¹¹ for cows in the Sahel zone. Karamojong cows have an average of 230 days¹². Mares¹³ indicates that Somali cows lactate for eight months. Joshi et al estimate the length of lactation to be 8-9 months for the cows of Murle north of Lake Rudolf, and to 200-300 days (6 1/2 - 10 months) for cattle kept by nomadic Arabs in northern Sudan. In Mauretania the Zebus give milk for 7-8 months¹⁴. Galukande et al¹⁵ and Lambkin and Lambkin¹⁶ studying East African Zebu cows under much more favourable grazing conditions have obtained values of 239 and 252 days respectively. Marples¹⁷ gives 259 days as the normal time for Ugandan Shorthorn Zebus and Alimi¹⁸ gave a mean of 253 days for a sample of Sudanese Butana cows.

From the point of view of human consumption it should be remembered that the length of the cows' lactation is not a measure of its effectiveness. Schneider¹⁹ states that cows only give maximum milk yields during four months per year. Furthermore, not all cows produce extra milk beyond the needs of their calves. This is pointed out by the Dyson-Hudsons²⁰ who give an example where only 13 out of 27 Karamojong cows with calves gave excess milk.

7.2.1.2 Volume of milk for human consumption

It has already been stated that there often is some confusion about what the measures²¹ given in the literature really imply. In the case of milk yields, veterinary sources often give the total yield per day or per lactation, while anthropologists with their prime interest in individuals' consumption give measures for "excess milk", i.e. the milk over and above the needs of the calf. This is sometimes explicitly stated but by no means always.

McKay²² who has made a study of cattle in the Northern Frontier District

of Kenya, gives an average total lactation yield of 518 kg for Boran cattle. Given the average length of lactation this would imply a daily average of 3.72 kg. The daily yield of Samburu cattle was 2.7 - 3.2 kg. A good Samburu animal can even give as much as 4.5 kg per day during the rain season. Meyn²³ states generally for East Africa, that during the rains newly lactating cows will yield 2-5 kg. In the dry season they may give only 1-2 kg or be completely dry.

Epstein²⁴ states that a Boran cow during her best period can give 5-10 kg milk per day. He does not indicate whether that is also true for cattle under traditional management methods or only applies to selected, wellfed individuals under intensive care. Bartha²⁵ found the mean total yields from Sahel Zebus to range between 1 009 kg per lactation if the calf was born during the dry season and 1 060 kg per lactation if the calf was born during the rains. Marples²⁶ obtained 952 kg or 3.68 daily, from shorthorn Zebu in Uganda. Galukande et al²⁷ have measured the milk yields of 568 East African Zebu (Nandi breed) under intensive management, and found a total average yield of 831 kg (183 gallons) per lactation or a daily average of 3.48 kg. Lampkin and Lampkin²⁸ studied Zebu cows, that had been bought from nomadic herds and introduced into areas with good grazing, where the total average yield was 1 118 kg per lactation implying 4.4 kg daily using lactation length of time indicated by the same authors.

Maure Zebu cattle of the type kept by nomads in Mauretania give total yields of 600-700 kg with peak daily yields of 6-7 kg²⁹, while Mbororo cattle in West Africa produce only 2 kg during their best period³⁰. Zebus kept by nomads in the Arabian parts of northern Sudan are thought to produce around 4.5 kg in the rainy season and 2.7 kg during dry periods³¹.

All the figures mentioned so far refer to the total yield of a cow, including human as well as calf consumption. Klima³² states specifically that the daily yield of Barabaig cows, 1.9 - 2.8 kg, has to be shared by calves and people alike. In the other cases, the yield available for human consumption can only be arrived at by reducing the values with the amounts needed for the calf itself. There is little data available on this problem. Cozzi³³

states that Somali calves usually get no more than one third of the total lactation yield. Brown³⁴ writes that a calf requires 400-500 kg of milk over five or six months in order to ensure full growth. Grunnet³⁵, Evans-Pritchard³⁶ and Joshi et al³⁷ note that during the first two weeks of lactation, Dinka, Nuer and Murle reserve all milk for the calf. Afterwards the consumption of the calf is gradually reduced. Grunnet states that Dinka calves when they are small get 50 % of the milk production, and when larger they get 25 %. No estimates can be made from these figures, unless the average yield of the mother at different times during lactation is known. Dinka reserve milk for the calf by letting them suckle at the start and end of the milking³⁸. The same procedure is applied by Fulani, and involves a risk that the calf may become underfed³⁹. In other cultures, as among the northern Sudan Arabs⁴⁰, or the Maasai⁴¹, the calves are instead given two teats to suckle until the lactation period ends.

The difficulty of wisely apportionating the needs of humans and calves is recognized by pastoralists themselves⁴². Turkana⁴³, for example, consider it to be bad husbandry to deprive calves of milk in the dry season except to be given to small infants. In Elam's⁴⁴ book on the Bahima culture, this conflict is a major theme, seen as one of the explications of the strict ritual seclusion of women from cattle and tasks associated with the care of cattle.

Most of the sources quoted hitherto are veterinarian. The other sources, mainly anthropological, give instead of the total yield, only the amount of milk available for human consumption. Brémaud and Pagot⁴⁵ give a Sahel average yield of 400-450 kg for the whole lactation period or daily 1.9 - 2.1 kg, if calculated over the average lactation length. Unfortunately they do not indicate the differences in yield between the dry and wet seasons. This is also true for the information given by Evans-Pritchard⁴⁶ that Nuer cows yield 1.9 - 2.4 kg per day for human consumption, Grunnet's⁴⁷ information from the neighbouring Dinka of 2.5 kg and Haberland's⁴⁸ statement that Boran cows in the southern Ethiopian highlands give 2 kg of ex-

cess milk per day. In the Hunting Report⁴⁹ it is stated that 1.5 kg is a normal excess yield.

Joshi et al⁵⁰ quote an estimate stating that the cows in Nilotic Sudan, 20 days after giving birth to calves, produce 1.8 - 2.3 kg (4-5 lbs) for human consumption and in exceptional cases 5.0 - 6.4 kg (11-14 lbs).

Elam⁵¹ states that each Ankole cow gives 0.9 kg (2 pints) a day. Bondestam⁵² gives an estimate of 0.5 - 1.0 kg for the Afar of Ethiopia and French Somaliland, though this figure may be unreliable. The exceptional information that Afar camels produce even less than cows throws a shadow of doubt on the general validity of the information on milk yields in this otherwise valuable and informative survey. Smeds⁵³ assumes for Ethiopia that each cow at the commencement of lactation will give up to 3 kg daily, diminishing to 0.5 kg daily at the end of lactation.

The remaining available information relates to wet and dry seasons. Dodoth⁵⁴ cattle give roughly 0.9 kg a day in the wet season, but during the dry season their yields drop to around 0.2 kg per cow per day. Jacobs⁵⁵ estimate for the Maasai is that during the wet season the cattle rarely produced more than 1 - 1 1/2 kg per day and in the dry season less than 1/2 kg or even no milk at all. This agrees well with information obtained during the authors' field work in Kenya. Boran informants in Kenya mentioned that 1.0 - 1.5 kg milk could be expected from a cow in the wet season but only 0.5 - 0.75 kg during dry periods. No actual measuring was, however, done.

Widstrand⁵⁶ estimates that Pokot cattle in Kenya give around 2.4 kg during the rainy season and only 0.2 kg in the dry period. According to Gulliver⁵⁷, Turkana cows give 1.9 - 2.4 kg in the wet season and 0.5 kg in dry periods.

In Figure 7.1 two detailed illustrations of the seasonal variations in individual yields are given; one from sedentary Fulani, mainly based on Van Raay's data⁵⁸, and one based on Dyson-Hudson⁵⁹, who has made one of the most thorough studies that exist on pastoral economies.

FIGURE 7.1: Daily individual yields for human consumption from lactating cows in two pastoral economies

a. Sedentary Fulani in Zaria
Province, Nigeria

b. Seminomadic Karamojong,
Uganda

RAINFALL

The rainfall figures are averages for Katsina, which lies in the same ecological zone as Zaria. They can therefore only be taken as an indication of rainfall variations in the area (Joshi et al 1957, p 103).

The seasons given in the figure are those given by Dyson-Hudson 1970, p 95-97 as "normal". They do not necessarily accord with the actual outcome of any specific year.

FODDER

The graph showing variations in the total availability of fodder 1968-1970 in Zaria and Katsina has been obtained from Van Raay 1975, p 111.

MILK

The data was collected in 1970 by Van Raay among sedentary Fulani in Zaria (1975 p 49). The mean of the recordings of daily yield was 0.77 kg.

The data was collected by Dyson-Hudson in 1958, a year with a "not very severe" dry season (1970 p 113). The mean of the monthly recordings was 1.5 kg.

For the calculations on herd yields that follows in sections 7.2.1.5 - 6 and 7.2.4 we have taken the mean from Dyson-Hudson's study (1.5 kg) as an overall estimate of the expected daily yield of a cow. 2 kg is assumed to be a normal peak yield and 0.7 kg a normal low season yield.

7.2.1.3 Seasonal fluctuations in the number of milk-givers

The volume of fresh milk available at a certain season is not only dependent on how much each cow produces but also on how many cows are lactating. Brown⁶⁰, trying to calculate the size of a minimum herd for a family of 6.5 adult equivalents, states that in order to produce the 16.6 kg of milk that he considers necessary for such a family every day, the number of lactating cows should be about seven. He concludes: "As the lactation of cattle in such areas is usually short - less than six months - it is necessary to double the number of cattle to about fourteen or fifteen cows, to ensure the daily diet". Brown assumes that the number of lactating milk-givers can be 50 % of the total number of adult females. As we shall see, this gives a too conservative estimate of the number of cattle needed, should the calving rate be low or should the normal length of lactation drop below seven months.

From data concerning the fertility rate and the length of lactation it is possible to calculate how many milk-giving cows there are likely to be at a particular period of time. This is unproblematical if all births are spread evenly over the year. When births are concentrated to one or two seasons some periods will have fewer milk-givers than are indicated by average figures.

In Table 7.1 is given the estimated average percentage of milk-givers in an adult female herd, together with the estimated number of days in milk per year and adult cow. The calving frequencies are those used in Part 2.4.2 for the herd growth models.

TABLE 7.1: Estimated average portions of lactating milkgivers in an adult female herd, calculated for different lengths of lactation and different calving rates

Calving rate	Length of lactation		% lactating cows
	210 days	240 days	
	Average number of days in milk per year		
0.45	94	108	26 - 30
0.65	137	156	38 - 43
0.70	147	168	40 - 46
0.80	168	192	46 - 53
1.00	210	240	58 - 66

"Normal rates", represented by 70 % and 80 % calving rates, can be said to agree with Widstrand's⁶¹ conclusion about the Pokot that out of ten cows, two are in calf, three are dry and five are giving milk.

When breeding is seasonal, as it is in many places, the percentage of milk-givers can be even lower than is indicated by the averages shown in Table 7.1. As an illustration, the expected number of milkgivers per month have been calculated from data on monthly births in an area which has one main rainy season, and for another area that has instead two main rainy seasons.

The first example, shown in Figure 7.2, is based on monthly births in western Sudan as given in the Hunting Report. The length of lactation is assumed to be eight months. With a shorter period of lactation the general tendency in the graph will be even more stressed, with the result that the peak lactation period will be concentrated to the rainy season. The calving rate reported from western Sudan was 65 %; see 2.2.2. This rate would mean that around 38 % of the adult cows are lactating at a given period, if births and lactation periods are spread evenly over the year.

FIGURE 7.2: Proportion of milkgivers in the total adult female herd when there is only one main rainy season.

- A. Hypothetical distribution of milkgiving animals in % of adult female herd based on calf births per month in western Sudan as given by The Hunting Report (1974 p I.3). Assumed length of useful production is 8 months. Monthly births 1972 have been estimated by the number of births in 1973 in order to assess the number of milkgivers at the beginning of the latter year.

- B. Monthly births in 1973 in some western Sudan herds as given by The Hunting Report (1974 p I.3).

This hypothetical example represents an area with only one main breeding season. In February when the percentage of lactating cows is lowest they represent only 14 % of the total adult female herd. Not only is the number of lactating cows low at this stage, but their yields will be low because they are at the end of their lactating period and poorly nourished.

In Figure 7.1, an example was given from northern Nigeria, where rainfall distribution would lead one to expect a similar bias in the distribution of the milkgivers over the year. The information given by Van Raay⁶² does not accord with this however. He states that there was almost no seasonal variation in the number of lactating cows, their proportion in the total female herd being approximately 43 % throughout the year. He also points out, that this is to be expected as an average when the normal length of lactation is 7-8 months and the calving rates are 65-75 %. So, contrary to the case in Sudan, calf births in northern Nigeria are not concentrated to one season. This brings into focus the necessity of considering the total fodder situation and not that during the rainy season alone. Stenning⁶³ notes that for the Bornu Fulani, living as total nomads in Savannah zone of the Sudan, their calves are born mainly during the beginning or at the height of the rains, and that the number of milkgivers often drops to a low level in the dry season. Van Raay has carried out his study in Zaria and Katsina, the Fulani areas where crop residues from farm lands make up a very important part of the cattle diet especially during the middle of the dry season⁶⁴.

In this way, the effect of a single rainy season can be smoothed out by alternatives to ordinary free range grazing. A similar smoothing out can be observed in areas with two major rainy seasons. One example of this is given below in Figure 7.3, which is based on graphs showing two-seasonal female births in Ankole, Uganda. The birth data come from information published by Wilson⁶⁵ on births recorded during a period of four years.

The length of lactation is again assumed to be eight months. As there are indications in the data that male births are underestimated, the calcula-

FIGURE 7.3: Proportion of milkgivers in the total adult female herd when there are two main rainy seasons

- A. Hypothetical distribution of milkgiving animals in % of adult female herd based on calf births per month during the period 1959-1962 in Ankole, Uganda, as given in a graph by F Wilson 1963, p 179. Assumed length of useful milk production 8 months.

The thick line refers to mean monthly rainfall as recorded in Mbarara according to Elam, 1970 p 11.

- B. Births of female calves in Ankole, Uganda. The absolute numbers of female births are taken here to show the seasonal variations in all births as there were strong indications that the numbers of male calves were underestimated.

tions are made on the basis of female births only, and the calving rate has had to be estimated to be 70 %. This is, according to Ruthenberg⁶⁶, a normal calving rate for Hima (Ankole) cattle. This rate is also generally what can be expected in pastoral areas with two rainy seasons (see Section 2.2.2). Ankole is, however, an area with rather high rainfall compared with some other areas that also have two "major" rainy seasons. The relevant point here is that since the period of gestation and lactation exceeds the length of a normal dry period, the number of milkgivers is almost constant. The shorter the lactation period, the more pronounced will be fluctuations due to rainfall periods. But even if there is a fairly constant number of lactating cows, there can, of course, be a reduction in the total milk yield during the dry season. In this case the cows' low state of nutrition is more likely to be the cause.

A comparison between the two graphs, Figures 7.2 and 7.3, indicates how important the difference between one and two rainy seasons is for the analysis of pastoral societies and their ecological basis. Although it is outside the scope of this book, one could speculate on the possible restrictions to social organization in terms of the necessity for storage and for more effective systems of risksharing and food redistribution brought about by mono-seasonal rainfall.

7.2.1.4 The nutritional value of milk

The composition of milk produced in the East African arid zone is different from that consumed in industrialized Europe. Normally, when the amount of milk produced by a cow increases, the nutritional value decreases. Nomadic cattle give low individual yields, but the milk is of high quality.

Orr and Gilks⁶⁷ in their study of the diet of Maasai pastoralists during the thirties conclude that the milk of Maasai cows have the following composition: Fat 5.5 %, Protein 3.7 %, Lactose 4.9 % and Ash 0.73 %.

This can be compared with the average figures for tropical milk cows given by Williamson and Payne⁶⁸: Fat 4.8 %, Protein 3.3 %, Lactose 4.8 % and Ash 0.47 - 0.68 %. These figures refer to animals kept in sedentary and more humid areas, as well as animals under intensive European farming systems. McKay⁶⁹ gives 5 % and 5.5 % as the mean butterfat content of milk from Samburu and Boran cattle raised under traditional herding systems.

Luchini⁷⁰ found that Somali cattle gave milk with an average fat content of 5.4 %. Herin⁷¹ obtained up to 6 % fat from Ankole cows in Ruanda-Urundi. 4-6 % is also said to be normal for milk from Ethiopian cows⁷². It is probably safe to say that milk from cows in a pastoral economy is generally very fat. In comparison milk from European cows contains 3.5 % fat, 3.5 % protein and 5.0 % lactose⁷³.

The difference between "nomadic milk" and milk consumed in Europe should be taken into account when calculations on milk requirements are made as the calory content also differs. Deshler and Widstrand calculated 300 kcal per pint⁷⁴, i.e. 633 kcal per litre. The calculations on pastoral diets made by Brown⁷⁵ seem to be based on the assumption that pastoral milk gives approximately 710 kcal per kg. Pyke⁷⁶ gives 660 kcal/litre for European milk, but the cows studied by Orr and Gilks yielded 831 kcal per litre, almost 30 % more. The calory values are calculated on the basis of conversion rates given by Wikberg⁷⁷.

Although the calculations here are based on Orr and Gilks's values, one other factor should also be considered. Bartha⁷⁸ has shown that the quality of milk in Sahel Zebus changes seasonally. At the end of the long, single dry season the milk from these cows contains only 2.5 - 2.8 % fat, while during the rains it increases to 5-7 %. The protein content similarly varies between 3 and 3.8 %. It is very likely that such fluctuations occur fairly widely and should be given consideration in field studies of nomadic diets.

As the composition of milk is to provide a complete diet for newborn animals, it contains most of the nutritional components that cattle and people

need. Kon⁷⁹ notes: "Only the whole carcass of an animal including bones and liver could contribute as much as milk taken as a single food ..."

The main deficiencies of milk are the absence of iron and vitamin C, which have to be provided by other foods, such as meat and blood; fruits or berries or fresh vegetables. When fresh milk is drunk as it comes from the udder, it can give a steady supply of 20 mg of vitamin C per kg of milk⁸⁰, the ideal intake being 35 to 60 mg per day depending on age and sex⁸¹.

Milk also lacks vitamin D. This vitamin, however, can be produced within the human body when it is exposed to sunshine⁸², and should not be a problem in the tropics.

To survive on a mainly milk-based diet the "reference man" would need 3.4 kg to fulfil his needs for proteins (i.e. more than 65 g) and calories (2 600 kcal). Thus, Bondestam's⁸³ information that an adult Afar may drink up to 4 kg of milk per day seems fairly accurate.

The "reference woman" would need 2.4 kg, and the family of six described in Section 7.1 would need 16.6 kg in order to get their daily allowance of 13 800 kcal and 318 g of protein.

Not all pastoral people live on only fresh milk to the extent indicated by the figures above. The diet is often supplemented with agricultural produce obtained either through the barter of skins or meat, or from seasonal gardens. Milk is the staple food, as farming can only be carried out on a small scale in marginal drylands. It may be worthwhile to point out that the phenomenon of "a pure nomad" does not exist in the exact sense since pastoralists do not hesitate to try farming if it proves necessary or profitable.

The Maasai are an example of a people who had a very non-agricultural diet at least some decades ago. Jacobs⁸⁴ stated in 1963 that twenty years earlier, agricultural produce made up less than 15 % of their diet and that still the changes in Maasai diet are taking place only slowly – a statement that is still valid in 1976. Asking the Maasai how much milk a man consumes, Jacobs got the answer that an elder or a young herdsboy will if

possible drink 5-6 pints (2.4 - 2.8 kg) and a woman or child around 2 pints (0.9 kg) per day. The average according to Jacobs is 4-5 pints (1.9 - 2.4 kg). These measures are, however, only approximate; the Maasai count in calabashes rather than in pints.

It may be of interest here to note that Orr and Gilks⁸⁵ assessed the protein intake of Maasai men to 300 g per day and of Maasai women to 165 g. The women had instead a proportionally higher intake of carbohydrates. Not only had the Maasai better health and a better composed diet than their agricultural neighbours, they also had a protein consumption that was much higher than the necessary minimum.

7.2.1.5 Conclusion: Composition and size of a minimum herd

The proportions of lactating cows in the adult female herd has been discussed in Section 7.2.1.3. In order to assess the necessary minimum size of herds, it is also necessary to know how large the proportion of lactating cows is in relation to the total number of male and female cattle. For this purpose we will use the herd structure in Example 8 from Section 2.4.2.7, which is based on a 70 % calving rate and represents a "normal" situation. Note that the cows are assumed to be slaughtered in the age-class 11-12 years in this example.

The age structures of the simulated herds in Chapter 2 refer only to the female part of the herd. Out of the total female herd, the fertile cows make up 46.8 %. If to each agegroup of females is added the exact number of males that are necessary for reproduction, the proportion of fertile cows will decrease only to 46.2 %. (This figure is obtained when the bull/fertile cow ratio is approximated to 1:33.) This corresponds to a situation where almost all bull calves are slaughtered immediately after birth. But as this is not realistic, we will have to anticipate the discussion on cattle for meat production which follows in Section 7.2.2.2 and construct a total herd on the assumption that all males not needed for breeding purposes are kept

until the age of 4-5 and then slaughtered. The breeding bulls will start to serve at the same age⁸⁶. The proportion of bulls assumed is 1 bull per 33 cows, see Chapter 2.2.1. All males are ascribed the same mortality rates as the cows in Example 8, except that bullocks are slaughtered when four years old, and the remaining bulls are killed when they reach the age of ten. By applying these conditions, the age and sex structure of the herd given in Table 7.2 can be calculated.

TABLE 7.2: Total composition of the herd generated by herd growth, Example 8

	% of total herd
Bull and heifer calves	20.0
Young males age 1-4	20.9
Heifers	20.9
Bullocks for slaughter	5.4
Bulls of all ages 4-10	0.8
Fertile cows	29.5
Old cows	2.5
Total herd	100.0

From Table 7.2 it can be seen that if on average half of the fertile cows are lactating at a given time, the mean percentage of milkgivers in the total herd will be only 15 %.

In Section 7.2.1.4 above, it was concluded that the reference family would require 16.6 kg of milk daily. How large will the herd need to be in order to provide the required volume?

In the hypothetical example of Sudan conditions given in Figure 7.2, the calving rate was 65 %. This rate would not lead to an age-structure very different from that of Example 8, so the results of Example 8 can be used

here to illustrate the important seasonal variations in the required total size of the herd. The milk yield during one season is very high. Many cows are lactating, and they can be expected to give high individual yields after rain has fallen. In the same season there is probably good grazing. The average number of cows lactating during the best seven months is 51 % (see Figure 7.2).

Two kg corresponds to the daily individual yield for human consumption during the best season. Nine milk-giving cows per day are well sufficient to provide for the requirements of the reference family of six persons, described in Section 7.1. The total herd necessary to contain sufficient lactating cows would be in all sixty cattle, assuming the herd composition given above. When 1.5 kg represents the daily yield, more cows are needed, and the total herd size required is 73 animals.

In the dry season, small amounts of milk are produced by a small number of animals. At the height of the period only 4 % of the total herd are lactating; i.e. in February, when 14 % of the fertile cows are lactating, and when individual yields are low, maybe not more than 0.7 kg per cow. A herd of the required size for a family of the five adult equivalents would need to consist of 593 animals! If instead of the age/sex structure given above we assume one with only breeding bulls and female cattle the number is reduced to 395.

These conclusions can be compared with Jacobs' statement⁸⁷ that the Kenyan and Tanzanian Maasai say that they need more than 30 lactating cows per adult in times of drought. In a regular dry season they say that 10-15 cows are necessary, while 2-3 cows are sufficient to provide an adult with food in the rainy season.

Such conditions make it virtually impossible to subsist solely on fresh milk in places where there are large seasonal climatic variations. In many areas, however, there are individual pastoralists with as many cattle as this, but the required labour force would have to be much larger than that implied by the family referred to here.

Apart from agricultural produce that can be bought from neighbouring agrarians or sometimes grown locally in order to alleviate hardships, there are subsidiary sources of food within the pastoral economy itself. Fresh cow milk, although most important for a great many pastoralists, is not the only source of food. After a discussion of the possibilities of storing milk to even out the effects of seasonal variations, the contribution of blood and meat to the diet are discussed, and later on, in Section 8.2, the complementarity of cattle milk and goat milk will be referred to.

7.2.1.6 Milk storage and the possibility of reductions in the required herd size

Milk, though perishable when fresh, can be stored as curdled or dried milk. No systematic study has been carried out yet on the storage of pastoral products, the amount stored or the quality of the milk or meat. Drying and curdling of milk are, however, very common among nomads.

According to Mares⁸⁸ the Somali make a sun-dried curd which keeps for a whole year. They also make *han*, a curdled product reminiscent of yoghurt with a strong, smoky smell. Borana women also prepare this, calling it *ittitu*. It keeps for several months, even half a year. Similar products are made by the Tuaregs, the Turkana and many other peoples⁸⁹.

Yoghurt has the same nutritional value as milk⁹⁰. When the whey is removed from milk, its keeping properties are improved, but there is at the same time a partial loss of milk sugar content and vitamin B.

Most East African pastoralists boil the milk, thereby removing the water and turning the butterfat into ghee, which keeps well in hot climates.

If the herdowner's wife, who is responsible for the milk, has sufficient during the high yield period, some can be stored for the dry season. Where climate variations are haphazardous, great difficulties arise for individual householders in calculating and putting aside the right proportion of milk. This difficulty is stressed in areas with only one rainy season, where risks

must be shared via a system of food redistribution. In such areas the time between the rains may also approach the length of time it is possible to store milk.

It is also worth noting, that Elam⁹², in the study of the pastoral Bahima (Ankole), claims that although milk becomes seasonally scarce, the Bahima do not store curdled milk for a longer time than from one evening to the next morning. They do not make cheese, and only store butter to a very limited extent. Bahima live in exactly the same area that served as a bi-seasonal model above. The occurrence of the scarcity of milk is due mainly to the poor nutritional status of the cows during the dry period. This is, however, of limited extent compared to seasonal scarcities in other areas where some cows are not lactating at all during certain seasons. The term "scarcity" is therefore too subjective in the present context. It needs to be quantified if it is to be of any use at all in comparative studies of ecology and society.

Until now the calculations have been based on the assumption that only fresh milk can be consumed. What happens if the milk yield can be spread evenly for consumption throughout the year? As stated above, the "reference family" living only from milk needs to consume 16.6 kg of milk per day. The total yearly need becomes 6 059 kg. If the daily average yield per lactating cow is 1.5 kg (the average taken from Dyson-Hudson and quoted in Figure 7.1), the yearly yield of a cow is 220.5 kg in areas where the normal length of lactation is 210 days. If the normal lactation lasts 240 days, the yearly yield becomes 252.0 kg. These results are calculated by multiplying the daily yields by the expected number of lactation days per year for cattle with a calving rate of 70 % as shown in Table 7.1.

With the shorter lactation period, the family will need 27 fertile cows, and a total herd of 59 animals if we assume that only female animals and breeding bulls are kept; in accordance with the present assumption of a totally milk-based diet. With the longer period of lactation, 24 adult cows and a total herd of 53 animals would be sufficient. In most cases the age and sex

structure of the herd also include stock cattle, and when calculating the minimum herd size account should also be taken of these, in the same way as was done in Table 7. 2. The possibility of storing food "on the hoof" is important as it is the main method of evening out food resources during the whole year, and reduces the need to store milk. Keeping large stores of milk pots in a mobile economy creates in itself problems that do not so much relate to the quality of the milk, but rather to problems of transport and security against theft.

In the following section we will consider the place of meat in the pastoral diet, before proceeding further with calculations of the minimum herd size.

7.2.2 Beef

7.2.2.1 Cultural aspects of beef production

The second major food item provided by cattle herds is meat. As the slaughter of an animal means destroying one potential producer of milk or blood, the act of slaughtering is, compared with milking or bleeding, endowed with symbolic and emotional connotations. There are restrictions on when and how animals should be slaughtered, and these restrictions have both an economic and ritual significance. Productive female animals are very seldom slaughtered⁹³, and if they are, this marks the "special gesture of abnegation" referred to by I M Lewis⁹⁴ in connection with Somali camels.

Male cattle are seldom slaughtered just for food; to do so can be regarded as poor economics⁹⁵. The slaughter has to be postponed until periods of severe milk shortage, beef being the security against starvation⁹⁶. When meat is needed under other secular circumstances, it is much more common to slaughter sheep or goats.

There are, however, some situations other than drought, when meat is eaten and animals are slaughtered. When individual animals or larger

parts of the herd are hit by disease, the herdowner may decide to kill animals in order to prevent the disease spreading. Slaughter also takes place to anticipate natural death and as a consequence the loss of potential meat; Muslims have strict rules forbidding the consumption of animals that have died from natural causes. The Boran living in Uaso Nyiro in Kenya, for example, do not eat such animals, while in contrast the non-Muslim Boran in Ethiopia do. This seems to be common in non-Muslim groups; it is practised by the Bahima⁹⁷ and Karamojong of Uganda⁹⁸, the Samburu of Kenya⁹⁹, the Murle and Toposa of Ethiopia¹⁰⁰, the Barabaig of Tanzania¹⁰¹ and many others such as the Turkana, the Maasai etc. Limbs affected by anthrax or blackquarter, may be thrown away but the rest of the animal is still eaten¹⁰².

What food is considered clean and what is considered contaminated is very much a question of cultural attitude. It would be interesting to compare more systematically the actions of Muslim and non-Muslim herdsmen in terms of slaughtering requirements. Are Muslim herdowners more eager to slaughter than those who eat animals that have died from natural causes, since the latter represent a complete loss for them?

Cattle may also be specially slaughtered for sick persons or pregnant women when the circumstances of the ailment so demand. Examples of this are given for the Maasai¹⁰³ and the Pokot¹⁰⁴.

Apart from slaughter in cases of emergency, the most frequent type of slaughter is, however, for ceremonial purposes. These may relate to life cycle ceremonies¹⁰⁵, yearly thanksgivings or prayer for rain¹⁰⁶, etc. It should be remembered that such sacrificial feasts do not involve the destruction of the sacrificed animal, but rather public ceremonies with communal and communial sharing of food. The nutritional importance of ritual consumption has been pointed out amongst others by Schneider, R Dyson-Hudson and Van Raay¹⁰⁷. R Dyson-Hudson shows that many such feasts, such as appeasements for better times, occur during famines when milk production is low.

As all families who can afford it are supposed to contribute to such feasts or be the hosts at such feasts, the meat resources of one family cannot be strictly limited for its own use. The generous sharing of resources is often important for the social standing and prestige of a family. This communal sharing can be seen as an institutionalized way of giving all members of the community at least some meat at all times of the year, despite the difficulties in storing beef. The Turkana have a rotational system where all members of a neighbourhood are supposed to provide meat in turn¹⁰⁸.

Communal sharing does not only occur under ritual conditions, but is a practical way of disposing of a bulky and labour-consuming carcass before it has gone bad. Even animals that have died from natural causes are often distributed to kin and neighbours for the same reasons¹⁰⁹.

7.2.2.2 Weights of pastoral cattle

The information available on carcass weights for East African cattle is based on the weights of pastoral cattle brought to abattoirs for slaughter. There are great practical difficulties in trying to calculate the mean weights of cattle slaughtered or eaten in the field. First, it would involve weighing the edible parts of animals that have died from natural causes. Secondly, it would involve weighing meat slaughtered for ceremonial purposes. This is probably impossible to do for reasons of tact and politeness; the only way would be to estimate the weights by sight. To use figures from abattoirs also has serious shortcomings as they do not take into account animals that are slaughtered for ritual purposes, nor those that are slaughtered on-the-spot to avoid the uncleanness of natural death. In northern Kenya, for example, cattle are not sold by the individual herd-owner when they are in their prime, but when he is in acute need of money for taxation, school-fees or similar expenses, or when he needs money to buy substitute foods like grain.

Given that there is milk for household consumption, it is nutritionally more economic to sell an animal and to buy grain from the proceeds of the sale, than to consume the animal itself. This alternative will be taken into consideration by the household head in times of shortage¹¹⁰.

During a drought, the sale of cattle is one of the last resorts, a way of at least obtaining something out of the animal before it starves to death. Cattle traders may buy these animals and after feeding them up they are auctioned for high prices.

On the other hand, if the cattle reach the abattoir after long transport by rail¹¹¹ or by foot¹¹² the cattle may have lost some of their original weight due to the deprivations of the journey. All these factors mean that the figures obtained by weighing cattle bought commercially have only a limited value as estimates of mean weights of cattle slaughtered for subsistence purposes.

The carcass weights of cattle naturally vary considerably according to breed and its general level of nutrition. In East Africa there are two basic strains of Shorthorn Zebu, to which the majority of the cattle belong. These are the Large East African Zebu, of which the "Boran" breed is most prominent, and the Small East African Shorthorn Zebu, with subtypes like "Maasai Grey" and "Nandi". These two main breeds are not evenly distributed but the two types correspond by and large to the dryer and wetter zones respectively. Their differences in carcass weight can be attributed to genetic as well as climatic factors¹¹³. The Boran breed is the common strain of cattle used by the North Kenyan pastoralists. The Small East African Zebu is used to a great extent by the Maasai, who interbreed them with Boran cattle.

Epstein¹¹⁴ claims that under favourable conditions Boran cattle weigh live 450 kg, while cattle in less favourable areas weigh 160-180 kg. The normal weight of a wellfed Boran cow would be 262-314 kg, while Maasai cows weigh generally 108-180 kg, reaching 202-225 kg under better management.

In discussions on the weight of cattle, the measure used is often not that of the live animal, but of its cold dressed weight, i.e. the weight of the dead body when skin and offal are removed. The proportion of an animal's live weight that is left after slaughter and dressing – its dressing percentage – varies according to its condition. Sudanese cattle in poor condition have dressing percentages of 47 %, while the dressing percentage of well-fed animals is better, 50 %¹¹⁵. When there are many emergency slaughters, like those met in the Hunting study of western Sudan, the dressing percentage may even drop to 45 % or lower. Ledger¹¹⁶ compared the Maasai and Boran breeds of cattle under two different grazing conditions, and found that their mean cold dressed weights (c d w) varied as in Table 7.3:

TABLE 7.3: Cold dressed weights of Boran and Tanzanian shorthorn cattle according to Ledger, 1966

	Steers, 132 weeks State of nutrition		Heifers, 132 weeks State of nutrition	
	High kg	Low	High kg	Low
Boran	256.3	190.5	220.0	164.2
Tanzanian	225.0	144.2	190.1	136.5

Payne¹¹⁷ gives estimates for mean c d w of Kenyan and Tanzanian/Ugandan cattle which are even lower than the weight given by Ledger for poorly nourished cattle (who probably even if poorly nourished are raised under ranching conditions). Payne's values, based on cattle slaughtered at East African abattoirs during 1958, were 138.9 kg for Kenya and 117.5 kg for Tanzania and Uganda. The difference between them can be attributed to the difference in breeds. In a compilation by Meyn¹¹⁸, the mean weights are given for cattle slaughtered in various regional abattoirs in East Africa during 1965. The figures for some typical pastoral regions are given below in Table 7.4:

TABLE 7.4: Carcass weights of East African pastoral cattle slaughtered in abattoirs during 1965 (SOURCE: Meyn 1970, pp 162-163)

Area of origin of the cattle	Carcass weight (kg)
Northeastern Province, Kenya (mainly Boran)	118.5
Samburu, Marsabit, Isiolo, Northeastern Province; Kenya (mainly Boran)	107.5
Maasai (Boran and small East African Zebu)	117.7
Karamoja, Uganda	99.2

According to the same source higher values than those given in Table 7.4 were obtained by abattoirs in Tanzania. In that particular year Uganda and Kenya were hit by adverse climatic conditions, while Tanzania was more fortunate. The mean weights in the latter country ranged from 118.6 to 132 kg. The extremely low weights of Karamoja cattle quoted in Table 7.4 may have been due both to the severe drought and to transport difficulties. Baker¹¹⁹ has noted the substantial loss in liveweight which occurs in cattle transported on the long rail journey from Karamoja to the abattoirs.

Given the general shortcomings of the abattoir figures, it is difficult to make a fair estimate of the weights of animals consumed in the pastoral area itself. A general hypothesis would be that the majority of these cattle are slaughtered in poor condition and thus their mean weight would be rather low. One can expect that the proportion of wellfed slaughtered cattle will increase with the size of the herd and with more favourable ecological environments. There will be less need to slaughter cattle in order to obtain food in the dry season, and there will be a margin where higher risks can be taken with poor quality animals. The more secure the availability of milk is, or is subjectively felt to be, the less is the need for a live reserve store of meat, and the more lavishly the herdsman can disburse his herd on social obligations and ritual feasts. It could be interesting to test this hypothesis empirically. A similar difference has been shown between some pastoral and agricultural areas. Lewis¹²⁰ points out that slaughter for

secular consumption is fairly frequent in the dry areas of northern Somalia, but rare in the southern parts of the country, where agriculture is important; ritual consumption then became the main reason for slaughter.

As the present discussion deals with the lower limit of viable herd-size, it is reasonable to choose weight estimates that are, at least, not higher than those given by Meyn. Calculations made here are based on the assumption of a) 100 kg mean cold dressed weight and b) 120 kg mean cold dressed weight. Using these estimates, no differentiation has been made between animals of different ages or sexes. The size of a cow is only 30 % to 40 % of that of a bullock. The difference in weight between welfed adult animals of different sexes can be seen e g in Mc Kay¹²¹. In the present discussion 100 and 120 kg will be used as averages for adult animals regardless of sex. Small calves dying natural deaths within their first year have, for the sake of simplicity, been excluded from the calculations.

7.2.2.3 Proportion of herd available for slaughter

Having discussed the body weights of pastoral cattle, the question now is how large a proportion can be taken from each herd without prejudicing its growth and how much the meat will contribute to the diet of the pastoral family. The discussion will be based on the age structure developed in Example 8, representing a case of normal growth in a cattle herd.

The majority of cattle for slaughter is made up of young bullocks. The age interval 4-5 years has been chosen as a suitable age for slaughtering. At that age, the animals are fully grown. Van Raay¹²² shows that up to this age, the sex-ratios for Fulani cattle are almost fifty-fifty while the number of males above the age of five drops due to sale and slaughter.

To the categories that can be slaughtered must be added old cows that are no longer productive, and old bulls whose services are not as effective as those of young males. The upper virile age limit for male stock has been

set here at ten years. At this age the breeding ability of the bull goes down¹²³ and it is, as a rule, more economic to substitute a younger animal for an old bull. The upper limit of female fertility has here been set at eleven years as earlier. The slaughtering of old cows is, however, in practice more restricted than that of old bulls. If there are few milkgivers and calf-bearers in the herd, the herdowner may take the chance that the cow is still fertile and will produce another calf. In many cases cows are allowed to live until they die from natural causes, or are slaughtered at an older age than that assumed here.

The three categories of stock eligible for slaughter make up 8 % of the total herd. They can be slaughtered without prejudicing the long term productivity of the herd, and all of the meat can generally be consumed without waste caused by, for example, disease.

The figure 8 % can be compared with information from other sources. Ruthenberg¹²⁴ states that the normal offtake for sale or slaughter from Kenyan semi-nomadic herds is 6-10 %. Morgan¹²⁵ means that cattle offtake, including local consumption, ranges from 4 % to 9 % for the same groups. For the Sahel zone, Brémaud and Pagot¹²⁶ see 8-10 % as a normal yearly offtake.

Out of the old cattle which die natural deaths, or are slaughtered when natural death is imminent, some will be totally lost as food (e.g. those killed by lions or other marauding animals), some will be partially lost because of injuries or disease, and some will be consumed in full. The expected natural loss by death (calf mortality not included) is also approximately 8 % of the total herd. It is not possible to calculate the proportion of these 8 % that will be eaten. In the Hunting study¹²⁷ from Sudan, 46.2 % of all animals counted as "naturally dead" had been slaughtered of necessity and thereafter eaten. This percentage did not include any parts of animals that died from natural causes. With a "normal" offtake of 3.72 % in all, 14.8 % of the herd was converted to meat.

7.2.2.4 Storage of beef

Meat can, apart from being stored "on the hoof", be kept for some time after preparation. Common methods of storing are salting, sun-drying or smoking. Sun-drying is a process which takes at least one week and during this period the meat is partly spoilt. Smoking is more effective. Both methods are used for example by the Dinka¹²⁸. The Boran and Somali dry the meat and boil it afterwards with ghee and cut it up into small pieces. Such meat is said to keep for two years. The Baggara Arabs¹²⁹ also store dried meat from animals that have died from natural causes. Mann¹³⁰ states that meat, properly dried and stored away from insects, will keep for twelve months. Not all pastoral groups store beef for such a long time. The Maasai, for example, seldom keep meat for more than a week, although they know the methods for its storage¹³¹ and the Karamojong only store a few pounds each season¹³². Some factors that make the storage of meat less attractive than communal sharing will be discussed in Section 7.3.2 in connection with camel meat.

7.2.2.5 The nutritional value of beef

Payne¹³³ quotes a formula given by Callow¹³⁴, which can be used for calculating the percentage of protein in boneless meat, P, when combined with estimates for the fat and bone contents of African cattle carcasses. Such estimates are also given by Payne, basing his article on information from Ledger. Ledger's values are 10 % bone and 22 % fat. These may, however, be estimates concerning fat animals, as Epstein¹³⁵ gives a considerably higher percentage of bones for Ethiopian cows, with 12 % bone in the fore-quarters and 14.8 % in the hindquarters.

Using Payne's example based on the data from Ledger, the amount of boneless meat per 100 kg and 120 kg carcass can be calculated to be 90 kg and 108 kg respectively. The value for P becomes 16.15 % using the formula:

$$P = 20.7 - 0.207 \cdot F; \text{ where } F = \text{the percentage of fat.}$$

Each carcass then yields 14.5 kg (17.4 kg) of protein and 19.8 kg (23.8 kg) of fat in the two cases.

The calory yield of meat is calculated by using Wikberg's conversion values¹³⁶, giving the following rates. For each carcass weighing 100 kg there will be 236 000 kcal and for each one weighing 120 kg there will be 283 500 kcal obtained from the fats and proteins of the boneless meat. To this should ideally be added all those edible offals that are not included in the cold dressed weight. The proportions that some major edible items make up of the total live weight of the cow are given in Table 7.5.

TABLE 7.5: Some edible cattle offals, their proportions of the live weight and nutritional value

	Proportion of liveweight (%)		Kcal/100 g	Protein ² G/100 g	Fat ² G/100 g	Carbohydr. ² G/100 g
	Kenya ¹	Tanza- nia ¹				
Tongue		0.4	207 ²	16.4	15.0	0.4
Liver		1.4	140 ²	19.9	3.8	5.3
Heart		0.4	108 ²	17.1	3.6	-
Kidney		0.2	130 ²	15.4	6.7	0.9
Suet fat	0.9	0.8	902 ³	0.0	100.0	0.0
Caul fat	0.7	0.8	902 ³	0.0	100.0	0.0
Hump	0.9	1.2	236 ⁴	16.2 ⁴	22.0 ⁴	-

1) Source: French 1936a, p 110

2) Source: Pyke 1970, pp 20, 21

3) Source: Wikberg 1971, p 98 for caloric yield of meat fat

4) Hump assumed to be composed as meat; Cf above

The cold dressed weight of a cow or ox generally corresponds to a live weight of approximately double. From Table 7.5 it can be seen that the tongue, heart and kidney together make up only 2.5 % of the live weight,

i.e. 5-6 kg per animal. The hump is composed of muscles and will add some 2 kg meat. The fat deposits make up roughly 3 kg of food with high calory content. As the quantitative addition of offals to the diet is rather small, they are excluded from the calculations of total yield and minimum herd size. Their contribution to the total diet, mainly in terms of minerals and vitamins, should not, however, be underrated.

Most of the nutritional ingredients of meat are present in milk too, but meat also contains a certain amount of iron, which is not available in milk. Both milk and meat are high protein foods and it can be assumed that if the nomadic diet was based only on animal products and if this was the sole source of calories, from a universal or national point of view this would imply an uneconomic use of proteins. The latter should be used for rebuilding the human body instead of being wasted as "fuel" by those who already have sufficient protein — especially as there is a general dietary lack of protein in many other parts of Africa and the Third World¹³⁷.

After fulfilling the basic protein demand, the remaining calories can be equally provided from other sources, such as carbohydrates. Thus, if the herd can provide a sufficient supply of milk in terms of protein and the majority of calory demands, exchanging grain or meal for meat does not necessarily imply a poorer diet, not the least if other iron sources are available. Vitamin C and some of the components present in milk such as vitamin B6 or Carotene can also be more economically obtained from cereals or vegetables than from milk¹³⁸.

7.2.3 Blood

Most East African pastoralists bleed their cattle occasionally. Amongst some peoples, such as the Nuer, who are only part pastoralists, this is seen primarily as beneficial medical treatment for the animal itself¹³⁹. In most cases it is preeminently a way of obtaining extra food in dry periods. The Samburu¹⁴⁰, the Bahima¹⁴¹ and the Maasai¹⁴² as well as

other peoples, add blood to their diet, but the Fulani in West Africa do not bleed live cattle¹⁴³.

Blood is taken mainly in the dry season when milk is scarce, and because of its properties of "strength" is regarded as a food "suitable for real men". It has also been used as food for the ailing or for pregnant women or those who have just given birth¹⁴⁴. Sometimes, as for example among the Turkana¹⁴⁵, it is a food of ritual importance, only to be taken under secular circumstances when mixed with milk.

From a nutritional point of view, cattle blood contains 7.6 % protein¹⁴⁶. The protein makes up most of the approximately 330 kcal that can be obtained from one litre of blood, while the 0.06 % fat and 0.05 % glucose contribute only negligibly to the energy yield. Blood contains a certain amount of valuable minerals, especially iron which is lacking in milk; see above. Calcium and phosphorus are also present in blood but show higher concentrations in milk.

Most authors, when describing the custom of bleeding, stress how carefully it is done. The operation, which is carried out with a special knife and spear-head, or miniature bow and arrow, should not be performed too frequently, otherwise the vitality of the animal can be impaired.

Not all animals can be bled; the Bahima in Uganda are said to bleed only young males¹⁴⁷ and the Karamojong¹⁴⁸ do not bleed stud bulls, milking or pregnant cows or nursing calves. Blood is only taken once every three months among the Karamojong. With a severe dry season the animal may be allowed to recover for as long as five months.

On the other hand the Karamojong's neighbours, the Dodoth, are said to bleed their cattle once a month in the rainy season, and less often in the dry season. The information given on this by Deshler¹⁴⁹ is in some ways anomalous. In a graph he has shown the "inferred seasonal consumption" of meat, blood and milk and in which an increase in blood consumption is shown in the rainy season. While it is true that this is the best period for

bleeding the animals, most examples from other peoples indicate that blood is a food reserve utilized during dry seasons. For the Dodoth agricultural produce is of great importance for the diet, which changes the pattern of consumption. The amount of blood said to be taken each time (0.47 - 0.94 kg) is also low, which may explain the higher frequency of blood taking than elsewhere.

Few sources agree that one month is sufficient for the wound to heal and the lost blood to be regenerated¹⁵⁰. Leakey¹⁵¹ states that no animal should be bled more frequently than at five to six week intervals if its condition is not to be impaired. The Karamojong data indicates that each blood-giving animal can sustain between two to four bleedings a year. Similarly the Din-ka of Sudan do not bleed their animals more than "a few times" per year¹⁵².

Other sources indicate that higher amounts of blood are drawn from cattle than Deshler indicates for the Dodoth. Grunnet¹⁵³ states that one to two kg are taken according to the size of the animal. Dyson-Hudson¹⁵⁴ gives 1.9 - 3.8 litres as normal bleedings. The higher amount can only be obtained from well-fed bullocks during a good season. When a bull is bled in the rainy season, the highland Borana of Ethiopia can obtain up to three litres of blood¹⁵⁵. In the lowlands, cattle are generally said to yield half a gallon (2.2 l) once or twice per month¹⁵⁶. The Pokot¹⁵⁷ take "a couple of quarts", i.e. approximately 2.3 l and the Barabaig¹⁵⁸ are said to take a gallon (4.5 l) a time.

French¹⁵⁹ has measured the volume of blood from East African cattle carcasses and found it to make up 3.4 - 3.5 % of the live weights. A fully grown animal then contains totally 7.0 - 8.5 kg of blood. Up to half of this amount may be obtained by bleeding under the most favourable circumstances.

In the calculations, a bleeding of two litres is regarded as an average amount. The cattle are assumed to be bled three times a year. When calculating the number of animals that can be bled in a herd, we include only

those categories bled by the Karamojong, and therefore leave out all calves under one year of age. The remaining categories are therefore:

	<u>% of total herd</u>
Heifers, 1-4 years old	20.9
Young males, 1-4 years old	20.9
Old cows and bulls	2.6
Slaughter bullocks 4-5 years old	5.4
	<hr/> 49.8

From a herd of 100 animals, about 50 cattle will yield annually six litres of blood each. This means 22.8 kg of protein and 99 000 kcal. Some blood can also be obtained from slaughtered animals. We have no information as to how much blood is usually lost at slaughter. Assuming that each carcass gives seven litres and that the slaughter offtake is 8 %, each herd of 100 animals will give 56 l blood at slaughter per year, or 4.2 kg protein and 18 480 kcal.

Unlike milk, blood cannot be stored¹⁶⁰. When tapped, it should be consumed the same day or shortly after. The manner of consumption varies. The Boran drink it fresh, mixed with milk and sugar or fried with ghee. The Somali mix it with honey¹⁶¹. The Maasai either drink it fresh or mix it with boiled milk in order to keep it for a couple of days¹⁶².

Gulliver¹⁶³ notes that only on rare occasions is more than one beast bled per day in a Turkana homestead. This is not surprising. As there is no other way of storing blood, it must be stored "on the hoof". During one dry period of three months, each animal can only be bled once. As the animals need time to recover, great care is necessary in order to ensure that blood is available in times of food scarcity.

In sum, the importance of blood lies more in its use during seasons when little milk is available and in its particular qualities as a source of iron, rather than its total quantitative contribution to the pastoral diet. It bears little relationship, however, to the minimum herd size.

7.2.4 Total yield of food from pastoral cattle herds

When calculating the total yield from a herd of 100 cattle the easiest method is to assume that the herd's total produce is consumed by the household itself, or that the balance between food received from and given to other households is approximately equal. In this way the offtake of milk, meat and blood from one household's herd is equal to the household's nutritional needs. The only remaining problem is to estimate the human consumption of cattle that die natural deaths or are slaughtered by necessity. A calculation based on these premises will give the following results:

TABLE 7.6: Product estimates for a herd of 100 cattle

Product	Amount of protein, kg	Energy kcal	Total yield kg/l
Milk, 210 days lactation	244.8	5 497 065	6 615
Blood, from live animals	22.8	90 000	300
Blood, from slaughter	4.2	18 480	56
Meat, normal slaughter, mean c d w 120 kg	139.2	2 268 000	960
Meat, natural death and emergency slaughter	(max 139.2 ¹)	(2 268 000)	(960)
	411.0 (plus produce due to natural death)	7 882 545	-

- 1) This figure happens to coincide with the one for normal slaughter as the expected offtake is 8 % in both cases.

If this is compared to the needs of a family as described in Section 7.1, the following conclusions can be made:

1. By the use of products from live animals and "normal slaughter", a cattle herd of 64 animals is sufficient to provide for one family's calory and protein demands.

2. If all meat from animals that die from natural causes or are slaughtered in emergencies could be saved, this would lower the minimum herd-size to 50 animals.

For reasons already discussed in Chapter 6 it is as a rule difficult to obtain clear field information on how many cattle people "own", or ought to "own", per household. This is due to the difficulties of distinguishing between the herds as ownership units, and as units for household production and the problems of counting cattle in the field.

Another problem is that much of the information is given in terms of diversified herds, consisting not only of cattle but also of sheep and goats. This type of combination is extremely common, and we will return to it in Chapter 10. Data are sometimes published only on the average size of the cattle herd, without any indication of the size of the herd of small stock - or even of its existence. As the contribution of small stock to subsistence is important it is difficult to estimate the family's dependence on cattle alone. Sometimes the "average herd size" is simply calculated by dividing the total number of animals estimated to exist in the area by the number of families. However, this means that no differentiation is made between true cattle-owners and others who may be in the same area. Furthermore, of course, such a method does not provide any information about minimum herd sizes.

Morgan and Shafer¹⁶⁴ in a widely quoted estimate, state that for each Turkana, living basically on a milk, blood and meat diet, needs six cattle. Compared with our data, this seems very low. The same applies to the estimate quoted from Hunt¹⁶⁵ by Lewis¹⁶⁶ that a family can live "comfortably" on a herd of 20 cattle and subsist on less. On this we would only agree if the herd is made up solely of mature cows giving milk, and on the assumption that the cows will go on giving milk until their calves can take over after them as milk-producers.

Some examples of herd sizes actually found in pastoral economies are given below:

The Boran of Ethiopia, with slightly different customs and economy compared with those in Uaso Nyiro in Kenya, have small families of about four persons and herds averaging 50 cattle, according to Asmarom¹⁶⁷.

Spencer¹⁶⁸ estimates that the average Samburu family in 1958-59 consisted of 6.75 persons, and for each person, including children, there were 13.4 cattle.

Dyson-Hudson¹⁶⁹ gives the range 50-150 heads as the normal ownership unit size among the Karamojong.

The Fulani of Bamenda are said to have more than 20 cattle per person¹⁷⁰. Hopen's figure for the Gwandu Fulani is 61 heads per family of 5.51 adult equivalents according to Asmarom¹⁷¹.

Deshler estimates that the Dodoth, partly subsisting on dry savannah agriculture, have four to five cattle per person in the drier zones and less in the wetter zones¹⁷². This, however, "barely provided milk to the children" in the dry season.

The purely stock-tending Barabaig have 70-80 cattle per cattle-owner¹⁷³ while their relatives, who combine pastoralism and agriculture, have smaller herds.

If we look at the proportions between the different dietary constituents in Table 7.6 we will find that they accord with Morgan's statement that the calorific value of blood and meat only forms 20-30 % of the pastoral diet, the remainder being supplied by milk¹⁷⁴; and with Brown's¹⁷⁵ conclusion that a year-round diet of 3/4 milk and 1/4 meat would not be far off the mark for nomad families.

It has already been mentioned that the importance of the different pastoral food products varies seasonally, so that milk is the staple food in the wet season, while blood and meat grow in importance as milk yields decline during the dry season. In semipastoral societies the harvest of locally grown crops often coincides more or less with the period of milk scarcity.

Exchange may also take place between goods from purely pastoral areas and neighbouring farming zones.

The seasonal differentiation between the various constituents of the diet may be culturally expressed in ritual prohibitions such as the traditional rule among the Maasai and the Nandi that milk and blood should never be consumed on the same day¹⁷⁶. Such rules follow certain common patterns, but are not universal: for example the Turkana, in contrast to the Maasai, disapprove of blood being drunk unmixed with milk under non-ritual circumstances¹⁷⁷. Another example of such rules comes from the Bahima who prohibit the consumption of grain, which is lifted in the dry season, when it is obtained by barter with meat. They also regard it improper to combine meat and milk¹⁷⁸.

There are similar individual sets of rules regulating the who eats what and when between different categories of persons, men and women, old and young. These rules vary according to the culture, to the available ecological resources and to the accepted forms of the division of labour. Among the Turkana, for example, most ritual consumption of meat is restricted to males, while blood is made available to children and women at all seasons¹⁷⁹. Karamojong men drink milk and blood in the dry season, while the women primarily consume their own grain¹⁸⁰. Among the Bahima, women consume almost all the milk in the dry season, while they are forbidden to eat goat meat, which forms a major part of the male diet¹⁸¹. Such considerations may, of course, further complicate the calculations made here, since they are based on household consumption rather than individual consumption.

The discussion so far has been concerned with herds that are only kept for subsistence. Greater difficulties arise when calculating the minimum herd size, or the yield in calories or protein from, say, 100 cattle, if means exist of converting some of the produce of the herd into agricultural goods by trade or barter. With regard to the possible contribution of farm produce made to the family's consumption pattern the ideal herd size must be individually calculated as local conversion rates vary.

In terms of protein, the demands of the "reference family" could be met by the milk and blood of only 43 live animals. However, these would provide too few calories, but if a market for meat exists, "normal slaughter" could be substituted by the sale of cattle. The shortage of calories can be made up by buying about 730 kg of maize meal. In a household owning 43 cattle, 3-4 heads could be available for trade, but this would preclude "normal subsistence slaughter".

The reader who is interested in comparing the results obtained above with corresponding figures from other sources is referred to Brémaud and Pagot¹⁸² who estimate that in the Sahel zone "the nomad with the low figure of 50 head of cattle will have milk for himself and 4-5 animals for sale per year ... and with a herd of over 100 head he will have a comfortable life ..."

The sale of nomadic cattle has often been encouraged on the assumption that this would lead to a reduction in the number of cattle. One example is provided by Asmarom¹⁸³: "It should not be too difficult to persuade the nomad to sell most of his surplus herds. He can learn to accept this constraint as a 'necessary evil' in much the same way that he has come to accept the cattle tax as an inevitable burden". However, like many other statements about pastoralists, the central point of this quotation is based on an unverified assumption that there is usually a large "surplus" in pastoral cattle herds and that this "surplus" can be disposed of because it is unnecessary for the nomad. From the discussion here and in Section 2.2 one major conclusion reached is that the only cattle that can be regarded as a "surplus" are those animals that exceed the minimum number needed for subsistence and continued herd growth. This minimum number is made up of a certain number of milk and meat producers, a sufficient number of young animals, and a "risk margin" to cover "normal crisis". The distinction between subsistence herds and fallow herds has been made clear in Chapter 6. The size of the "risk margin" is hard to establish; this topic has been touched upon in Chapter 5. The total minimum herd size must be

seen in relation to the number of people who can look after the herd and be fed by it. The existence of large "surpluses" as defined above has yet to be mapped.

Schneider¹⁸⁴, Flou¹⁸⁵, Baker¹⁸⁶ and others have pointed out that the sale of pastoral cattle generally does not bring lower herd sizes. The sales only substitute commercial transactions for domestic slaughter. In our calculations, possible sales fall within the 8 % category mentioned above as available for slaughter. Such transactions do not change the total structure of the herd, and, as can be seen from Chapters 2.4.2 and 7.2.2.3, the sizes of the milk and of the meat herd are generally related.

A further difficulty when calculating the minimum herds involved in a cash economy, is that not all proceeds from sales can be converted into food-stuff. In a cash economy money is needed to pay tax, to buy clothes and consumer goods. These needs make such a conversion impossible and create a demand for larger herds, which in turn will depend on the size of those cash needs and the relative prices of meat and grain. Furthermore, it is unlikely that all 8 % of the herd, that can be slaughtered each year, can be sold. As Fielder¹⁸⁷ states: "Few pastoralists are likely to sell beyond a point which would make them unable to meet obligations and rights to help and be helped by a wide range of kin". After all, participation in public rituals and generosity and hospitality in connection with weddings and life-cycle rituals of one's own family are important ways of establishing links of solidarity and mutual help with other members of the community. Without such links there is no security against ecological hazards. The "economic" value of social relations is easily forgotten, but administrators and planners should be reminded not to regard fluid nomadic societies as "atomistic" in the same way as Western society. Thus, the social and ritual demands on cattle can often be regarded as real needs, and not something that can be easily dismissed¹⁸⁸.

Of course, the sale of other produce such as hides and skins can provide cash for the family. Such trade does not deplete the family's source of nutritionally valuable products but reduces the raw materials available

for household utensils that in turn must be substituted by consumer goods.

Some pastoralists such as the Boran ritually prohibit the sale of milk, but of necessity have recently begun to sell it. Hedlund¹⁸⁹ recounts that where markets exist, Maasai milk sales are common. Joshi et al¹⁹⁰ also mention that the nomadic Arabs of northern Sudan sell milk at times of surplus. The Fulani in Nigeria barter milk and butter for grain¹⁹¹. In traditional pastoral societies, generally the consumption of agricultural produce is deplored unless absolutely necessary. Usually, increasing milk sales or milk/grain barter are a symptom of scarcity in the pastoral economy, rather than of surplus.

Morgan¹⁹² notes that herds in areas of low-potential grazing generally have a higher offtake percentage (10-12 %) compared with herds in better areas with a general average of 4-9 %. The same difference also applies to the smaller herds held by the less well off Maasai, as compared with the larger herds kept by wealthier members of the same society. When there are sufficient milking cattle and milk supplies, there is less need to slaughter for meat, or for sales in order to buy grain. The sale of cattle is not a sign of "progressiveness" or "sophistication" as is commonly assumed but rather a reaction created by necessity and scarcity. In this context one should be aware of the dangers of substituting a more bulky but less nourishing diet for a nutritionally well-balanced one.

8. HOUSEHOLD PRODUCTION FROM PASTORAL CAMEL HERDS

In the same way as for cattle herders milk is the most important daily product for subsistence pastoralists keeping camels¹. Meat is mainly eaten on ritual occasions and as extra food in the dry season when milk production is low. It is therefore reasonable to consider milk production first, before discussing the offtake of meat and blood which, however important, must be regarded as subsidiary to milk.

8.1 MILK

8.1.1 Milk yields

Most camel breeds produce more milk than cows in pastoral cattle herds, and give milk for a longer period of time. 18 months is the most commonly mentioned upper limit of the lactation period. According to Leese² the dam will go dry after nine months if desert fed, or go on giving milk up to 18 months if she is well-nourished. Leupold³ gives 9 to 18 months as normal for one-humped camels and 16-18 months for the two-humped variety. Rendille camels in Kenya give milk for approximately one year, and those of the Somali from 8 to 18 months⁴.

Eraskov⁵ reporting on the ranched dromedaries of Kazakhstan, Turkmenistan and Uzbekistan that the length of lactation ranges from 7 to 18 months, 7 months being normal for females who have 2 pregnancies during 3 years. Musil⁶ states for the camels of the Rwala Bedouins that they give milk for twelve months if they get pregnant one year after having given birth, but otherwise can go on for a longer time. However, other sources state that a camel can go on giving her calf milk even during pregnancy. Nicolaisen⁷ specifies that the Tuareg camels may go on yielding milk for about six months after mating. If mating is delayed, the calf may go on suckling for an extended period even up to two years. Natural weaning occurs when the

dam goes dry⁸ but Blagoveščenskij⁹ recommends that the calf be weaned at 8-10 months so that the dam can be milked until the end of the 18 month lactation period.

From Chapter 3.1.3 it will be remembered that the calving of camels is often mono-seasonal. When this occurs and when the average length of lactation drops below one year, an annual scarcity of milk can be expected during the time just before the rains when the new calves are to be born. During this period individual yields are also likely to be low due to poor nutrition. Rendille camels give a "moderate supply" even during the dry season according to Spencer¹⁰ and the Rendille people do not seem to be affected too seriously by seasonal fluctuations. But that problematical milk shortages occur for example in Somalia is evident from Lewis' discussion of the diet of camel herdsman¹¹.

As a rule the length of time in which dams give milk should mean that seasonal variations are never so serious as for cattle herds; see Chapter 7.2.1.3. To some extent seasonal variations can be evened out by storing milk.

Camel's milk becomes sour very quickly. Swift¹² argues that it cannot be made into cheese for biochemical reasons. This statement seems doubtful though, with reference to sources like Mares¹³ and Hunt¹⁴ who claim that Somali householders often store camel milk in the form of curd. Rwala Bedouins do not churn camel milk, but cook it and prepare the curds into storeable cheeses, according to Musil¹⁵. The Ahaggar and Ayr Tuareg on the other hand never store camel's milk as butter or cheese. Concerning their attitudes to camel butter Nicolaisen¹⁶ writes: "... they consider /that it/ possesses a poor taste and besides it is very difficult to churn. They make butter of camel's milk only when butter of milk from other domestic animals is lacking for greasing of the hair". As for processing opinions seem to diverge. Purchase¹⁷ mentions the simple processing of camel milk butterfat into ghee while Gulliver¹⁸ states that it cannot be churned into butter. But as indicated above, the necessity for storing milk is less marked than in cattlekeeping economies.

During the first weeks of a lactation, about one quarter of the dam's production is reserved for the calf. It is said that too much milk can cause indigestion and the calf's death. Later, the amount given to the calf is gradually increased¹⁹. Tuareg herdsman often let the calf suckle all of its mother's milk for a considerable time, a fortnight, a month or even longer depending on the mother's yield and on how much milk there is from other dams²⁰. Generally the calves start grazing at the age of six weeks, but are fully weaned later²¹. The camel calves of the Rwala Bedouin receive only milk during 90 days until fresh grass is available after the rains²². Such ecological factors as the timing of birth and arrival of rains may also influence the amount of milk available for human consumption.

Calf mortality is commonly said to be very high. The dam who has lost her calf can be induced into continuing to produce milk with the help of a doll, made out of the skin of her young²³. Sometimes one single calf can act as the stimulus for the milk production of several dams. Musil²⁴ mentions the Bedouin custom of killing male calves so as to leave more milk for human consumption. It is not known whether this is a widespread custom, and it also seems doubtful that, in the long run, it will give the same amount of milk as if the male calf was still alive. The practise of using a doll is common when the calf dies of natural causes, and is also used by many East African cattle keepers like the Boran of Kenya or the Barabaig of Tanzania²⁵. Stein²⁶, however, mentions in connection with this technique, that a camel dam presented with a doll will only give milk for a few weeks. In Soviet, camels under intensive management have produced milk for a considerable period without suckling their calves²⁷ but under poor conditions a substitute calf doll may not be sufficient to stimulate milk production until the end of the lactation period. The total yield of a camel treated in this way may be lower than that of a dam suckled naturally.

A good dam should be able to yield 9.1 kg of milk at the peak of her lactation according to Williamson and Payne²⁸. The total lactation yield of such a dam would be as much as 2 727.6 kg or even more. The figure given above

is much higher than most of the yields mentioned in other sources. Apparently Williamson and Payne refer either to camels under intensive management or have given the total yield without deducting the amount consumed by the calf and the latter cannot be deducted from the literature available.

Capot-Rey²⁹ gives the daily yield of Saharan camels for human consumption as 1.9 - 4 kg. Musil³⁰ states that North Arabian Bedouin camels might give from one to seven kg per day depending on the season and the quality of the grazing. For Kenya, Spencer³¹ gives the average Rendille camel yield as 3.8 kg per day. Morgan³² thinks that a wellfed camel of the East African type should be able to produce 5 kg per day. The tawny "grain" camels of Eritrea, primarily said to be pack animals, give daily yields of 5-6 kg for human consumption³³. A sample of 150 camels in Somalia showed an average yield of 6 kg according to Rossetti and Congiu³⁴. The same average rate is referred to by Cozzi³⁵. A very exceptional figure is given by Bondestam³⁶ who claims that Afar camels give less than 1/2 - 1 kg per day. It is difficult to say what the reason for such a low figure is assuming that it is a correct general daily average, but the Afar camels are said to be particularly small and gracile³⁷.

Given the above figures it seems that the overall average for East and North African nomadic camels is likely to be around 3 1/2 or 4 kg per day, with fairly continuous production throughout the year.

Dairy ranches with camels have been mainly established in some Soviet republics, viz Uzbekistan, Kazakhstan and Turkmenistan. Some daily records from these farms have been published: Eraskov³⁸ quotes 4 kg while Aueljbekov³⁹ mentions 6-7 kg daily for Bactrian (two-humped) camels who seem to be better milkers than dromedaries in these circumstances. There are also records of total yields during the whole lactation, ranging from 1385 to 3600 kg per dam⁴⁰.

In Pakistan total lactation yields of around 1350 kg have been recorded for poorly fed camels, and up to 3632 for those that are wellfed⁴¹. The

daily amount of milk from individual dams in a herd naturally varies according to the stage of lactation, nutrition levels, etc. The daily yields in Pakistan ranged from 9.1 kg to 14.1 kg for the wellfed animals, while those in poor condition only produced 3.6 kg per day⁴². Nicolaisen⁴³ states that the individual Tuareg female camels may yield 10 kg at the beginning of lactation but at its termination it may not give more than two or three kg even if wellfed. When the grazing is very poor, a man with 20 female camels may not get more than 2 kg of milk for his family.

8.1.2 The nutritional value of camel milk and human requirements

The milk of camels is thinner than that of cattle or goats and is sometimes said to be more difficult to digest. As seen from the following table, it is difficult to obtain data on its general constitution, irrespective of its area of production.

TABLE 8.1: Nutritional value of camel milk

	Fat	Protein	Carbohydrates; Lactose	Ash	Kcal/kg
1.	2.9	3.9	5.4	0.77	-
2.	2.9	3.67	5.78	0.66	-
3.	3.2	4.2	5.3	-	670
4.	4.2	3.7	4.1	-	700

Sources: 1. W L Davies 1940, quoted by Williamson & Payne 1959, Indian camels
 2. Yasin and Wahid, 1957, Pakistani camels
 3. Pyke, 1970, General
 4. Kon, 1972, General

The first two sets of figures in Table 8.1 agree rather well. There are also other sources who tend to agree with the fourth set with its high fat rate,

given by Kon. Purchase⁴⁴ made a sample of camels milk from the semi-arid Northern Province of Kenya. He found fat rates ranging from 3.4 % to 4.4 %. Rossetti and Congiu⁴⁵ obtained an average for Somali camels of 4 % fat and 7.3 % non-fat solids.

The farmed camels of the central Asiatic and southeastern parts of the Soviet Union give milk with even better fat yields - from 4 to 5 % for the two-humped variety and from 3.2 to 6.5 % for dromedaries⁴⁶.

As the main concern in this book is with the nomads of East and Northeast Africa, Kon's values will be used for the following calculations. This assumption should be remembered in connection with calculations of the possible output from nomadic camels in other zones, where the fat content of the milk may be either lower or higher.

To meet an adult's daily calory requirement, he would have to drink 4 kg of camel's milk. By drinking 1.8 kg he would meet his total daily protein requirement. Lewis⁴⁷ quoting Drake-Brockman⁴⁸ claims that the requirements of one Somali male can be covered by two milch camels, who will then also provide enough for their calves. This statement agrees well with the conclusions just made, especially if the camels produce four kg per day and/or the length of lactation is more than twelve months so that yields overlap. Four kg will also be used in the following calculations (Section 8.3.4) as a general estimate for daily yields. When the daily yield exceeds six kg, two camels will meet even more than one adult's requirements. Rendille⁴⁹ assert that two camels who are in milk would give enough for both a man, his wife and several small children. The "reference family" that has been used earlier in this study and which is presented in 7.1, would need 19.7 kg of milk each day to meet its calory requirements. However, 8.5 kg would be sufficient for their protein requirements assuming that calories are mainly obtained from other sources.

It may also be interesting to note that camel's milk has an unusually high content of vitamin C if drunk fresh (compared with cattle or human milk). Somali herdsmen are said to obtain most of their vitamin C from this source⁵⁰.

8.2 MEAT

As indicated in the introduction to Chapter 8, camel's meat is not everyday food for camel pastoralists, but rather saved as a reserve food in times of scarcity or for ritual consumption. Lewis⁵¹ relates that in Somalia few animals are slaughtered in the rainy season except for ritual occasions or for entertaining guests. In the dry season, on the other hand, young herdsmen in the isolated camel camps may have to slaughter camels in order to obtain food⁵². Sweet⁵³ also states that among the North Arabian Bedouins few mature camels are slaughtered except for ceremonial and sacrificial purposes. The Rwala do not regard it as everyday food, but as a luxury⁵⁴. Rendille eat it when the camel dies naturally or when the animal is slaughtered ceremonially⁵⁵. Mason and Maule⁵⁶ claim that the Somali in the countryside also eat camels that have died a natural death. This may be correct, but is doubtful since the Somali are generally faithful Muslims who regard animals that die from natural causes as polluted (*haramu*).

The difficulties met with in trying to obtain proper information on beef production from cattle herds are also met with in connection with the meat yield from pastoral camel herds. The difficulties are more apparent due to the slight interest shown in camel husbandry studies. According to Lee-se⁵⁷ the range of liveweights is 453.6 to 557.9 kg. Kababish baggage camels in Sudan weigh around 450 kg⁵⁸. Congiu⁵⁹ gives 554 kg as the average male liveweight and 514 kg as the mean female liveweight for Somali camels of the Benadir variety. The Benadir is a rather large animal used in southern Somalia and probably identical to the one common in northern Kenya. In other parts of Somalia viz in the north, the typical breed weighs 350-400 kg⁶⁰. Cozzi⁶¹ states that male Somali camels weigh on average 550 kg and female camels 500 kg. Schinkel⁶² refers to a general variation in weight between different breeds. The camels of Eastern Sudan are bigger than those of the Horn, and the camels of Afar in the Djibouti area are particularly small. Exact weights are not given. Farmed Kalmyk camels in Astrakhan seem to be much bigger than those of North East Africa, the females weighing 455-850 kg and the males 651-970 kg⁶³.

These weights generally apply to fully mature camels. Male camels are generally full-grown at the age of four to six years⁶⁴. This is also when they can be used as breeders for the first time⁶⁵.

According to Musil⁶⁶, the Rwala Bedouins value the meat of fat females highest. The ideal age is four to ten years. Older animals do not give good meat. It remains tough and tasteless even after long boiling and meat from camels under three months is considered to give indigestion. The Shammar Bedouins living in the area between Euphrat and Tigris are said to have a preference for meat from male camels four to six months old, and this preference shared by many other nomadic groups. They are usually not totally dependent on camels - dates being an important supplement to their diet - and it may be that when grazing conditions limit the number of animals that can be kept, or when it is not necessary to maximize the offtake from the pastoral part of the family's economy, the slaughter age may diminish⁶⁷.

There is no information on weights at six months of age. Bhargava et al⁶⁸ have measured the weights at birth of male camel calves and obtained 38.2 kg as the average. Aueljbekov⁶⁹ reports 35-40 kg as normal in Kazakhstan. In the latter area the optimum slaughter age for ranched meat camels has been found to be 2 1/2 years⁷⁰. As there is no information directly available on the weights of these camels either, the calculations that follow are based on the assumption that all males are kept until the age of six, and then slaughtered before they enter the age interval of 7-8 years. This presupposes an individual strategy to maximize the absolute quantity of meat from the herd.

Mean cold dressed weights are not given by any of our sources. Sweet⁷¹ states that one North-Arabian fullgrown camel is considered equal to seven sheep in its meat yield. In Congiu's⁷² study the dressing percentage averaged 54-57 %. Such averages are good compared to those for pastoral cattle, but we do not know whether they are representative for camels kept under harsh conditions. Soviet researchers⁷³ report 50 % as the dressing percentage for animals of average fatness, and 48 % for those that are leaner.

The exact proportions of bone, fat and meat are not known. These are not necessarily the same as the corresponding proportions for a cattle carcass. Thus Kuznecov et al⁷⁴ found that the meat/bone ratio was more favourable than in cattle. Nasr et al⁷⁵, when comparing camels of varying ages, found that the meat of younger camels had a higher moisture content and that higher rates of protein, crude fat and ash were found in the meat of older animals. The figures for old camels were 22.02 % protein, 1.01 % crude fat and 0.86 % ash, and for younger camels 20.07 %, 0.92 % and 0.76 %. There was no difference between males and females. The camel meat itself contains only a low percentage of fat, and this leads to a consideration of the most striking difference between camels and cattle which is the peculiar hump of the dromedaries. Although zebu cattle have "humps" these are built up of muscular tissues with only little fat⁷⁶. The camel hump, on the other hand, contains a lot of fat which can be fried or made into shortening⁷⁷. The fried fat of the hump is considered a great delicacy among Bedouins⁷⁸. Cut up and boiled it can be stored for up to three years as suet⁷⁹. The average fat yield per hump given by Mann is 15.8 - 27.0 kg⁸⁰. Camel's meat resembles that of beef in taste⁸¹. It is easily sold on local markets at least in northern Kenya and in Somalia. In Sudan there are regular camel meat markets⁸². Westerners are often said to be prejudiced against camel meat, but this is a cultural attitude having little to do with the objective quality of the meat. Borans in northern Kenya do often express a dislike of camel meat; this however relates to cultural idioms and is a way of expressing the cattleowner's clan or subtribe identity versus neighbouring camel-owning groups.

In the following calculations, each carcass will be assumed to yield 225 kg of meat and 20 kg of hump fat. The protein content of camel's meat is estimated to be 21 % and the fat content to be 1 %.

No discussion has been given yet on the possibilities of storing camel meat. The main problem is probably that 200 or 250 kg of meat is a large amount to prepare. This difficulty is pointed out by Schinkel⁸³. Storing and trans-

port may also involve problems as large amounts of meat are both bulky and can attract thieves⁸⁴.

Koche, the Boran variety of dried and cooked meat stored in fat, can be prepared from all kinds of meat, but it is a labour consuming process. The meat has to be cut into very tiny pieces. Even the larger strips prepared by the Turkana are so time-consuming that it is likely to be difficult to prepare a whole camel or even a cow in this way. Thus communal sharing is a more rational way to deal with a carcass of this type and size. Gulliver⁸⁵ has described rotational sharing of slaughter duties among the Turkana, and mentions that when a beast is shared with neighbours and relatives of the owner, the recipient families each dry and store its own share. In other circumstances ritual occasions are excellent opportunities to share meat. This does not mean that families in general can rely on others for their meat supply; the system is one of reciprocity and one can expect to be asked to contribute as much as one receives.

8.3 BLOOD

The custom of bleeding live camels seems to be common only among some East African camel herders. It is known by Nilotic peoples who have acquired camels, by Sakuye Borana and by the most western Somali. In Stein's⁸⁶ account of the diet of the Shammar Bedouin, he does not mention bleeding. He relates that when an animal is slaughtered, the blood is not collected at the ritual cutting of the throat, as the Somalis of Kenya would have done, but let to drain into the sand underneath. Musil⁸⁷ mentions that the Rwala Bedouin may either let the blood flow away or collect it in a bowl. Blood is not shunned by them as a food, but Musil gives no information on the bleeding of live camels. Maybe this should be taken as an indication that the real gain from bleeding camels is small, and that it in other places than East Africa may be substituted for other types of food.

The only source that has been found on the topic of blood yields is Morgan⁸⁸

who states that Turkana can take five litres of blood once a month from a healthy adult male. Lacking other information, this amount will be used for the calculations in Section 8.4, together with the assumption that camel's blood does not differ significantly from that of cows (76 g of protein per litre) or goats (80 g of protein per litre). We assume that camel's blood contains around 80 g of protein per litre.

8.4 COMPOSITION AND SIZE OF A SUBSISTENCE CAMEL HERD

In this section the possible total yield of food from a pastoral camel herd will be summarized, and a suggested minimum herd size will be given. The calculations are based on the herd structures arrived at in Chapter 3.2. The model herds developed there suffered from a lack of information on normal mortality rates, but as can be shown from a comparison of the structures generated in Examples 1 and 2 this did not in the long run significantly influence the proportions of fertile dams or slaughtered oxen in the two herds. The age-structure used in this section is based on computer values for the 50:th year. The examples in Chapter 3.2 represent only the composition of the female part of the herd. To this the males must be added, i.e. young males, slaughter oxen and bulls kept for breeding or for loading purposes. Let us assume that all males are kept until the age of six years. Some are then slaughtered, and some are kept until their active life as loaders or breeders is over, maybe after another fifteen or twenty years⁸⁹. If 5 % of the male animals in the ages 6 to 7 are reserved for this purpose and they are subject to the same mortalities as the females, the total ratio of bulls/dams will also be 5:100. This ratio seems reasonable if compared to ratios given in Chapter 3.1.

This gives the following composition of the herd:

TABLE 8.2: Composition of the model camel herd

	% of total herd
Calves	17
Young males	22
Heifers	22
6 year old oxen for slaughter	3
Bulls	2
Adult dams	34

The milch dams make up a larger part of the camel herd than do the milch cows in a cattle herd. As the life-span and milk-giving period of camels is so much longer, fewer calves will give rise to more milk-givers. The purpose of a certain part of the herd is not for the production of food for daily use today, but to ensure the continuity of milk supplies in the future. This part is smaller in the camel herd than in the cattle herd. It would be interesting to compare the relative efficiency of the relation milk production/ grazing requirements between an average camel herd and an average cattle herd, taking the herds rather than the individuals as the point of reference.

The relative proportions of female fertile camels and of slaughter oxen are, of course, increased if the slaughter age is lowered. If the male calves are slaughtered before one year of age, the proportion of adult dams will be 45 % and the possible offtake of meat animals will be 10 % of the herd's total number. The meat yield per animal is much lower than if the bull calves are kept until they are fully grown. If the oxen are slaughtered at the age of two years they will make up 5 % of the total number in the herd and the adult dams will be 40 % of the herd. In terms of the relative number of milk- and meat-producers such herd compositions may seem more efficient, even in terms of the relative output of milk. But whether it is more economical from a conservation point of view can only be assessed after comparisons of figures showing the grazing needs of different age and sex categories of camels.

In Table 8.2 the possible offtake for slaughter is only made up of young oxen, representing 3 % of the total herd. When the breeding animals reach the end of their reproduction life they are slaughtered. If they are killed at the age of 20-21 years this will add further 0.5 - 1.5 % to the possible offtake for slaughter. Meat from animals that die from natural causes may also be added to the pastoral diet. We have not included the meat from these older bulls and females in our calculations, due partly to the limited quality of available information on age structures, and partly to the limited quality of the meat from these older animals⁹⁰.

Very scanty informations is found in the literature on the possible offtake from camel herds. Alwan⁹¹ gives an estimate for the possible offtake from a herd of 100 camels in the western desert of the UAR, suggesting that it would be possible to slaughter 20 young camels and 12 old camels per year. Given the age structure and calving rate assumed here, such a heavy off-take would, of course, be unrealistic in a pastoral economy and would reduce the long-term viability of the herd.

The proportion of animals for bleeding does not show in Table 8.2. Only 12 % in the herd can be classified as "adult males", if breeding bulls, load carriers, bullocks and slaughter oxen over four years old are included. Not all of them can be fully used for bleeding. The loaders, breeders and those immediately reserved for slaughter may be given extra consideration or at least bled less frequently. Taking this into account, only 8 % of the herd will be regarded for the present as giving full blood yields.

Table 8.3 below shows the total expected yield from a herd of 100 camels. If the figures are compared with the protein and calory requirements for the "reference family" described in Section 7.1, it can be seen that their requirements are only 10.5 % (10.8 %) of the production of protein, and 27.5 % of the production of calories. Consequently, a herd of 28 animals would ideally produce enough for a family's requirements.

In practice individual herds are seldom composed according to the ideal or average herd; they may include less or greater number of milkproducers

TABLE 8.3: Yearly yield from a camel herd of 100 animals

	No of animals	Individual yield (Kg)	Yield from all the herd		
			(Kg)	Protein (Kg)	(Kcal)
Milk	17	1 460	24 820	918.34	17 374 000
Meat	3	225	675	141.75	664 605
Blood	8	60	480	38.4	163 968
Hump fat	3	20	60	-	527 400
TOTAL				1 098.49	18 729 973
(TOTAL EXCEPT BLOOD:				1 060.09	18 566 005)

Basic information used:

Milk: 50 % fertility, 12 months lactation, average daily yield 4 kg milk with the following nutritive values:

4.2 % fat, 3.7 % protein, 4.1 % lactose and caloric yield 700 kcal/kg

Meat: 225 kg per carcass, containing 21 % protein and 1 % fat

Hump fat: 20 kg per carcass

Blood: 5 kg per month and bleeding beast

Transformation values kcal/g according to Atwater (Wikberg 1971, p 98): 8.79 for fat, 4.27 for proteins in meat.

and animals for slaughter. Thus one cannot say safely that a family with 28 animals will always have enough produce for household consumption. Even if the herd has ideal composition, the milch dams may not give milk alternate years in exact fifty fifty proportions. On the other hand, if the herd decreases to under 28 animals there is reason to believe that either the food production will be too low or the regrowth of the herd may be endangered because the number of young animals will be too small.

What does the literature say about the minimum number of camels per family? Johnson⁹² indicates a minimum of 10-25 camels per household. Sweet⁹³ states that 18-20 dams, half of which are pregnant and half in milk, should be enough for a Bedouin family. The Rer Shammar had 20-30 camels

per household in 1917⁹⁴. But as stated above these Bedouins often have a substantial dietary supplement of dates and other agricultural produce. The number needed for a family that is solely reliant on its camels may be greater than that indicated by Sweet. Asad⁹⁵ states that an independent Kababish Arab family head with wife and a couple of small children would need 20-25 camels or a number of sheep. Lewis⁹⁶ quotes Hunt⁹⁷ who is of the opinion that 10-20 camels will suffice to support an average well-to-do family among the Somali⁹⁸. Such an "average well-to-do family" will probably have also small stock, although it is not apparent from Lewis whether Hunt has taken this into consideration. Spencer⁹⁹ talks about an "average herd of about 20 Rendille camels". There seem to be few small stock kept by Rendille camel owners especially in the northern areas: further south poor Rendille without stock try to build up new herds with goats and sheep, but apart from this, Rendille seem to rely very heavily on their camels.

In conclusion the empirical sources generally indicate a lower minimum number of camels per household than our analysis would imply. On the other hand we have not included in these calculations all the above-mentioned supplementary food sources that are available to camel pastoralists. Taking these into account, the results agree reasonably well.

Before concluding this chapter on food yields from a camel herd, one other aspect of the camel should be mentioned. This is its ability to carry loads over long distances. Trade forms a major part of the economy of many camel-owners. Therefore, this ability is a feature that can be transferred into food. Agricultural produce can be bought not only by the sale of camel meat and milk or hides and skins, but also by the profits from transportation. The comparative importance of trade in different camel economies has not yet been systematically studied and lies outside the scope of this study. Needless to say, although trade has also been important in the Horn of Africa and the Lake Rudolf region, its impact on the camel economies of Arabia and North Africa has been much greater.

9. HOUSEHOLD PRODUCTION FROM PASTORAL SMALL STOCK REARING

While the main purpose of normal cattle and camels is to produce milk for consumption, small stock is kept primarily for the production of meat. This is particularly true when the herdowners combine e g cattle and sheep/goats. Goats are often kept close to the home compound when the herds of cattle are taken to faraway pasture and water¹. Thus they can provide the remaining family members with milk. In Iran pure small stock breeding is the common form of nomadism and individuals practising "pure" small stock nomadism probably exist in all East African pastoral tribes since this kind of herd is a means of rebuild a man's wealth, see Section 10.1.

In connection with meat from cattle the symbolic significance of slaughter has been briefly discussed. The slaughter of small stock does not have the same value load as the slaughter of camels or cattle. It does not involve the same potential destruction of productivity. Sheep and goats have a very rapid rate of reproduction (see Section 4.2) and the gap after an animal is killed will soon be filled. Small stock are easy to slaughter for "guests, minor ceremonies and meat"². The meat resulting from slaughter is not more bulky than that it can be consumed by the family itself within a couple of days or stored without lengthy preparations.

In this chapter goats and sheep will be discussed separately only when the data makes this necessary. This is partly because of the great overlap in the information, partly because "small stock" of the above two kinds often are kept together and regarded as one unit.

9.1 MEAT FROM SMALL STOCK

9.1.1 Meat yield from sheep

As will be seen from the following information, the different breeds of sheep vary greatly in terms of body weight and size. The Lohi sheep of the

Thar desert in India and the Sudan desert sheep may have ram liveweights of up to 68 kg³. West African dwarf sheep have mean ram weights of 36.3 kg while the Nilotic sheep of Sudan can be really small, the males weighing from 11 to 25 kg after obtaining full size⁴.

The average carcass weight for sheep in Iran, according to Demirören⁵ is 21 kg for sheep in extensive nomadic husbandry. This is a comparatively high weight.

The Hunting Report⁶ refers to some studies on protein fed sheep of the Sudan Desert type who had a dressing percentage of 47 %. According to the same source, this is higher than one can expect from free range sheep in the Sudan. The sheep in the Hunting study, which was conducted in western Sudan, had average dressing percentages of 40 %. Their average c d w was 16.6 kg for males and 15.3 kg for females. Mason and Maule⁷ give normal liveweights of the longlegged hairy "Northern sheep" of Sudan as around 47 kg. That animal is used by Arabs such as the Kababish living in the arid and semiarid zones of Northern Sudan, while the pastoral peoples of southern Sudan keep the small Nilotic breed already mentioned.

The average c d w of sheep bought and slaughtered by the Kenya Meat commission in 1958 was 9.8 kg⁸. Using 44 % as the normal dressing percentage for sheep of pure nomadic breeds, the liveweights as Williamson and Payne suggest⁹ can be estimated to average 22.3 kg. For Maasai sheep in Kenya and Tanzania the females weigh 24-27 kg and the males 27-36 kg¹⁰. The sheep of the northern part of the area are of the blackheaded, fattailed and fatrumped Somali type, for which Mason and Maule cite a number of different liveweight averages for adult rams ranging from 33 to 52 kg.

In addition to the latter type, Somalia also have sheep of the Hejazi type, a very drought-resistant breed common to the Arab peninsula, with a normal liveweight of 32 kg¹¹. Williamson and Payne¹², in giving 44 % as the expected dressing percentage, also stress the variability of this measure, and mention that Somali sheep may have percentages above 50 and Hejazi

even as low as 35-40. This would imply male c d w for Somali sheep of 17 to 26 kg and for the Hejazi of from 11 kg and up.

In general, it would seem that the expected dressed carcass yield per nomadic sheep could be anywhere in the interval 10-25 kg. An average is therefore of little use; types of breed and local conditions must be taken into account.

9.1.2 Meat yield from goats

Goats, in the same way as sheep, also exhibit a wide variation between dwarf and larger breeds. The extremely stocky Jumnapari goats of India have, for example, an average liveweight of 79 kg for males and 53 kg for females¹³. They are, however, not adapted to arid zones and arid zone goats are generally smaller. Liveweights for Libyan goats are 50 kg and 35 kg, respectively, and for Barbari goats of the Near East the values are 40 kg and 32 kg¹⁴. The Nubian breed normally weighs around 27 kg¹⁵. In Somalia, two kinds of breeds are generally recognized; The Deguen goats that exhibit the most voracious drinking and eating habits weigh 42 and 32 kg, while the Deglier goats of the arid parts of that country and of Kenya have an average liveweight of 28-31 kg for female animals and 37-43 or even up to 50 kg for bucks and castrated males¹⁶. East African Mubende wet-zone goats have a birth weight of 2.1 kg for single born males. At weaning these goats weigh 11.9 kg and at one years age 20.3 kg¹⁷. The adult weight of the Mubende goat is also typical for the Sapel goats of West Africa, or the Sudanese Desert goats¹⁸. Another Sudanese breed, the Nilotic dwarfgoat may only weigh 11 kg when fully adult. This kind of goat is used by Nilotic pastoralists¹⁹.

Although average goat liveweights are recorded in the literature, it has been more difficult to obtain a good estimate of the proportion of liveweight lost at slaughter. Williamson and Payne²⁰ state that among the longlegged meat goat varieties like the Cutchi, Sapel and Sudan Desert breeds, the

carcass weight is approximately 47 % of the liveweight, while shortlegged varieties have better dressing percentages. 50 % will be used here as an approximation of the dressed carcass weight of East African varieties.

Payne²¹ makes some calculations based on figures from the Kenya Meat Commission (KMC) in 1952 and 1958. The average cold dressed weight (c d w) of goats slaughtered by the Commission was 12.7 kg. Using the above-mentioned approximation this would correspond to a liveweight of 25.4 kg. The goats slaughtered by KMC are likely to have included a large number of goats from breeds kept in the highlands, which are smaller than the goats of the arid zone pastoralists. Not even from the Somali types of goats would it, however, be possible to obtain more than 20 kg c d w per slaughtered animal, and the average should probably lie somewhere in between the figures mentioned.

The Hunting study of pastoral flocks in western Sudan recorded the average c d w of castrated goats as 18.3 kg and of male goats as 16.7 kg. Many goats slaughtered for home consumption were smaller than that. Wilson²² has pointed out that the dressing percentage usually used represents a smaller portion of the animal than is considered "edible" by local people. 15-20 kg can be taken as an estimate of the normal meat yield of pastoral goats but it should be kept in mind that Nilotic goats may only give 5-6 kg meat.

9.1.3 The nutritional value of meat from small stock

Applying a formula developed by Callow²³ on data obtained from French²⁴ dealing with Tanzanian sheep, Payne²⁵ tried to calculate the amount of proteins in boneless mutton. The proportion of proteins in meat P, according to Callow, is equal to $20.7 - 0.207 F$, F being the percentage of fat. The sheep carcass weight is first reduced with 8 % for bones, and then the value of F is taken as 43 % and gives 11.8 as the value for P.

From a carcass weighing 9.8 kg we should obtain 1.04 kg of protein according to Payne, which if reformulated becomes 0.106 kg protein per kg of dressed carcass. The approximate figures 0.1 kg of protein and 0.4 kg of fat correspond to a caloric yield of 4 035 kcal/kg of dressed carcass, if the conversion factors 4.27 and 9.02 kcal/g are applied²⁶. The total possible yield of meat from a flock of sheep varies according to the breed, see Section 9.1.2.

To give some estimates, a slaughtered male northern Sudan or Somali sheep of 20 kg c d w may on average yield 80 700 kcal, 2 kg protein and 8 kg of fat, a "Maasai" or "Hejazi" ram of 15 kg 60 525 kcal and 1.5 kg of protein and 6 kg of fat, and a "Nilotic" sheep not more than 40 350 kcal and 1 kg of protein and 4 kg of fat. These approximations should, however, be used with caution as they are all based on a general estimate of the yield of nutrients, and do not take into account variations in the fat content of the meat yield from different breeds. Mutton can vary substantially in its fatness, and thereby also in its caloric yield. East African sheep, e g those of the Maasai African breed²⁷ often have very lean meat, but on the other hand they have large deposits of fat in the tail or rump; Somali sheep can yield up to 2.7 kg rump fat²⁸. In well-fed European breeds fat is often stored in the muscles or tissues of the body, and so the mutton itself becomes fatter²⁹.

Indigenous breeds used under pastoral conditions in different parts of the world may also vary in the extent fat is stored one way or the other, and there may be differences in the total volume of fat in the body. Payne's article and the report by French that he refers to, are however based on information on the carcass (not mutton) composition of indigenous East African sheep. It should be noted that the yield described is the yield of the dressed carcass and so, ideally, one should add the nutrients obtainable from edible offals. These are not included in the dressed carcass weight. In goats, such edible offals make up around 5 % of the liveweight, but no information on their proportion in sheep has been obtained. The in-

interested reader is referred to Pyke³⁰ who in a table gives the proportions of nutrients of various lamb organs. Generally, offal has lower rates of fat and calories than meat, but the same amount of protein. It has also some carbohydrates and vitamins that are lacking in meat. Sheep's liver is rich in vitamin C³¹. No correction is made here for the nutritional value of offal, due to the lack of information on their relative size.

Payne assumed for the purpose of his paper that goat carcasses had approximately the same composition as sheep carcasses apart from containing less fat. We will try to estimate the carcass composition of goats from other data. The proportions of different constituents change with the sex and age of the goat, as has been shown by Wilson³² who has made the main study on this topic referred to in the literature. The calculations here are based on data obtained from Wilson, applied to East African dwarf goats with a live weight of 13.6 kg. Using Wilson's figures, the total edible portion of a goat carcass is 48.3 % of its liveweight. The nutritional values of goat meat, formulated as percent of the edible parts of a carcass, are given by Platt³³. For each edible 100 g we can get 16 g of proteins and 9 g of fat, giving in all 145 kcal (or with Wikberg's conversion rates 150 kcal). If reformulated in terms of liveweight, we should get 7.7 % protein, 4.3 % fat and 700.35 (723.63) kcal per kg liveweight.

These values, unlike those given above for sheep, include offals. However, the caloric yields of sheep are much higher than those for goats.

The arid-zone goats of Kenya and Somalia, or the near-east Barbari bucks and castrates, weighing around 40 kg alive, can after slaughter, yield 28-29 000 kcal, 3.1 kg of protein and 1.7 kg of fat. The Nubian goat of 27 kg can yield 18 900 - 19 600 kcal, 2.1 kg of protein and 1.2 kg of fat, while the little Nilotic goat of only 11 kg will provide 7 700 - 8 000 kcal, 850 g protein and 470 g fat.

The fat in a goat is distributed differently from that of a sheep. In a goat, the fat is concentrated in the viscera and not spread inter- or intramuscularly³⁴; nor does it have any deposits of fat in the tail.

The meat of young goats is tender, becoming tough in older goats. Many people regard mutton as more tender and more digestible, but some, for example the Samburu, still prefer goat's meat; it is believed by the latter³⁵ to be more healthgiving. Other peoples, such as the Sakuye of Kenya or the Saharan Tuareg³⁶ consider mutton to be superior. European food habits also give mutton priority, which often puts its stamp on the monetarized meat market.

9.1.4 Meat off-take and composition in sheep and goat flocks

What is the possible off-take from a total flock of sheep or goats? In order to ascertain this, one needs first to consider the species, age and sex composition of the herd. For this purpose, Examples 1b and 2b from section 4.2 will be used.

Many nomads keep mixed flocks of sheep and goats. The proportions of sheep and goats in the flocks are usually not specified in the literature. As a result, the calculations will be based on two flocks, one containing only sheep and the other only goats. When the total composition of the herds is derived from the theoretical female flocks of Examples 1b and 2b, some breeding sires and young male animals for slaughter must be added.

If a limited grazing area is available and there is dependence on the sale of meat from the flock, the age when the best meat is obtained can be considered as very important. Under the circumstances of nomadic pastoral life, it is reasonable to assume that the quantity of the meat rather than its quality is the main objective of the herdowners, except when meat is required for some particular purpose, or when the herdowner has a herd much bigger than required for subsistence purposes. As the control of the quality of pasture lies outside the scope of the herdowner, the main way he can increase the off-take of meat, is to keep as many breeding females as possible and to allow animals for slaughter to grow until fully mature.

Keeping them longer would entail more work and poorer quality meat; slaughter will be made at an occasion for ritual consumption or for the relief of milk scarcity. By retaining the females, the milk yields can be maximised at the same time. This is especially important in pure small-stock nomadism; in diversified herds goat milk is mainly of seasonal importance and sheep milk is sometimes not used at all.

In the model, the optimum time for slaughter will be defined as when the young male animals, probably castrated, reach the age of 18 months. The number of breeding male animals has been calculated to be 4 % of the number of mature she-goats, and 8 % of the number of mature ewes.

This gives the following composition of two herds:

TABLE 9.1: Total flock composition for sheep and goat flocks based on Examples 1b and 2b, Chapter 4.2

Sheep (1b)		Goats (2b)	
Female lambs 0-18 months	29 %	Female kids 0-18 months	32 %
Breeding ewes	39 %	Breeding female goats	35 %
Male lambs 0-12 months	21 %	Male kids 0-12 months	24 %
Male lambs 12-18 months	8 %	Male kids 12-18 months	8 %
Rams	3 %	Billy goats	1 %
TOTAL	100 %		100 %

If the meat offtake is restricted to young male kids and ram lambs of 12-18 months, it will consist of eight animals in a flock of 100. One possible way of raising the offtake is to deprive the herd of its capacity to expand each year. If we calculate the number of female kids or lambs needed to give a longterm stable flock size and slaughter the surplus females at the same age as the male kids, we can add four female kids or two ewe lambs to the offtake. This offtake can only be further raised if old does are slaughtered instead of letting them die from natural causes.

The proportion of ewes in the highest age category is 4 % of the total flock in Example 1b. In Example 2b the female goats of the highest age group make up 2 % of the total flock. When the flock is kept static, they would make up a still larger proportion, 8 % and 4 %.

It is hard to imagine a situation where herd growth would not be desirable for the individual family. To find such a situation, one must assume a static or diminishing population and the unwavering availability of grazing and water, so that recurrent periods of growth are not required as an insurance against the disturbance of mortality rates by cyclical droughts or disease.

If the various age and sex categories for slaughter are added together, the figures given in Table 9.1 show that flocks having fertilities such as those in Examples 1b and 2b, seen over a longer period of time, could have a half-yearly offtake of 16 goats or sheep out of 100 animals, assuming that the herd size is allowed to remain static. Assuming that a growth rate similar to that in Examples 1b and 2b is desirable, this offtake is reduced proportionally to be at the most 12 (sheep) or 10 (goats) per 100 animals during half a year. The annual number of animals for slaughter in a growing herd, which at the beginning of the year consists of 100 animals, would then correspond to 25 sheep or 21 goats.

How does this compare with information given by other authors? Asad³⁷ calculates with an annual offtake of 15 % from a Kababish herd. This is slightly lower than what we would expect. Demirören³⁸ states that for Iranian sheep the annual offtake could be 33 %. Brémaud and Pagot³⁹ give a similar rate, 25-30 % for the Sahel. Payne⁴⁰ using a lambing rate of 1.20 and 25 % mortality estimates a 27 % annual offtake. "Animal Production and Research in Tropical Africa"⁴¹ also considers 30 % a possible annual offtake from flocks of small stock. These figures compare well with the calculations given here.

The total yield of meat from a herd of 100 animals is summarized in Table 9.2.

TABLE 9.2: Possible meat offtake from a flock of 100 small stock

GOATS	Yield per carcass			Yield per flock of 100			
	kg liveweight			Growth according to Example 2b		Stable flock	
	kcal	kg protein	kg fat	kcal	kg protein	kg fat	
40	28 960	3.1	1.7	608 160	65.1	35.7	926 720 99.2 54.4
27	19 548	2.1	1.2	410 508	44.1	25.2	625 536 67.2 38.4
10	7 240	0.77	0.43	152 040	16.2	9.03	231 680 24.6 13.8
				(21 goats for slaughter)			
SHEEP				Stable flock			
				Growth according to Example 1b			
20	80 700	2.0	8.0	2 017 500	50.0	200	2 582 400 64 256
15	60 525	1.5	6.0	1 513 125	37.5	150	1 936 800 48 192
10	40 350	1.0	2.0	1 008 750	25.0	50	1 291 200 32 64
				(25 sheep for slaughter)			
				(32 sheep for slaughter)			

The calculations on energy and protein yields made in Section 9.1.3 were based on different formulas, which made use of the liveweights for goats and the dressed carcass weight for sheep. The information in the upper and lower sections of Table 9.2 is thus not directly comparable unless this difference is taken into account.

9.2 MILK

9.2.1 Yields of milk from small stock

Most sources agree that under traditional pastoral conditions goats are more effective milk producers than sheep. To give one example, Stauffer⁴² gives comparative estimates for the Middle East. There, goats give 50-100 % more milk than can be obtained from sheep. Only Capot-Rey⁴³ claims that Sahelian goats produce less milk than Saharan sheep, and also of poorer quality. Nicolaisen on the other hand⁴⁴ states that under Tuareg conditions, sheep excel over goats in milk quantity only during good grazing periods.

Most nomadic sheep and goat types are not specialized meat or milk animals but dual purpose animals. In the whole of Africa, there is only one breed of goat which is a truly specialized milker, i e the Nubian⁴⁵. This is, however, not primarily a dry-zone goat.

In many places only goats are milked. The Samburu⁴⁶, the Maasai⁴⁷ and the Borana Gutu in Kenya are examples of people who seldom milk their sheep, finding it difficult and giving poor rewards. Somali blackhead sheep are generally rarely milked according to Rossetti and Congiu⁴⁸. Among some peoples both sheep and goats are milked, however, e g by the Turkana and the Boran sub-group Sakuye, or among the nomadic peoples of Iran.

What are then the possible milk yields from goats and sheep seen in terms of kg per day and length of lactation? Williamson and Payne⁴⁹ state that the most likely yield for tropical goats subsisting on "diligent foraging"

would be somewhere in the range of 57-85 g per day during a short lactation period. The Njemps goat in Kenya would normally give less than 85 g (3 oz) a day, according to Maher⁵⁰. The authors of the Hunting Report⁵¹ met with difficulties in obtaining data on milk yields or lactation lengths for goats in western Sudan, but state that most of the goats were able to provide sufficient milk to feed two kids and provide a small amount in excess for their owner's use, on the forage that they picked up themselves. The length of useful production was estimated to three months.

Brémaud and Pagot⁵² estimate for the Sahel that she-goats produce 125 kg during 100 days. As nothing else is indicated, this measure probably gives the total yield available for kid and human consumption together. It can be compared with the daily 1/2 - 2 kg (average 1.4 kg) produced for human consumption by a wellfed Nubian female⁵³. The Shukria variant of the latter breed, used in the western lowlands of Eritrea and by the Beni Amer can give 1 - 1.5 kg daily (as total yield?) or 60 to 70 kg per lactation. In the least dry parts of Somalia, Deguen goats can give (totally?) 3 kg daily and "Arab" goats 1 to 2 kg per day⁵⁵. Danakil dry-zone goats were found to yield only 331 g per day during the three months after parturition⁵⁶. Rossetti and Congiu⁵⁷ recorded 325 g as the mean yield from 477 Somali goats of the typical arid-zone Deghier type. However, Boran informants in northern Kenya, where this type is common, told us that when the goats get fresh leaves to eat, they can yield even 2 kg of "very heavy" milk. This would, however, not be an average for the amount available for drinking.

The problem with many of the statements above is that it is not clearly stated whether they relate to total milk yield or milk yield for human consumption alone. The milk need of goat kids of non-specialized breeds is given by Williamson and Payne as 0.55 l per day⁵⁸, while the average litter size given by them is 1.3 (see 4.1.2). This would mean that on average 0.72 l/day are consumed by the kids. With the litter size of 1.6 given by Epstein and Herz⁵⁹ or by the Hunting Report⁶⁰ 0.88 l/day would be needed for the kids alone. No information is provided on the requirements for lambs.

Probably all the yields mentioned are to be taken as yields for human consumption. But given the uncertainty it is safer to employ only those figures which are clearly stated as for human consumption. Demiriören⁶¹ estimates the sheep milk yield of Iranian sheep to be 45 kg per year under extensive husbandry, where 0.8 lambs are born per year and ewe. This would mean a total of 54 kg per lactation. French⁶² gives 60-80 l per year and goat as the probable milk yield for human consumption under extensive herding. The corresponding figure for sheep would be 40-60 l per year according to the same author.

The normal length of useful milk production is not given by these two authors. From the other sources cited we can see that it can range from 90 to 150 days. Furthermore, the age of three to four months is the recommended weaning period for nonspecialized goat kids given by Williamson and Payne⁶³ who, however, state that lambs usually are weaned at 4-5 months⁶⁴.

In Somalia the practical upper limits of goat and sheep lactation is 150 days according to Mares⁶⁵. Should the kids suck for longer time, they are forcibly weaned by smearing the udders of the female goat with juice of an euphorbia. The reason for this is to save the mother animal. Sweet⁶⁶ gives a lactation length for Arabia similar to that given by Mares and also without specifying the two species.

In the following discussion we will use 90 and 120 days as the normal lengths of useful lactation for sheep or goats in semiarid areas.

If 70 l per year is the normal yearly yield for a goat and 50 l per year normal for a milking ewe, daily yields will be 0.52 l and 0.31 l assuming a 4 months' lactation period and 0.69 l and 0.52 l if we use the Hunting estimate, i.e. a lactation period lasting three months.

9.2.2 Seasonal fluctuations

Given a known average lactation length, the average number of milking days per year can be deduced from the frequency of births. The number

of births per adult female and year (the number of occasions as opposed to the number of kids or lambs at each birth) in the Hunting Sudan study⁶⁷ was 1.12 for the goats and 1.36 for the sheep. The average number of days in lactation per year using the estimate of a 90 day lactation period given in the same source, would be 101 days for the goats and 122 days for the sheep. If lactation was 120 days the average annual number of days when milk was available would be 134 and 163 respectively.

As births do not occur at the same rate during all seasons, one can not arrive at the expected number of lactating animals per day just by dividing the flock's expected yearly aggregate of lactation days by 365. Lambs are conceived in the rainy season and thus the sheep lactation is restricted to a period of five to eight months after the rains, often coinciding with the next rains⁶⁸. Goats breed more indiscriminately and are a reliable source of milk in dry seasons. Certain peak seasons will probably occur also among them. In western Sudan, with only one major rain season, sheep also have a dry-season lactation, as will be shown below.

The distribution of milk-yielding animals over the year is illustrated in Figure 9.1 a and b. These figures are based on data given in the Hunting Report⁶⁹ for monthly births in western Sudan. Calculations have been made to show the expected number of lactating animals each month, given 90 and 120 days lactations. The total number of female goats and ewes in the Hunting study were 152 and 177 respectively. Here, the figures are instead given in percentages for the sake of clarity.

The percentage of lactating animals in the female flock ranges from 16 to 60 for goats and from 18 to 62 for sheep. Lewis⁷⁰ notes that in Somalia rarely more than half of the animals (in the total flock) are in milk at any one time. If breeding does make up 35 % or 39 % of the total flock, it is hardly surprising that so few animals are in milk. Note the larger seasonal differences in sheep. Sheep are not milked among the peoples of western Sudan, although this is the case in other areas with a similar ecology. The figure has been included for illustrative purpose rather than to show the availability of milk in this particular area.

FIGURE 9.1: Hypothetical percentage of milkgiving does among a total female herd in a western Sudan flock (Based on birth data in the Hunting Report, 1974)

a. SHEEP

(included for illustrative purposes.
Not milked in Sudan)

b. GOATS

3 months useful lactation

4 months useful lactation

Individual milk production cannot be expected to be equal at all seasons or for all stages of the lactation. It has thus been shown for goats that the maximum daily yield is reached first after eight or twelve weeks⁷¹. For sheep, Sacker and Trail⁷² show that milk production depends on such factors as the state of nutrition of the ewe during her later stages of pregnancy and during the lactation itself, as well as on the age of the ewe. For such reasons, seasonal fluctuations are also likely to occur in the amount of milk produced per ewe or she-goat.

The amount of milk available to a family cannot be judged from the production of fresh milk only, as was seen in Section 7.2.1.6 on cattle, since some milk products such as curdled milk, cheese or ghee can be stored for some time, even for several months. This also applies to products from small stock. Barth⁷³ states that all goat and sheep milk is soured before consumption by the persian Basseri. Some is churned to butter, made into cheese or curdled and dried for storage. Similarly, the Kenyan Njemps curdle goat milk for storage⁷⁴.

The calculations that follow in Section 9.4 are based on the assumption that the herdowner and his wife can distribute the total resources evenly over the year. As was seen in the chapter on cattle, blood and milk and meat do not make equal parts of the diet all the year around. The live store of meat and blood is used primarily in the season when milk yield is low.

9.2.3 The nutritional value of milk from small stock and human requirements

Some of the major constituents of the milk of small stock are given in Table 9.3:

TABLE 9.3: Nutrients in goat's and sheep milk

	kcal ¹	kcal ²	g per kg of milk		
			protein	fat	carbohydrates
GOATS MILK:					
Williamson & Payne (1965, p 385)	-	636	34	40	36
Pyke (1970, p 43)	760	754	37	48	45
Kon (1972, p 3)	710	707	33	45	44
Devendra & Burns (1970, p 59)	-	695	43	49	41
SHEEP MILK:					
Williamson & Payne (1965, p 385)	-	1 200	67	85	43
Pyke (1970, p 43)	-	1 074	65	69	49
Kon (1972, p 3)	1 050	1 069	56	75	44

1 The calory yield as given in the source literature

2 The calory yield as calculated with conversion factors from Wikberg (1971, p 98): 4.27 kcal/g for milk protein, 8.79 for milk fats and 3.87 for milk carbohydrates.

From Table 9.3 it can be seen that ewe's milk is very fat and has a high calory yield. It also contains a higher percentage of vitamin C than is found in milk from cattle or humans⁷⁵. Goats milk is more similar to human milk. It is easily digested and nutritionists and nomads agree on its value as food for children and sick persons⁷⁶.

Both the information from Williamson and Payne and that given by Devendra and Burns is based on Indian data. For goats, Parkash and Jenness⁷⁷ give figures pertaining to a herd in the United Arab Republic almost identical to the figures given by Williamson and Payne. Pyke's and Kon's data relate to unspecified goat breeds and areas. French⁷⁸ points out that the composition of goats milk is very variable, and gives e g a range of 2.4 - 4.5 % for fat contents and from 3.4 - 5.4 % for lactose.

Rossetti and Congiu⁷⁹, however, record even higher fat contents from low-yielding Somali goats; the value given by them is 6.0 % fat and 10.4 % other solids. The corresponding rates of protein are not available.

It is reasonable to apply the highest values for fat, assuming that the same effect can be seen among small stock as among cattle, that the lower the yield the higher the fat content so that animals on the range under pastoral conditions give better values than those bred e g in Europe. The highest fat yield for goats given in Table 9.3 is the one used by Pyke, which will serve us as a base. For sheep we will use that given by Williamson and Payne.

To meet an adult man's calory requirements (see Section 7.1), 3.7 kg of goat milk or 2.3 kg of ewe's milk are sufficient. The "reference woman" would need 2.7 kg of goat milk or 1.7 kg of ewe's milk. The protein requirements of the man could be met by 2 kg goat's milk or 1 kg ewe's milk, while the woman would only require 1.5 kg goat milk or 0.8 kg ewe's milk.

A family like the one described in Section 7.1 could obtain all they require for one day from 18.3 kg of goat milk or 11.5 kg of sheep's milk.

There is not much information on the consumption of these kinds of milks. In diversified flocks they are usually kept for consumption by children or as reserves during the dry season.

A child aged between one and eight years needs between 25 and 35 g of proteins per day and from 1100 up to 2000 kcal a day. 0.9 - 1.6 litres of ewe's milk or 1.5 - 2.7 litres of goat's milk would be necessary for a pure milk diet, the amount depending on the child's age.

The reasons why milk is especially reserved for children are obviously that a) the needs of children are given priority in dry periods, b) the quality of the milk makes it easily digestible and c) that small stock are easy to keep close to the homestead which is where the small children are, while large stock cater for the needs of more mobile adults.

9.3 BLOOD

Among some pastoral cultures of East Africa, blood is taken from live goats and occasionally sheep. Examples of this are the Maasai⁸⁰ although this is denied by Jacobs⁸¹, the Turkana⁸² and the Sakuye, who take blood from these animals by piercing the vessels above the eyes. Blood from small stock is primarily a source of extra protein, the ratio being 80 g per litre plasma according to French⁸³. Sakuye informants told the authors that 2.5 dl of blood can be taken from a goat, but that sheep are only bled at slaughter, as they are generally too weak to be bled.

The blood yield of a single animal, or of a flock, is not indicated anywhere else, so its contribution to the nomad's diet will be disregarded.

9.4 FLOCK SIZES AND TOTAL YIELDS FOR SMALL STOCK

The large variations in the way flocks of small stock are utilized and in the yields from different breeds makes it impossible to generalize about a minimum viable flock. In Table 9.4 a summary is given of the possible yields from flocks of 100 heads, for various typical liveweights of goats and carcass weights of sheep. The milk yields from sheep have been put within brackets, as sheep are milked less frequently, and for the dwarf types of both species, as milking has been considered too unprofitable to be included. The "normal" annual milk yields for pastoral small stock have been calculated from French's estimates; see Section 9.2.1.

In Table 9.5 some corresponding "minimal herd sizes" for a milk- and meat-based diet are given.

Table 9.5 shows that in order to cover all the calory requirements of a "reference family" with only milk and meat from small stock, the flock size must be considerable.

TABLE 9.4: Total yearly yield of calories and protein from a flock of 100 small stock

GOATS	meat including edible offal (21 animals)		milk total 2 450 kg (35 animals)		milk and meat taken together	
individual live- weight (kg)	total yield of kcal	total yield of protein (kg)	total yield of kcal	total yield of protein (kg)	kcal	protein (kg)
40	608 160	65.1	} 1 847 300	} 90.7	2 455 460	155.8
27	410 508	44.1			2 257 808	134.8
10	152 040	16.2			-	-
SHEEP	meat excluding edible offal (25 animals)		milk total 1 950 kg (39 animals)		milk and meat taken together	
individual carcass weight (kg)	total yield of kcal	total yield of protein (kg)	total yield of kcal	total yield of protein (kg)	kcal	protein (kg)
20	2 017 500	50.0	} (2 340 000	} 130.7)	4 357 500	180.7
15	1 513 125	37.5			3 853 125	168.2
10	1 008 750	25.0			-	-

TABLE 9.5: Minimum flock size needed for the reference family's milk and meat diet

	To cover calory need	To cover protein need
GOATS: 40 kg liveweight	205	74
27 kg liveweight	223	86
SHEEP: 20 kg carcass weight	116	64
15 kg carcass weight	131	69

A survey of the literature gives a number of examples of "minimum flock sizes" required by a family, but in most cases these refer to circumstances where additional food is obtained from other types of stock, from agriculture or from trade. The latter is important in Iran, where e.g. the Bassari keep flocks of sheep and goats for milk (both types) as well as wool that can be sold or exchanged for agricultural produce. Stauffer⁸⁴ states as a wellknown fact that in Iran forty sheep/goats are the absolute minimum. Barth's Basseri informants⁸⁵ in Iran, who on average kept slightly less than 100 heads of sheep and goats, were of the opinion that to let the flock go below sixty heads would lead to the vicious decline of the flock, ending in poverty.

In Sudan, the Kababish Arabs engage in exchange or sale of whole animals or the wool and meat from their stock and so get subsidiary goods from the profits of this trade. According to Asad⁸⁶ "an independent /Kababish/ man with wife and a couple of children" – i.e. a smaller unit than our "reference family" of six – would need 40-50 sheep or a number of camels.

Among the Uaso Nyiro Boran of Kenya, goats and sheep usually form a minor complement to the cattle herds. There is, however, one area, Kula Mawe, which is considered a traditional typical "goat" area, where today a number of pastoralists have herds consisting mainly of small stock. It

is interesting to note that this is in the vicinity of a traditional salt market, and also the Boran are closest to the Meru agricultural zone, where the demand for goats has always been high.

Hunt⁸⁷ states that a Somali mother within the pastoral areas would need as few as 50 sheep and goats to exist together with three children, and on 100 animals she would subsist "reasonably" with meals every day. Lewis⁸⁸ gives almost the same information, stating that a mother with 4-5 children should have at least 50-60 animals in the home camp. The "household" so described would generally belong to a larger family, and the male head of the family would also own camels and often allocate at least one or two milk camels to the home camp. The Somali have a good market for meat stock "on the hoof" as well as for goat skins. The family economy is thus not strictly limited to the subsistence use of small stock. Even if 50-60 heads make up the minimum flock, larger flocks of a couple of hundred sheep and goats are common in Somalia — on average 150 heads per married woman.

In such trade based economies, it would again be necessary to know the exchange rates for meat, skins and wool versus food obtained from other sources, in order to calculate a "minimum herd size"⁸⁹.

The general place of small stock in pastoral Africa is as a subsidiary to cattle and camels. Among the semi-pastoral Karamojong, a "moderately prosperous" family would have 100 sheep and goats in addition to some 100-150 cattle⁹⁰. Maasai with few cattle often have several hundreds of sheep and goats⁹¹. Maher estimates that among the Kamasia (Njemps) 100 goats would be a necessary famine reserve for a family of five. The average for east Pokot families would be 129 goats. Unfortunately, this source does not inform us of the number of cattle owned by the same families⁹².

In Chapter 10 we will discuss the complementarity of different stock species. Here it should be enough to point out, that even if the flocks of sheep and goats exhibit a large potential for rapid expansion, African sheep and

goats are also very liable to rapid death due to epidemics. To rely on sheep and goats alone, particularly when such large flocks are required, may not give sufficient security under these circumstances. Someone with large numbers of sheep and goats would certainly exchange some of them for cattle and camels, which would not be affected in the same way as the small stock, and which would give a steadier supply of milk.

10. HERD DIVERSIFICATION; DIFFERENCES AND COMPLEMENTARITY OF TYPES OF STOCK

The variations in growth in pastoral herds and flocks that have been presented in earlier chapters, clearly indicate that the question of production strategy, choice of species, etc should be one of the basic issues in the international discussion about improved breeding. With the exception of the analysis of domestic food production in Chapters 7-9 the discussion here has so far dealt with either cattle or camels or small-stock, though many references have been made to the fact that pastoral people keep if possible several species at a time. This chapter deals more specifically with the differences and complementarity of types of stock; e g why people either keep cattle or camels, the benefits of combining different types of stock, their relative values as food producers, and questions concerning the best kind of stock to invest in after a drought, etc.

10.1 THE COMPARATIVE PRODUCTIVITY OF DIFFERENT LIVE-STOCK TYPES AND THE USE OF STANDARD LIVESTOCK UNITS

When comparing the various animal resources in different grazing areas or communities, many authors have found it convenient to make comparisons in terms of standard livestock units. Such units ascribe different weights to the various types of animals and make possible the comparison of, for example, 10 camels with 22 sheep, or can be used to express the overall stock carrying capacity of an area in one single figure. Very often livestock units are based on the average liveweight of different animals, or on their fodder intake. The most commonly used set of figures are the ones given in the FAO livestock statistics¹; see Table 10.1a, Column 1, while similar figures given by the International Cooperation Administration of Somaliland² also ascribe varying values for animals of different ages and capabilities; see Table 10.1b.

TABLE 10.1a: Various livestock conversion rates

	1 FAO livestock units	2 INT. COOP. ADM livestock units (See Table 10.2b)	3 BROWN SSU	4 SAND- FORD SSU	5 HAR- RISON live- stock units	6 ASMA- ROM sheep equiv- alents	7 HEADY ³ camel equiv- alents	8 HUNTING REPORT adult average
Cattle	0.8	0 - 1.25	0.5	0.36	1	2	?	1* 0.72
Camel	1	?	1	0.61	1.5	2	1	?
Goat	0.1	0 - 0.25	0.1	0.036	0.125	1	0.2	0.10 0.10
Sheep	0.1	0 - 0.25	0.1	0.036	0.125	1	0.2	0.14 0.06

* 300 kg

TABLE 10.1b: Conversion rates used by the International Cooperation Administration of Somaliland

<u>Cattle for meat production</u>	
Cows	1.0
Calves 6-18 months	0.6
Bulls	1.25
Suckling calves	0.0
<u>Cattle for milk production</u>	
Dry cows	1.0
Lactating cows	1.5
<u>Sheep and goats</u>	
Doe with lamb	0.2
Lambs 6-18 months	0.12
Bucks and rams	0.25
Suckling lamb	0.0

The FAO Production Yearbook warns that the conversion factors do not take into account regional differences in fodder consumption or animal weights, and are meant as theoretical uniform averages for the whole world. However, these figures are sometimes used for more specific areas, such as East Africa, and, together with other figures, are used to summarize stocking rates, or the carrying capacity of particular regions, or even in assessments of the minimum number of heads per family.

Even if these figures were based on averages that were specific for the smaller region, there would be clear limitations to their use. For example, the conversion factor for camels (1.0) and cattle (0.8) does not mean that an area capable of feeding, say, 125 cattle can feed 100 camels, since their respective pasturing habits are geared to different ecological conditions, see Section 10.4. This is also pointed out in the Hunting Report⁴, where camels are equaled with cattle as corresponding to one LSU.

In terms of household economy, the obvious limitation of livestock units is that the economic gain from a herd, as seen in terms of food production, is not necessarily a direct function of the average liveweight or fodder intake of the individual animals. Nevertheless, L H Brown⁵ in his calculations of the requirements of Ethiopian peasants and nomads, implicitly assumed that liveweight gives a good estimate of economic usefulness, and defines 1 SSU as 454 kg of animal liveweight; see Table 10.1a, Column 3. Allan⁶ uses the same relative conversion factors for different species as Brown, and suggests, tentatively, that a pastoral family requires 6 LSU. He, however, points out that if the problem is looked at from the point of view of household consumption instead of grazing economics, valid "Stock Units" should be based on the relative productivity of the herds. That means that both average yields and total herd composition should be taken into consideration. The Ethiopian Government Relief and Rehabilitation Commission⁷ (see Table 10.1a), Column 4, from "Harerghe Under Drought" use conversion factors that accord better with our discussion. The Standard Stock Units that are used, and that are based on figures given by S Sandford⁸, reflect "the relative productivity of different animal types, in terms of mortality, fertility, meat and milk production ... /assuming/ normal herd or flock composition". The Hunting Report⁹ makes a corresponding adjustment to normal herd composition by allowing for grazing requirements; see Table 10.1a, Column 8.

In Table 10.2 the different Standard Stock Units have been converted into cattle equivalents for ease of comparison. The table also includes the conversion factors given by Harrison¹⁰ (Table 10.1a and 10.2, Column 5, from eastern Sudan), and by Asmarom¹¹ (Table 10.1a and 10.2, Column 6); it should be noted that Asmarom only makes a rough estimate of camels and cattle as equal to two sheep equivalents. Finally, the results from Chapter 5 are included in the form of conversion factors for protein and calory yields. These factors are further elaborated in Table 10.3.

TABLE 10.2: Comparison between "livestock unit" measures converted to cattle equivalents

	1	2	3	4	5	6	7	8
	FAO	INT.COOP.ADM. Somalia	BROWN	SANDFORD	HARRISON	ASMAROM	HEADY	HUNTING REPORT
Cattle	1	1 (0-1.25)	1	1	1	1	?	0.7
Camel	1.25	?	2	1.7	1.5	1	?	?
Goat	0.125	0.2 (0-0.25)	0.2	0.1	0.125	0.5	?	0.10
Sheep	0.125	0.2 (0-0.25)	0.2	0.1	0.125	0.5	?	0.06

Results from Chapter 5	
PROTEIN	CALORIES
Cattle	1
Camel	2.4
Goat	0.02 - 0.3
Sheep	0.13 - 0.5

TABLE 10.3: Production estimates from Chapters 7-9 converted to cattle equivalents

	BASED ON	
	Protein yield	Calory yield
Cattle, including milk, blood and meat from normal slaughter	1	1
Camels, including milk, blood and meat from normal slaughter	2.7	2.4
Camels, as above but excluding blood	2.6	2.4
Goats, medium size (27 kg liveweight) meat and milk	0.3	0.3
Goats, as above but excluding milk	0.1	0.05
Goats, small (10 kg liveweight) meat only	0.03	0.01
Sheep, medium size (15 kg carcass weight) meat and milk	0.4	0.5
Sheep, as above but excluding milk	0.1	0.2
Sheep, small (10 kg carcass weight), meat only	0.06	0.13
Human requirements: adult man	5.8	13
Human requirements: reference family	28.2	64

We would like to point out, that although the rates have been based on the present state of knowledge about pastoral herds, we do not regard them as definitive since they are based on particular assumptions about fertility and mortality. We would strongly advocate that when making calculations for a particular pastoral economy, data must be obtained on fertility, mortality, nutritional aspects and yield amounts for that area. It is also necessary to take into consideration the different ways in which small stock are utilized. The importance of this is easily seen in Table 10.3 above. The most striking discrepancy between the various conversion rates lies in the relative value ascribed to camels as compared with cattle. This reflects the present lack of knowledge about the former animal. On the

basis of our calculations, camels compare much more favourably with cattle than is indicated by other conversion rates, but more information is obviously needed to establish the correct rate. However, the Tuareg estimate for the camel is as high, a fully grown camel being rated as the equivalent of 25-30 goats¹².

In Table 10.3 we have also included a "basic herd size" for the "reference family" and for adult equivalents. It is worth noting that the "basic herd size" needed to meet the protein requirements of only one adult male is larger than the commonly quoted figure from Allan¹³ who states that 6 livestock units (4.8 cattle equivalents) are required per adult.

Standard units for livestock can be most useful when the total wealth of a large aggregate of pastoralists is to be estimated. Whichever way they are calculated, they should however never be used in estimates of the wealth of individual families. This also applies to estimates of minimum herd size. Without an analysis of the actual age distribution and production capacity of a particular herd, the viability of the household/herd enterprise cannot be estimated. With more specific demographic data, it would be possible to ascribe values to different age- and sex categories in terms of their expected future production and reproduction. Such data would make it possible to estimate the "wealth" of a particular family, which is not the case today. However, it is doubtful whether such data can be obtained or whether this would be desirable from a nomad's point of view.

10.2 THE COMPLEMENTARITY OF GROWTH RATES

The higher rate of reproduction of small stock give them a special place in pastoral economies. Many authors have classified sheep and goats as the "small change of the pastoral currency"¹⁴. As each sheep or goat represents a minor value¹⁵ in itself compared with a camel or a cow, the small stock are useful "cash buffers" and can easily be sold to cover limited immediate cash needs. The gap that is left by the loss of one animal is rapid-

ly filled, and problems are rarely met in finding a market for small stock, which compared with the infrequent cattle auctions in for example northern Kenya means that it is difficult to sell cattle in order to meet temporary cash demands.

Chapter 4 shows that sheep and goats are characterized by the possibility of rapid growth. The flocks, however, can decline rapidly due to diseases and droughts, and changes and variations in the composition and size of small stock flocks occur generally rather rapidly. Cattle herds fluctuate with a lower frequency and camel herds are relatively static.

The following table presents the yearly growth rates arrived at in earlier chapters for cattle, camels, sheep and goats in fairly typical examples. These growth rates are expressed in the number of heads, as in Chapters 2-4, and in stock units, as calculated in Section 10.1. These stock units are based on potential productive capabilities of domestic stock for household consumption without respect to cultural variations that may occur.

TABLE 10.4: Typical annual growth rates*

Total herd or flock	Focus of production	Growth in no of heads	Stock units	Growth in no of stock units
Cattle	milk + meat + blood	3.4 %	1.0	3.4 %
Cattle (max)	milk + meat + blood	11.1 %		
Camels	milk + meat + blood	1.5 %	2.4	3.6 %
Camels (max)	milk + meat + blood	7.5 %		
Sheep	meat	18.0 %	0.2	4.4 %
Sheep	meat + milk	18.0 %	0.5	11.0 %
Goats	meat	33.0 %	0.05	1.8 %
Goats	meat + milk	33.0 %	0.3	11.1 %

* The figures for camels are only speculative; see Chapter 3

The stock units employed are based on milk and meat production from herds or flocks of domestic animals. The assumed mortality rates of Example 2 for camels has been used here, see Chapter 3.2, while for sheep and goats in the above table, Examples 1b and 2b (with the later age of first lambing/kidding) have been used. These examples form the basis of the calculations of stock units.

The maximum annual growth rates for cattle and camels is 11 % and 8 % respectively; see Chapters 2.4.2.6 and 3.2. For goats Example 2b in Chapter 4.2.2 provides an annual growth rate of 41 %. However, this figure, based on the birth of kids at an early age, cannot be regarded as the theoretical maximum. In order to calculate this the highest degree of multiple births should be used together with the assumption that all female goats reproduce twice a year. This results in the maximum annual growth rate for goats being considerably higher than 41 %. It can be noted that Spencer has estimated the possible increase of a flock of small stock among the Samburu to be four times the rate for cattle¹⁶.

The various typical yearly growth rates can be compared with estimates given by other authors. This has already been done in the chapters dealing with the different domestic animals. It is sufficient to state here that there is no point in generalising about pastoral herd growth without mentioning what types of "pastoral herds" are concerned¹⁷.

The table also shows that the annual growth rate for goats, expressed in the number of heads, is by far the largest. If the growth rate is instead expressed in stock units, sheep and goats intended for meat and milk production are still outstanding with a rate of 11 %. Cattle and camels show a considerably slower rate of increase, around 3.5 %¹⁸.

Small stock are more vulnerable to disease than larger stock. Thus, investing a household's surplus in small stock involves taking greater risks but may give a higher return in terms of meat and milk for consumption. For a pastoral household the best strategy would obviously be to diversify the herd as much as possible, whereby large stock make up the "big mon-

ey" and small stock the "change", using the analogy of domestic animals as capital and where the "change" can accumulate very quickly.

The situation is very similar to the Jamaican fishing-men described by Davenport 1960. Here, fishing-gear could either be placed at some distance from the shore providing large fish but with the risk of losing the gear, or close to the shore providing smaller fish but with little likelihood of equipment losses. Using knowledge of the probability of epidemics to affect flocks of small stock it would be possible to treat herd diversification in a formal manner employing game theory, in this case a two-person (the pastoralist household versus nature) zero-sum game¹⁹.

For poor pastoral households that have lost all, or most, of their domestic animals the situation can be interpreted as follows. Given that they cannot rely on their herds or flocks for household consumption, there remains only one opportunity for rebuilding their herds, with the exception of redistribution. It is assumed here that their social space has been emptied of domestic animals that could be redistributed. Thus all possible surplus is invested in small stock, especially goats. The risk involved is that the whole flock may die from recurrent epidemics or droughts. If not, the growth rate of the flock is rapid. The off-take from the herd can then be used for the acquisition of larger stock which is less of a risk in terms of disease or drought, and more reliable as a producer for household consumption.

There are many examples of poor households investing in goats and sheep. Jacobs²⁰ mentions this in connection with the Maasai in Kenya and Tanzania. Spencer²¹ relates how many poor Ariaal Rendille (in northern Kenya) prefer to invest in small stock rather than herding other people's camels. Stockless Boran (in northern Kenya) who take paid jobs as policemen or herdsmen on commercial ranches often invest in small stock, so that they can build up their own herds. When Kababish men (Sudan) earn camels from herding activities they systematically exchange them for sheep until they can establish themselves as independent households²².

B A Lewis gives an example from the Murle, living north of Lake Rudolf, of how a herd of cattle can be built up by means of small stock. There are a number of occupations that the less well-off Murle can engage in, such as the handicrafts, small scale trade, the cultivation of tobacco, or hunting and fishing. Through the sale of their produce or through gifts of meat and fish they can acquire small stock as payment or gifts. Then, having established a flock of small stock, they lend rams and bucks for breeding purposes to livestock owners, and as traditional payment receive oxen in return for their service²³.

According to our Boran informants in northern Kenya, small stock breeding entails something of a gamble. Large flocks of small stock entail greater risks than having a subsistence herd of cattle, as epidemics spread very rapidly among goats and sheep, killing off all the animals.

Sheep, with their need for frequent watering and constant access to grass, become very weak in times of drought and become highly susceptible to disease. During these periods "it is sometimes impossible to distinguish between the mortality from disease and that from starvation"²⁴. Similarly goats are easily affected by contagious pleuropneumonia when heavy rainfall finally arrives after a period of prolonged drought²⁵.

This is one of the reasons for converting at least part of the small stock wealth into cattle. Another explanation might be that in East Africa, a cattle-economy is more efficient in terms of the labour input/food output ratio. The size of a flock of goats and/or sheep, to provide for one family's total food requirements, is obviously very large (see Section 9.4). When grazing is scarce, the labour input for such a flock will also be large. Large stock also have the advantage of longer lactation periods.

10.3 THE SEASONAL AND NUTRITIONAL COMPLEMENTARY OF DIFFERENT TYPES OF STOCK

In the sections dealing with the production of food in the various types of

herds, the seasonal variation in the composition of pastoral diet has been briefly touched upon. It has been stated that meat and blood often are major items of the dry season, while milk is the staple food of the wet season.

Variations to this pattern occur primarily when agricultural produce is easily obtainable.

The combination of different livestock species has implications for the seasonal dietary composition. Many observers have noted that goats tend to give milk during the dry season when bovine milk is scarce. This is a direct result of their shorter length of pregnancy²⁶. In Figure 10.1 the curves from Figures 7.2 and 9.1 have been superimposed on each other. They show the hypothetical number of lactating animals in herds of adult female cattle, sheep and goats in an area with one major rainy season (and with no important fodder alternative sources than the grasses, herbs and bushes of the open range). The number of lactating sheep rises markedly during the period when the number of lactating cows is lowest. It should be

FIGURE 10.1: The percentage of lactating cattle, sheep and goats in an area with one major rainy season

remembered however that they were not used for milk in the case that Figure 9.1 was based on. The number of lactating goats follows a curve which is slightly higher in the dry season than that for cows.

It appears that goats, conceiving in the rainy season, like sheep do, respond quicker to the arrival of rain than sheep so that they will begin giving milk at an earlier stage in the dry season.

It is likely, however, that goats, being able to browse dry bushes, can make use of the available fodder resources for a longer period than cattle, and do not react to dry periods with a drop in individual milk yields in the same way as cattle and sheep. In an area with two major rainy seasons, the dry period is much shorter, and the greater number of lactating goats can, to some extent, compensate the reduction in milk yield from individual cows that occurs as a result of the temporary reduction in quality of fodder.

Combinations of goat milking and cattle milking can be given for both climatic types, for example Maasai, Somali, Karamojong, etc. A curious exception, however, are the pastoral Bahima of Uganda, discussed in Section 7.2, who never milk goats and generally state that goats are detrimental to the welfare of cattle and make cows "disappear"²⁷. Occasional sheep in the cattle herds are, on the other hand, seen as a blessing, but are not used for subsistence purposes. From a pastoralist point of view the Bahima seem to live under rather exceptional conditions in a relatively well-watered area, and it may well be that the combination of goats and cattle either has other ecological implications than elsewhere, or that the actual need for "evening out" seasonal food resources is very small.

Some aspects of the complementarity of large and small stock from a dietary point of view are related to their rapid rate of reproduction. This characteristic makes small stock good investment objects for members of pastoral groups without stock. But herding small stock is also advantageous from a dietary point of view. When, for example, drought reduces the fertility and

concomitant milk production of a herd, cattle and camels begin lactation relatively slowly when rainfall arrives. Goats that have survived the drought start to give milk as early as five months after the first rains, while larger stock take considerably longer because of their lengthier period of pregnancy. This has been pointed out by Swift²⁸.

Under normal conditions small stock can be slaughtered to meet temporary demands for meat when milk is scarce, when guests arrive, or when minor ceremonies are carried out. In addition they can be sold to meet temporary cash needs. The long-term perspective that the slaughter of a camel or cow involves is not entailed with goats or sheep, since the latter reproduce rapidly and each unit has a low value. See Section 10.1 for further comments on this aspect.

Other aspects of complementarity are closely allied to the management practices associated with each species, which will be discussed in the next section. Larger stock are often taken considerable distances from the settlements during the day. Small stock, especially goats, can be kept close to the homestead all the day, and so provide a convenient store of fresh milk for the benefit of children²⁹.

10.4 ECOLOGY AND LABOUR; IMPLICATIONS FOR HERD DIVERSIFICATION

In Section 10.1 the dietary and seasonal complementarity of different breeds was briefly commented upon, and in Section 10.3 the complementarity inherent in the different growth rates was discussed. Herd diversification offers advantages in terms of spreading the available food resources over the year, and that the slower growth of herds of large stock can be alleviated by their exchange for small stock. In addition a herd owner with different types of stock is not as vulnerable as one with only one major species; misfortunes are more likely to hit all animals, if they are liable to get the same diseases, use the same type of ecology, etc.

The previous discussion has been concerned with the different capacities of stock in terms of production and reproduction. But the choice of a pastoralist is limited by other factors; animals cannot be combined solely according to their growth rates or milk yields. Different species have different fodder requirements, are adapted to different ecological conditions, and their behavioral differences create varying degrees of difficulty in their tending, which has consequences for the division and organization of labour within the pastoral group. A summary of the ecological and organizational aspects will be given in the remainder of this section.

10.4.1 Management requirements

10.4.1.1 Camels and cattle

It is usually impossible to manage both cattle and camels in the same herd. If there is sufficient manpower they can be kept in two separate herds, but as a rule they cannot be kept in the same area.

There are several reasons for this. The obvious ones are the animals' different abilities to travel, and differences in grazing habits and water requirements. In the type of marginal drylands inhabited by pastoralists, access to water points often limits both the number of animals in an area, and the species that can survive.

In general cattle have to be watered frequently. Baxter³⁰ reports from the Boran of Marsabit and Moyale districts in Kenya, that all cows, whether dry or lactating, should get water at least every second to third day in the arid lowlands. Higher on the mountain sides or in the highlands, water every fourth day is sufficient. Chenevix-Trench³¹ gives watering every second day as general for milk cattle in northern Kenya. Lewis³² states that nomadic cattle in Somalia can go unwatered for up to four days, and in Williamson and Payne's animal husbandry handbook every second or third day is recommended as a general rule for cattle in the tropics³³.

French³⁴ found that mature tropical oxen in Kenya drink 35 litres when they are watered every second day. Payne³⁵ found that Zebus in semi-arid environments require daily 0.19 - 4 litres of water per 45 kg liveweight. When giving recommendations for the provision of water to ranched cattle, Williamson and Payne³⁶ suggest that each animal should have at least 45.5 litres of water daily.

The amount of water needed is so large that, in the absence of lorries, it is more convenient to bring cattle to water than the other way around. The need for frequent watering means that cattle cannot be taken far from the wells. Williamson and Payne³⁷ state that the grazing area is limited to a radius of 8 km, assuming that cattle are being taken to the wells each day.

Nomadic cattle in the Sahara must be watered twice a day in the dry season and consequently cannot be more than 4-8 km from the watering place³⁸. The grazing area can be expanded by watering cattle one day and allowing them to graze the following day, but even then, the cattle will still need to be relatively near to water.

The effective grazing area is limited to a circle around the homestead where the radius is half the daily manageable distance. Within this circle the most heavily grazed area will form an ellipsis. This general pattern has been explained by Spencer³⁹.

The pattern may be complicated by topography or the presence of other households within the same zone, the use of riverbeds rather than waterholes or wells, etc. The radius is normally about 12 km according to Spencer, who also notes that cattle have a tendency to spread while they are walking to the wells, so that the herdsmen must zigzag between them to keep them together.

Baxter⁴⁰ estimates that the ideal distance between well and homestead (where cattle are kraaled during the night) is five herding hours; the average speed when driving milk cows to water or back to their calves is 3 - 3.5 miles per hour (4.8 - 5.6 km/h); i.e. a total distance of 24.28 km can be covered.

FIGURE 10.2: Effective grazing area for cattle between a settlement and a water point (From Spencer 1973 p 15, cf Groeneveld 1968, p 228)

However, a day's journey of this distance is likely to be too strenuous. Brémaud and Pagot⁴¹ estimate that Sahel cattle can travel 15-20 km per day, and Van Raay⁴² found the actual daily averages for semi-nomadic Fulani cattle to be 16 km walking at 1-5 km/h, with a maximum distance of 30 km.

This discussion on the producing herds is not directly applicable to the fallow herds. For them the animals should only survive without necessarily producing. They can therefore be herded at greater speed and under more harsh conditions than the milk cows of the subsistence herd.

Van Raay has made a detailed study of herding and grazing activities for sedentary and seminomadic Fulani⁴³. In the dry season, these West African herders spend around 10 hours grazing their cattle⁴⁴, for a minimum

of 7 1/2 hours when fodder is abundant and for a maximum of 12 1/2 hours when it is scarce. Williamson and Payne⁴⁵ estimate that working cattle should graze at least seven hours a day, and this leaves around two and a half hours as the maximum time that is available for the outward and return journey, giving 12.5 km as the farthest possible distance to the grazing area. In order to increase the time available for grazing, and reduce loss of body water, cattle are sometimes moved during the night⁴⁶, although this is generally only possible when there is moon-shine.

When cattle are allowed to graze freely they will first take the best grass close to the wells⁴⁷. Nomadic pastoralists generally try to avoid this, so that grazing furthest from the wells is used during the wet season, when cattle are stronger and can travel longer distances.

Camels, on the other hand, can go considerably longer than cattle without water. The reasons for this exceptional tolerance to drought have been explained by Schmidt-Nielsen⁴⁸ in terms of the following physiological factors. Camels can stand fluctuations in body temperature even exceeding 6°, and instead of using water for cooling, they "store heat" during the day and slowly dissipate it during the night. This means that the loss of water during the day is much less than for animals that perspire greatly or that like cattle and sheep⁴⁹ have a high respiration rate in order to lower the day temperature. The hair of the camel acts as insulation against heat, and in addition, camels have very efficient kidneys which concentrate impurities in the waste water of the body, so that the water can be recirculated several times.

Williamson and Payne⁵⁰ recommend that where practicable, camels should be watered every day. In semi-arid and desert conditions this is of course seldom possible, but camels manage without being watered this frequently⁵¹. For Example, Ruthenberg⁵² indicates that in the hot period dromedaries in the Sahara need water every two or three days, and in the cool season every two to three weeks.

Rwala camels get water every day only at the height of the dry season, each time taking 70-80 l⁵³. In northern Sudan, camels are watered every nine days during the hottest period, but in the cool, wet period they are not even given water from one month to the next⁵⁴.

In Somalia, camels can go for two to three months without water when the pasture is green, while during the dry season they require watering every 14th day according to I M Lewis⁵⁵ and every third to seventh day according to Leese⁵⁶. For northern Kenya, Chenevix-Trench⁵⁷ states that every tenth day is sufficient when pastures are green but when dried up every four to five days is the maximum period. Spencer⁵⁸ states that Rendille in the same area never water their camels more often than every ten days. Generally, water requirements are correlated to the quality of the fodder; dry or salty fodder thus necessitating more frequent watering.

Leese found that camels who had water everyday drank around 36 l, but if they had gone a long time without water they drank up to 91 l. If a large and thirsty camel herd is to be watered by raising water manually from a deep well, the labour input and organizational efficiency needed is considerable⁵⁹.

The frugal habits of the camel enables them to be kept further away from wells than is possible with cattle. The form of a camel grazing area does not necessarily take the shape of a circle or an ellips, particularly not in the case of land grazed by dry camels. The general form can be described more as a loop of successive grazing circles.

The herders' camp is continuously moved with the camels and is not, in the same way as the cattle settlement, a camp in the center of the grazing area, sometimes stationary for several months. Depending upon the grazing, the herders will only camp for one night or for a limited period. In Somalia, the period rarely exceeds a couple of weeks⁶⁰.

FIGURE 10.3: Schematic description of camel grazing area

Even when camels are kept in stationary camps, they can move further from wells than cattle can, because they can move more rapidly between the grazing and the wells than cattle. Spencer⁶¹ writes "Moreover, camels jog to their daily browse at a steady 3-4 miles per hour (4.8 - 6.4 km/h) which gives them more time when they reach a suitable spot, and is also less tiring for the camel herdsman - as long as they have the herd under control." This last issue is important, as camels are easily frightened and it is difficult to reassemble a herd that has been panicked e g by a lorry.

Most of the information on the possible speeds of camels relates to loaders and riding camels. Specialized riding camels can jog 65-80 km per day, or even 130 if they are only carrying a rider without a load⁶². This speed can be kept up for at least a fortnight⁶³. Musil even mentions that good riding camels of the Rwala Bedouins are able to graze while being ridden and without stopping⁶⁴. Baggage camels, keeping a lower speed because of their loads, move at 4 km/h on average, and can cover at least 24 km per day for an indefinite period⁶⁵.

Spencer⁶⁶ points out that the effective grazing area of the camel is limited by the herdsman's rather than the camel's ability to move. 25 miles (40 km) is the maximum distance that a man can cover each day at least in the hot arid Rendille areas. Thus a radius of 20 km is the furthest distance that can be travelled from the camp site.

Williamson and Payne⁶⁷ recommend that camels are allowed to forage for at least six hours per day, and when compared with Spencer's information this seems to be the maximum when combined with maximum walking distances. Assuming a total of twelve hours of daylight, the outward journey to the grazing areas takes three hours, foraging six hours and the return journey three hours. In the most hottest part of the day, camels do, however, rest rather than forage, and this reduces the time left for travelling on a normal foraging day, assuming that the herd is not in transit to better grazing areas.

Generally, the low water requirements of camels means that it is possible to keep them in areas unsuitable for cattle, and in this way zones that would otherwise be unexploited can be made use of. This does not mean, however, that camels just use those areas "leftover" by cattle. The climate and vegetation of areas suitable for cattle are often quite unsuitable for camels.

Camel feed on browsing, primarily from low bush plants like camel-thorn and salt worts⁶⁸. Browsing is preferred to grass; prolonged grass feeding is even undesirable⁶⁹ although some sources⁷⁰ claim that grazing camels are common in Somalia. Cattle on the other hand browse only when grass is scarce. This means that cows and camels generally do not compete for the same kind of fodder.

Johnson⁷¹ claims that cattle dislike salty vegetation, which is usually an important source of salt for camels⁷². Salt is a third component urgently needed for pastoral animals, besides water and grazing, and is recognized by both camel nomads and cattle herders⁷³. Except for salt-herbs, other possible sources are salt-licks and brackish water which can be used by cattle as well as camels⁷⁴.

An eternal worry for the cattle pastoralist is the disease trypanosomiasis. This is transmitted by the glossina fly or tsetse. For a short presentation of the more important tsetse flies, see Manson's Tropical Diseases⁷⁵. Tsetse have very specific demands on their habitat. Porter⁷⁶ summarizes as follows: "The necessary habitat involves heat, moisture and shade, all in close proximity, and accordingly moist lowlands and drier plains of thicket and dense Acacia thorn scrub near perennial streams are commonly tsetse infested". In agricultural zones, tsetse-encouraging vegetation can often be cleared⁷⁷, but in areas too dry for agriculture it is left.

One such area which has traditionally been too dry for agriculture but is seasonally too wet for stock-keeping is Kinna on the border between Boran and Meru areas in Kenya. Boran herdsmen dislike the area during the wet season due to the prevalence of tsetse. Hornby⁷⁸ even argues that the nomads have to constantly overstock the area in order to keep it arid enough to reduce parasitism. Whether this is true or not, when the area becomes too humid this also leads to other disadvantages. Fulani avoid taking their cattle out to graze early in the morning during the rainy season, to prevent them becoming infected with diseases as well as to prevent them eating wet grass, which is filling but of little nutritional value⁷⁹.

Although cattle can be affected by these disadvantages, they can on the whole tolerate them much better than camels. Cattle have a higher resistance to diseases carried by ticks and insects, parasites that are particularly attracted to the young calves of both species⁸⁰. Although tsetse does not occur in camel areas, trypanosomiasis can be spread among camels by "almost any kind of biting fly"⁸¹.

The low resistance of camels might explain why they are not penned together with cattle during the night. Spencer⁸² argues that common penning can lead to latent diseases being transferred from the more resistant cattle to the vulnerable camels.

It also appears that in general camels dislike high humidity⁸³, which can

be detrimental to breeding⁸⁴. Camels are seldom found in areas with more than 350 mm annual rainfall (exceptions being parts of Somalia and the Jijiga area in Ethiopia)⁸⁵. In Senegal, Rousseau found that they were restricted to areas with at least three totally rainless months⁸⁶. It is, however, not completely clear in the source literature whether high air humidity in itself is a negative factor, or whether it is a causal factor of disease or the occurrence of fodder that is disliked by camels.

The different habits of camels and cows have been commented in terms of their long-term ecological consequences. An explanation of the Somali expansion into Galla areas during the last two hundred years is attributed by Asmarom⁸⁷ to this difference: "The process of displacement seems largely ecological in nature ... " "When drought hits, the Borana move west and south and the Somali move into the newly vacated territory. The Somali camel herds can survive on thornbush which cattlemen have no use for ... " "After one or two seasons have elapsed, the Borana find it virtually impossible to return to their former grazing grounds, because the land is by Boran standards perpetually overgrazed. "

Although this is a fascinating hypothesis, it can be discussed on a number of levels (not least at the level of empirical ethnographic history). In this context the relevant question is whether camels really do create an expanding zone of aridity. There have been camels in the Horn of Africa probably long before there were Somalis. Bulliet argues that camels must have come to Somalia and Socotra from southern Arabia in the period 2500 - 1500 B.C.⁸⁸, and have been introduced by people who were already pastoralists. Thus the idea that ecological consequences of the extent hinted at by Asmarom, would not have been felt in southern Ethiopia and northern Kenya until during the 19th century seems unlikely.

Brown⁸⁹ appears, however, to take the opposite view. The camel, he argues, is the ideal arid zone animal seen from a conservation point of view. While cattle must keep close to wells, resulting in overgrazing of the areas around the wells, and by their repeated trekkings make deep erosion fur-

rows, camels do not need to remain in the same area to the same extent, browse instead of destroying the grass cover shielding the soil, and finally their soft, broad hooves do not destroy the vegetation cover.

Whether camel browsing is so extensive to effect rainfall and regrowth by destroying trees and bushes after the soil cover has already been damaged, must be left to the ecologists to discover.

The differences in ecological requirements also result in the requirement for different forms and quantity of labour. Camel herders must be fit and healthy in order to move about freely and to follow the herd at speed. This task seems to be universally allocated to young men. In Somalia they are between seven and twenty years old⁹⁰ and among the Rendille young men over fourteen are considered suitable⁹¹. Women tied down by child care cannot follow the herds, and are generally unable to look after camels with exception of those that are used for milk or transport and therefore kept at the homestead.

Camels also have a tendency to stray. While browsing, they do not keep together but in looking for browse easily get further and further away from the herd, and having a poorly developed sense of direction, do not find their way back again⁹². The trouble created by this is considerable, and an owner can spend several days looking for a lost animal. This is a task commonly allotted to the senior herdowner himself. Pregnant camels may leave their herd in order to give birth in the bush, and also disappear. Sometimes the fast speed of the camel can also be a disadvantage to the owner because it is very easy to steal a camel and then quickly disappear⁹³.

Cattle are as a rule, much easier to control. They do not move very quickly and they graze in herds. Cattle who have calves are eager to return to them in the evening. This means that in areas where there is little risk that animals will be taken by marauders or raiders, the herd can be left alone without herders, returning by itself with the dry stock following those with calves.

This is, of course, not the general pattern, but it is common among the Turkana⁹⁴ and in some parts of Sahara⁹⁵. It is also said by Cunnison⁹⁶ that the cattle of the Humr Arabs in Sudan sometimes even leave the camp at night of their own accord and then return to the right pen, leaving and returning as a herd. In addition the Borana at Uaso Nyiro told us about particular areas where it was possible to allow cattle to look after themselves.

Camels left to look after themselves in this way are less frequent, but are mentioned by Swift, Schinkel and Ruthenberg⁹⁷. In north Arabia Musil maintains that only sterile young female camels and other non-fertile females are left to stray in search of the best pastures⁹⁸.

Where cattle have to be watched, which is usually the most common case, they can be herded by a wider range of people than camels. The hardships that are met are to a large extent due to the presence of raiders and carnivores; where protection against these are necessary, the task of herding will be limited to young men.

Another important factor affecting labour organization is the type of water sources that are available. Taking water from a wet season water pond or from a riverbed, unless it is dry and requires digging, usually does not create any labour problems. When water is taken each day from a shallow well or water hole, the total labour input seen over a period of time is considerable, but even though it is hard work it can be carried out by a limited number of persons. Among the Borans of Uaso Nyiro, this task is allocated to young people, men as well as women, depending upon the labour available in the camp. In other areas, for example, the Marsabit area, watering is often done from deep wells, "at the bottom of precipitous and rocky paths", where several strong men have to stand at different levels, forming a chain, each one handing water to the next. Between four and forty men can be required for this task according to Baxter and this necessarily involves several households⁹⁹.

It is not possible to distinguish a particular type of well used for watering camels or cattle, but it seems reasonable to assume that water is general-

ly more difficult to obtain in camel areas. If the camels have gone thirsty for a long time, the amount of water that has to be brought up from the well per animal is twice that necessary for cattle. To water a herd of thirsty camels returning from the camps is therefore much more labour-demanding than watering an equivalent herd of cattle, but this may, on the other hand, be compensated by the fact that each household has a smaller number of camels.

10.4.1.2 Sheep and goats

Small stock, especially sheep, have to be watered more frequently than large stock and must therefore be kept close to the wells most of the time, at least during the dry season. Their daily water intake ranges from zero to 0.7 litres of water per day, and this limited amount means that it is sometimes possible to take water to them rather than to bring them to the wells¹⁰⁰.

In the Kababish areas of Sudan, sheep need to be watered every fourth day in the dry season. Goats can manage for a longer period, but are usually watered at the same time as the sheep, because they are usually herded together¹⁰¹.

The Boran and Somali also keep sheep and goats in mixed flocks, and generally refer to them with a common term. In the Boran highlands, the herds can manage without watering during the whole wet season, but Boran opinion does not accept that small stock except occasionally are kept in the best cattle areas. In the semi-arid lowlands, small stock are watered at least every two to three days¹⁰².

Samburu and Rendille let their small stock go without water in the wet season from ten to fourteen days or even longer, but for only up to four days in the dry season¹⁰³. In Somalia, sheep and goats fed on green pasture can go without water for two to three months, but must be watered every four

to eight days under normal, dry conditions¹⁰⁴. Pregnant and lactating animals need water more frequently.

In many areas both in North and East Africa sheep and goats are kept together despite their differences. This has practical advantages. Goats act as flock leaders and lead the sheep to graze in a wider area¹⁰⁵. Nicolaisen writes: "The goats then always march at the head of the flock ... It may happen however that goats and sheep become divided during grazing, as goats move too quickly for sheep to follow them ..."¹⁰⁶. Like camels, sheep have a tendency to stray. "The Tuareg say that sheep are more stupid or less intelligent than goats. Sheep do not respond to their names, they become more easily lost during grazing, and they do not return to the camp by themselves" (*ibid*).

Sheep that become lost in this way, and that wander off on their own, are very easy prey for lions and hyenas¹⁰⁷. They are very flock conscious animals, normally, and stay bunched together when grazing¹⁰⁸. If one animal runs away, the others are likely to follow, so that a large part of the flock can even run away in the middle of the night¹⁰⁹. Goats spread more while on the pasture¹¹⁰, but the flock does not split up totally. They could even graze without a herdsman or only accompanied by a small child and return by themselves at sunset¹¹¹. When flocks of sheep and goats meet danger, the goats tend to spread in small groups forming a line facing the danger, at the same time leading the sheep away from it¹¹².

Herding difficulties arise when the proportion of goats to sheep in the flock is decreased. "Goats need constant attention but the work is easy" writes Swift, while sheep tending is "labour-intensive, demanding full time shepherd"¹¹³.

The need for a constant, preferably daily, supply of salt is particularly important for small stock¹¹⁴. Spencer notes that the areas primarily used for small stock are those where both salt licks and continuous water supplies are available¹¹⁵. It is significant that the area considered by the Uaso Nyiro Borans as most suitable for goat breeding lies close to a salt crater.

The grazing requirements of the two kinds of animals differ somewhat. Sheep are selective grazers, that need areas where grass regenerates at regular intervals. Goats survive on thorny bushes and Acacias¹¹⁶, but they also eat grass. There are differences in the dietary preferences between different breeds of goats, and also variations in individual tastes. The goats diet is one of the main ecological controversies, summarized long ago in the title of Colin Maher's book "The Goat - Friend or Foe?"¹¹⁷. The discussion mainly concerns the question of whether they create erosion or have a beneficial effect on grazing areas, keeping down tsetse-infested thicket and clearing bush¹¹⁸. French¹¹⁹ gives a good review of this discussion and summarizes some of the data concerning the characteristic behaviour of goats.

Goats do not like moist conditions, but are well adapted to both cold and hot climates; they can also travel longer distances than sheep each day¹²⁰. These factors make them more suitable as desert animals than sheep.

Apart from taking the domestic animals to pasture and protecting them against predators, herding involves giving help at birth and when disease or injuries occur. Fat tail sheep in Sudan have difficulties in giving birth as well as mating¹²¹. Goats sometimes desert their kids in the bush without the herdsman being warned whereas sheep, on the other hand, usually bleat when they are going to give birth¹²². Both animals have sensitive hoofs that can be severely infected by thorns unless great care is taken¹²³ and their eyes also need considerable attention¹²⁴.

10.4.2 Practical combinations and manageable herd sizes

The possible combinations of animals must be based on the local ecological conditions. Here we will limit ourselves to brief comments on some general principles.

From the discussion above of the ecological requirements of different animals, it can be seen that a combination of large herds of cattle and camel within one family's economy is only possible when the two species are kept in different ecological zones. Unless the family is large it is likely to be difficult to recruit labour for both large scale camel and cattle herding within the household itself, because the two herd types commonly require the same type of personnel. Polygyny is occasionally a way of solving this problem, as well as making other multi-niche adaptations possible for the family of one man, such as the use of several agricultural zones, the combination of an urban economy with rural subsistence, the establishment of different cattle herds in various separate areas etc. Among the Uaso Boran such pastoral multi-niche economies combining camel- and cattle economies, occur in very wealthy families.

According to the Gullivers¹²⁵, the Turkana usually have two settlements, or homesteads and which are both rather mobile, within the same family. One is for cattle and the other for "browsers" i.e. camel and small stock, predominantly goats. The family needs either to be composed of two generations, or of at least two matri-units.

More commonly in Kenya and elsewhere, one type of large stock is combined with small stock. We have seen that goats and camels are both suited for the more arid areas, and they can therefore be combined, although they compete to some extent for the same resources. Sheep and camels can only be combined if placed in different zones. This is sometimes an advantage. The household personnel can be split into those tied to the domestic settlement having greater accessibility to milk, and those who follow the camels in mobile units exploiting the more arid areas.

When the household is split, it is more likely that the goats will stay in the settlement than that they will follow the camels, as they are more useful to the home encampment, providing an accessible "store" of meat and milk.

When small stock are combined with camels, the general division of labour between the sexes arises from the characteristics of the herd animals. Women who are bound to the homestead by child caring are also responsible for the care of small stock, that must remain near to water¹²⁶. The actual herding may be done by the women themselves or by children. In the Middle East, where small stock herding is even more important than in the mixed economies of East Africa, herds are often larger and have higher proportions of sheep. The task of watching the herd may require a fulltime shepherd occupied from 4 a.m. to 6 p.m. This task will be given to a male dependent of the head of the household who in turn is responsible for the managerial organization of migration¹²⁷ as well as domestic tasks in the camp.

When sheep are combined with cattle they remain in the same area if the grass resources allow this. The advantages of combining sheep and cattle seem to be less than those of combining goats and cattle (see Section 10.3) both from the point of view of the complementarity of demands and yields. If there are seasonal shortages of cattle milk, goats in particular may prove advantageous in providing milk during part of the time that milk production from cattle is low; see Section 10.3. Cattle and sheep are both grass-eaters, but on high grass pastures cattle are likely to thrive better than sheep, and on short grass pastures the opposite is the case¹²⁸. Goats can also use those pasture components that are rejected by cattle. They can survive either by browsing close to the camp, where grass is rapidly depleted, or by being taken further away than cattle to drier areas¹²⁹. Williamson and Payne¹³⁰ note that the combination cattle/goats can be more satisfactory than the grazing of only one type of stock in areas where bush is rapidly replacing grass. This discussion is, however, part of the goat/ecology question mentioned earlier.

To conclude this section we will briefly touch upon the upper limits to the number of animals that can be kept in one management unit. The maximum size of a flock or herd depends upon a number of factors such as the availa-

bility of grazing, the density of households in the area, the speed at which domestic stock move, the distance between waterholes, the available manpower and the choice of breeds. Furthermore, the maximum size of a herd is related to the frequency with which the animals need watering and milking, as well as the amount of protection they require from wild animals and raiders. The maximum size can also be affected by topographical factors, which can limit grazing to particular areas and/or restrict movement, factors that have already been discussed.

To relate the optimum sizes of households to their herds and flocks of domestic animals¹³¹ would elaborate this discussion too much. We shall, however, briefly indicate the "threshold situations" where an individual management herd or flock needs to be split or constantly culled.

In this case we disregard the most obvious restrictions on herd size, which depend on the carrying capacity of the grazing, and concentrate instead on restrictions inherent in herding and management. This is a topic that has only recently become a focus of systematic interest for studies of pastoralism, and the data given here can only indicate what factors may be relevant.

Spencer and Cunnison¹³² have discussed the upper limits of cattle herds, the former pointing out the difficulties of watering a large herd. Watering a herd of, say, 300 cattle can be so time consuming that little time is left for grazing. Such a herd may also exhaust the grazing within a particular area so quickly, that it has to be constantly driven to new pastures. Cunnison mentions that those animals in a large herd that arrive first at the grazing may trample the grass so much that nothing is left for the other cattle. In addition, it is difficult to supervise a large herd when it is moving in areas of dense vegetation. The largest size that is suitable for all seasons is approximately 150 for the Humr Arabs of Sudan.

The same restrictions should apply to camel herds. Spencer¹³³ mentions that camels are more docile and easy to handle in larger numbers. Up to a certain maximum size it is thus advantageous to keep the herds as large

as possible. Spencer does not mention any upper limit, but Asad¹³⁴ estimates that at most 150 camels are herded together by the Kababish Arabs.

A similar behavioural advantage in large herds has been noted among sheep. Tribe¹³⁵ made an experiment with free range sheep and found that there is a positive relation between grazing behaviour and flock size. Sheep have a tendency to "eat for the sake of company" even if they have already eaten sufficiently. This is why goats stimulate sheep to eat more. Tribe's findings have been used by Swidler¹³⁶ to explain why the Brahui nomads of the Baluchistan highlands prefer to have sheep flocks of about 250-500 animals. More than 500 cannot be supervised by a single herdsman with dog, but if they are fewer than 250 they become difficult to herd and do not fare as well. Barth, quoted by Swidler, states that "the Basseri sheep are not happy in small groups, they spread and wander and join larger herds: they will not move predictably, in a body".

Barth notes that 300-400 sheep and goats can be herded in one flock by one person without a dog (the Basseri have no large stock) though few owners have more than 200 sheep¹³⁷. The figure can be compared with Talal Asad's conclusion regarding the Kababish Arabs in Sudan (who have also large stock) that the maximum flock size is 200 heads whether in mixed herds or flocks of only sheep¹³⁸. If the flock consists purely of goats the maximum size would be as small as 25 heads (*loc cit*).

A maximum figure akin to Asad's is given by Hunt¹³⁹ for a household in Somalia under similar conditions. His estimate is that 250 sheep and goats is the maximum number that can be managed by one woman and three children without hiring extra help.

The Dyson-Hudsons¹⁴⁰ give an illustration of labour requirements in a diversified herd. A moderately prosperous herdowner among the Karamojong, having 100-150 cattle, 100 sheep and goats and a couple of donkeys, would need about six herdboys aged five to twentyfive years.

Barth¹⁴¹ provides a good example of a "threshold situation" from the Bas-

seri in southern Iran. When the total stock wealth of a family has reached a certain limit, households prefer to invest in land and become partly sedentarized rather than continuing investment in their flock of sheep. The limit is the availability of manpower within a household or family. Even though investing in flocks is more beneficial than investing in land, the costs of employing herdsmen makes land investments more attractive¹⁴².

In Section 6.2 we have discussed the system whereby animals under the authority of one herdowner are spread in his network of contacts. The total number of animals that can be kept under his authority is not restricted to those that can be handled together in one management herd, but also to the number of herds he can keep. As was stated earlier, polygyny is one way of establishing a number of sub-households that can be spread into different areas: any accumulated "surplus" of animals may be converted into a new household unit through the mechanism of bridewealth. In this way the balance is kept between human and animal population. In purely pastoral societies where cattle is the only private form of property, no large scale economic differences are likely to arise between households. Apart from polygyny, another way to keep several subherds under the authority of one herdowner is by not giving younger generations full ownership of stock until the father is very old or dead. But even such amassing of wealth under one management authority can only be temporary, since the wealth is finally spread by inheritance.

In pastoral societies, stratification and inequality appear when there are other forms of property, that can be kept intact independently of access to manpower; property such as strategic land stretches, permanent wells, salt mines, money etc.

11. SUMMARY AND GENERAL CONCLUSIONS

Much of what social anthropologists have written about nomadic societies rests on insufficient knowledge about the biological, demographical and ethological characteristics of domestic animal herds. On the other hand, planners, administrators and veterinary experts usually have insufficient knowledge about the social and cultural conditions in nomadic societies. This book compiles the scattered, contemporary data available on the material prerequisites for subsistence herding. The main topics are herd growth in pastoral herds of cattle, camels, sheep and goats; their food production capacity, and the relative advantages, disadvantages and complementary merits of the pastoral domestic herds.

Chapters 2, 3 and 4 present simulations of typical, as well as extreme cases, of growth in herds and flocks, on the assumption of particular values to parameters such as birth frequencies, mortalities for young animals, age structures etc. In Chapter 5, the demographic consequences of a disaster are discussed with the help of hypothetical examples. Chapter 6 deals with some typical social mechanisms, that reduce risks in marginal ecologies. In this context problems related to the definition of herds as productive units, management units and ownership units are referred to, as these raise some of the major difficulties that confine empirical research on herd characteristics. Chapters 7-9 give a comprehensive analysis of the milk, meat and blood production of the four kinds of domestic herds, relating their productivity to human nutritional requirements. This discussion begins with subsistence pastoralism and only briefly refers to the consequences of various combinations of agriculture with stock-raising or involvement with cash-economies. Finally, Chapter 10 contains a comparison of the four different species of domestic stock, from the point of view of production, ecological and management demands, and herd diversification.

The analysis of herd growth in Chapter 2 begins with a number of examples of growth in cattle herds. The characteristics of the eight examples are

summarized in Table 2.6. In Table 2.8 the results are summarized in terms of the number of years needed for a herd to double its size or be reduced to half of its numerical strength. A "normal" rate of growth per annum, given that the herd has a steady development over a number of years, would be 3.4 % according to our simulation model (Example 8). A typical herd of cattle would double in about 24 years, which is a considerably longer period than that generally assumed in the literature. On the basis of an estimate of theoretical maximum growth, the annual growth rate would be 11 % resulting in doubling of numbers in six and a half years. Sources quoted in Chapter 2 give even faster growth rates than are shown to be possible by our model. Annual growth rates exceeding 11 % probably indicate non-typical conditions, like those immediately after a drought when the proportion of female cattle in reproducing ages may be higher than normal (since they have the best chance of survival). If the total number of cattle are counted when the surviving dams have reproduced, there may be a very large "increase" but this is only possible due to a previously biased age structure.

From the point of view of subsistence, herd growth as seen in the increase of the total number of animals, is less interesting. As pastoral nomads often depend mainly on milk products, the growth in the number of potential milkgivers is more relevant for household economy. In a normal case, again according to our simulation, milk cows make up only about 45 % of the total female herd, the remainder consisting mainly of younger animals that must be kept to ensure the long-term continuity of the herd.

The size of the male herd varies according to cultural preferences and practices. If mature bulls are kept in a proportion of 1:33 to mature cows, and all the rest of the males are slaughtered as bullocks at the age of 4-5, the total proportion of males will be 37.1 % and of females 62.9 %.

An unusually rapid expansion of the number of cattle in a particular area can also result from the redistribution of cattle from neighbouring zones. The degree of such redistribution may not always be appreciated by a local

stock surveyor. Redistribution of cattle through kinship and friendship links and through raiding is common in pastoral societies and can be seen as a form of insurance or as a logical precaution against climatic uncertainty. A rapid increase of cattle in a particular area may thus be due to a "flow" of cattle in the social network as well as to biological reproduction.

The growth rates simulated in the eight examples are naturally only averages that are valid for large aggregates of stock. The fortunes of an individual herdowner may deviate considerably from the average. However, for illustrative purposes we have also included a simulation of the building-up process of an average herd. The question asked is: If a boy is given a heifer at birth, another on his fourth birthday and yet another when he is fifteen, how many cattle will he have a right to if he marries at the age of twentyfour? The answer is that with an average calving rate of 75 % and a calving life-span of 4-9 years he will have around 10 milk cows in his herd: if the calving period is prolonged one year this will increase the number of adult fertile cows to 17. Although this is only what can be expected on average, and therefore not necessarily true for even a majority of individual households, the average rate of building up a herd in a particular society can have important consequences for the timing of household segmentation and average marriage ages.

Research on pastoral economies carried out outside of anthropological circles has been centered on topics related to production opportunities for the meat market. This may account for the greater difficulties in obtaining reliable data on camels than on cattle. Given the scarcity of information on camels, the herd simulations for camels are only speculative. Two simulations have been made, one showing theoretical maximum growth assuming all female animals that survive their first year live until the age of 21; the other introduces a set of hypothetical age-based mortality rates in order to give a more realistic appraisal of the possible growth of camel herds. The annual growth in the maximum case is just under 8 %, and in

the example where adjustment for mortality rates has been made, the simulated annual growth rate becomes 1.5 %. The maximum growth implies that the number of fertile camels can double in 15 years under favourable conditions, while the slower rate of growth results in numbers being doubled after 50 years.

Due to the higher ages of first calving, and lower calving rates, camels reproduce considerably slower than cattle, in spite of being fertile for a longer period. The longer life-span of camels means that they are a more constant resource for nomads, the composition of the herd being less affected by variations in the birthrates of individual years. If however, the majority of a camel herd is erased by disaster, the herd takes a longer period to rebuild and to give milk when calves are born after the disaster.

The demographic effects of a major drought on the composition of a herd is discussed in Chapter 5. A simulated disaster has been introduced in a typical cattle herd, corresponding the conditions in the eighth example of herd growth in Chapter 2. This is done by temporarily increasing the particular mortalities and reducing the number of calvings. The surviving animals and their descendants are then followed through two generations to investigate the long-term effects of a drought lasting two and three years respectively. A similar simulation is tentatively proposed for camels.

The immediate effect of a major drought is, naturally, a reduction in the total number of animals for household production. By reducing the number of calves and of old animals more than it reduces the number of fertile adult animals, the drought will also create irregularities in the age structure that will have long-term effects on the production of milk and calves. For example, a reduction in the number of calves will reduce the proportions of calf and milkproducers four years later. Some of the fluctuations in the age-structure can still be seen 18 years after a drought, but before that, it is likely that another drought has occurred. The effect of a second drought depends on when it occurs: it will be felt most if it occurs four years after the end of the previous drought, when the proportion of milk

producing animals is at its lowest. If drastic reductions occur in individual herds, redistribution mechanisms may smooth out the effects over a longer period, but if a disaster hits a whole region the total cattle population in the area may be subject to this kind of fluctuation.

The evolution of some typical flocks of sheep and goats are simulated in Chapter 4. These species have considerably higher growth rates than large stock. The annual growth rate for a flock of sheep corresponds to 26 % and 18 % in the two examples given, the difference being due to variations in the age of first birth. Each ewe is expected to give birth to 5.3 - 6 lambs during its lifetime.

In the two examples of goat flocks, the annual growth rates correspond to 41 % and 33 %, depending on average ages of first birth, each female goat giving birth to 9-10 kids during her life-time. The goat examples given approach the maximum practical growth of flocks under usual conditions in East Africa. Variations between different regions are great, due not only to variations in grazing and climate, but also to the considerable differences between breeds. The rates given here are generally much lower than the theoretical maximum. Should the biological potential of multiple births be taken into full consideration the rates would be considerably higher than the ones proposed here. Though the growth rates arrived at here are high, they are lower than some of the estimates of annual increases found in the literature. Similar over-estimates of growth rates to those of pastoral cattle herds can also be found for flocks of sheep and goats.

One example, that is treated separately in Chapter 4, is based on information on the sheep and goat flocks of the Yomut in Iran. These live considerably longer than the breeds that are simulated in the other examples. The annual growth rate of a flock, given the range of yearling survival rates stated by Irons, lies between 4 % and 15 %. A Yomut flock reproduces considerably slower than East African breeds, at least in terms of absolute

numbers: but if the growth rate in terms of meat yield is considered there might be less difference.

A major draw-back in calculating long-term changes to herds of pastoral domestic animals is the insufficiency of data available on herd composition, both in terms of relative proportions between the sexes and in terms of age distribution. Various techniques have been used by different surveyors to collect such data, but with limited success. Aerial surveys involve the difficulty of controlling systematic errors. Stock censuses on the ground present other difficulties: it is often a "cultural offense" to count stock, it may prove difficult to cover the vast areas inhabited by pastoralists and it is very difficult to estimate the age of a fully grown animal without removing e.g. a tooth or a horn, which is, naturally, not possible for every animal. There is an urgent need, however, for sufficiently detailed stock censuses for the prediction of realistic, long-term developments. Information on camels and small stock is particularly scarce.

In addition to the practical problem of acquiring sufficiently detailed data is the difficulty of defining the herd as a unit. Management responsibility and property rights do not always coincide among pastoralists. The stock friendship system, which can be interpreted as a system of insurance against disaster, is a central feature of East African cattle cultures as well as many other pastoral societies. This redistribution system creates a "flow" of animals from those with more cattle than they can look after to those related households that need extra animals at particular periods. Seen as a management unit the composition of a herd is not only a result of internal biological processes, but of a situational characteristic which depends on the total number of domestic animals in the region or rather the man-animal ratio in the area, the availability of labour in a household, etc.

From the point of view of milk production, the "herd" is simply the management unit. Slaughtering animals for meat, on the other hand, normally involves property rights. However, a herdsman can always slaughter some odd animals with reference to poor grazing conditions, disease, or the risk that the animal may die in any case.

The number of pastoral stock that can graze near the compound, and provide the household with milk, is usually limited by the availability of pasture. The total herd can be split into two parts: a subsistence herd close to the main settlement and one or several reserve herds kept further away. Typically, dams will be circulated between the fallow herds and the subsistence herd, depending on whether they are dry, pregnant or lactating. In order to underline the quality of reserve herds we have introduced the term *fallow herds* in Chapter 6. The labour force available in a household restricts the possible number of reserve or fallow herds and limits herd sizes.

The practical and theoretical problems involved in delimiting and counting the household herd as a unit for production and management are also discussed in Chapter 6, and are particularly relevant when dealing with large stock primarily kept for milk production. When it is possible, such milk herds are often supplemented with flocks of sheep and goats, the object of the latter being to supply meat. From the above discussion, it appears that the relation between property rights and management responsibility is not as complicated for small stock as for large stock. The growth of an individual flock is to a greater extent the result of rapid reproduction, and redistribution systems are less important. Obviously, the reason for this is that the usefulness of small stock, especially sheep, is not the yield from live animals, but the products of their slaughter.

The milk production of pastoral herds or flocks varies seasonally and depends on the type of breed, the quality and amount of grazing, access to water etc. These issues are discussed in detail in Chapters 7, 8 and 9, where different examples are given of the herd structures resulting from the simulations in Chapters 2, 3 and 4.

In areas with only one rainy season, there is a tendency for cattle reproduction to be mono-seasonal. Milk scarcity is both a result of a seasonal decrease in the proportion of lactating cattle, and of the poorer quality of pasture at the end of a dry period. To survive on fresh cattle milk alone

in these areas would be virtually impossible. Questions of milk storage and the availability of alternative foods are of major importance. When there are two rainy seasons, calf births are more evenly distributed during the year. While a general decline in milk production may occur as a result of the lack of pasture in the dry seasons, the demand for milk storage may decrease because the proportion of lactating cows is constant.

Even if milk production is the primary object of the household economy, the offtake for meat is also important. Since slaughter eliminates a potential producer of milk or blood, slaughtering is loaded with symbolic and emotional connotations, involving restrictions on when and how an animal can be slaughtered, how the meat is to be redistributed, etc. Apart from emergency slaughter, the most common form of slaughter is for ritual purposes, involving communal sharing. In the present context ritual slaughter can be seen as an institutionalized way of ensuring that all members of the community have at least some meat at all times during the year. In this way sharing is an alternative to each household storing beef, which involves great difficulties.

Given the age- and sex structure of our "normal" cattle example, the annual offtake for slaughter is around 8 %. This proportion of the herd consists of mature bullocks and aged animals, that can be slaughtered without risking the long-term productivity of the herd. Within the limits of an additional 8 % that die from natural causes more meat can be obtained from the herd.

Seasonally, meat is of greatest importance when milk is scarce. This is also true for blood. The nutritional importance of blood may be small in terms of total annual food consumption. But on the special occasions when blood is taken, its importance for the pastoral diet is considerable. It also provides some of the nutrients that are lacking in milk. Calculations have been made on the required herd sizes assuming that the total yield of the herd can be evenly distributed throughout the year.

In order to evaluate the required herd size for a family, a "reference family" of 4.9 adult equivalents has been proposed. Such a family would for example consist of a father around 30, a pregnant mother of 25, two children of 3 and 8 and two related youngsters, one boy of 18 and one girl of 15.

If the "reference family" obtains milk, meat as well as blood from the herd, sufficient calories and protein are provided by a cattle herd of 50 or more animals, assuming that all meat from animals that die from natural causes and from emergency slaughters can be used. If only products from live cattle and "normal slaughter" are consumed, the minimum herd size needed is estimated to be 64 cattle.

Similar calculations have been carried out for the herd size needed for a family depending totally on a herd of camels. The main production differences between camels and cattle are that 1) although camels breed seasonally and only every second year, their length of lactation often covers a full year so that there is not such a marked drop in the number of lactating animals as for cattle; 2) there is a higher proportion of milk animals within the camel herd; and 3) camels give milk which is less nutritious, but available in larger quantities. The minimum herd size for the "reference family" is 28 animals.

We have referred to minimum herd sizes for both camels and cattle, but the reader should be aware, however, that these minima are based on the assumption of an ideal age- and sex structure in the herd. That an actual family has 28 camels or 64 cattle does not in itself guarantee that they have sufficient animals. If the herd size declines below the minimum limit, it is likely, however, that the family either has too little food, or that the continuity and regrowth of the herd is endangered.

In this summary, we have only mentioned minimum requirements that presuppose that subsistence is totally based on the products from the herds and that no exchange or trade takes place. In the text, however, we discuss

the possible addition of grain to the pastoral diet, and the reductions in herd sizes that are made possible by trade in its different forms.

Most pastoral sheep and goats are dual purpose animals and not specialized for meat or milk production. Sheep are however sometimes not milked at all, while goats are generally more efficient milk producers. The rump or tail fat from sheep is, on the other hand, a frequently appreciated item. When small stock are kept to supplement large stock, meat and fat production are often the most important functions. The ways in which flocks of small stock are utilized vary considerably, making it less meaningful to generalize about the minimum size of a viable flock. In order to identify the required minimum, reference must be made to a particular area and economic adaptation. In Table 9.4 we give some examples of the possible yield from a flock consisting of 100 heads of goats or sheep. We also give some examples of the required minimum herd sizes for a "reference family" given that they subsist exclusively on produce from their small stock (see Table 9.5). It is shown that considerably more than 100 heads are needed to meet the family's calory needs, while well over 50 animals are needed for protein. If the energy demand can be partially met by farm produce, flock sizes can be lower without the protein intake being endangered.

Many pastoral households have more than one kind of domestic animal in their herds. Small stock can increase quickly in number but are also subject to rapid reductions due to disease and drought. Cattle herds fluctuate less in size and composition, and the camel herds are fairly static in comparison with flocks of small stock. Table 10.1 summarizes the typical annual growth rates for various types of domestic herds. It also presents herd growth seen in number of standard stock units, which have been calculated from our estimates of production for household consumption (see Section 10.2). From the results it can be understood that, for a poor household with too few animals to meet its requirements, it is a realistic alternative to re-build the herds by investing in sheep and goats. This strategy has also been empirically observed in a number of places. How-

ever, this means that greater risks are taken than by investing in cattle. The advantage is a quicker building up of the herd.

The combination of different livestock species has implications for the seasonal composition of the diet. Many observers have noted that goats tend to give milk in seasons when bovine milk is scarce. A short period of pregnancy means that they often give birth and start to lactate during the dry period, after having conceived in the rainy season. This is not only advantageous in normal dry seasons, but also after a major period of drought when small stock start to produce milk much faster than cattle or camels.

It is also advantageous for a family to combine different types of animals if an epidemic occurs killing off a substantial part of the animals of one species, or during a drought when some animals of one species are more vulnerable than others. The slow start of growth in herds of larger stock can also be overcome by exchange for sheep and goats.

Each type of animal has its own management requirements. These are basically due to different travelling abilities, different grazing habits and different requirements for water and fodder.

Access to water points often limits both the number of animals in an area and what species can survive there. Arid zone cattle need to be watered every two to three days. Camels can go for a considerably longer period without water. Both species consume so much water that it is inconvenient to take water to the herds rather than the reverse. Cattle may consume 35-50 litres during one watering and camels 50-100 litres. When many herds utilize the same water point, they must be well organized so that the animals move quickly to and from watering and drink efficiently and orderly. Skillful management and sometimes even a large labour input is required when water is taken from deep or difficult wells.

Small stock are normally watered at least as often as cattle, but water can

sometimes be transported to the animals rather than vice versa. On the whole it is advantageous to have them in areas where there is immediate access to both water and salt.

Cattle, needing frequent watering and moving slowly, are preferably kept within an area of 10–12 km from the camp, which in turn must be situated within walking distance from a water point. The herd keeps together while grazing, and this makes herd administration relatively easy. The faster camels can travel further away from the well. They are more difficult to herd, as they spread during grazing and stray easily. Their effective grazing area is limited by the herdsman's ability to follow them rather than by their own mobility. The different grazing habits of cattle and camels are illustrated in Figures 10.2 and 10.3.

Cattle and camels do not compete for pasture: in many cases they do not even fare well in the same type of area. Camels generally prefer to browse, while cattle if possible graze on high grass. There is a similar difference between goats and sheep, who also have slightly different demands for water. However, it is useful from many points of view to herd the two types of small stock together. A mixed flock grazes more efficiently. Goats lead the way to pastures while sheep tend to keep the flock together while grazing. Combining them means that a smaller labour input is needed, compared with herds of one or the other animal.

Cattle and camels can not be kept by the same household unless they can be herded separately, which normally requires that the household be split into subunits. Not only do they frequent different ecological zones during daytime, they also need to be kept separate during the night so that disease does not spread from the more resistant cattle to the camels that are vulnerable.

A more common type of herd diversification is the combination of either camels or cattle with a pure or mixed herd of sheep and goats. The spatial consequences of such combinations and the various forms of resultant division of labour are discussed in Section 10.4.2.

One of the main subjects of this book is the minimum size limits of nomadic herds. Several factors influence the upper limit of the number of animals that can be kept in one management unit. As examples can be mentioned the availability of grazing or browse, the household density within an area, the speed at which animals and their herders can move, the distance between waterholes, the manpower available in an average household, the presence of marauding neighbours or wild animals, topographical and administrative restrictions on pasture, animal behaviour, etc. Generalizations are difficult to make, but we have attempted some: to herd 300 cattle together may be possible, but as watering is too time-consuming they would probably not have enough time for grazing. Camels are more docile in large herds, but it may be very hard to supervise more than 150. A single shepherd without a dog can manage 3-400 sheep or goats: if he has a dog, he can handle up to 500.

As indicated earlier in the Introduction some of the basic economic and ecological aspects of pastoral livelihood have not always been sufficiently investigated or understood in the debate about pastoral nomadism. It is our hope that the present book will contribute to a better understanding.

Some of the central issues that have been discussed are:

- (1) Pastoral subsistence production has multiple foci, and of these milk production rather than meat production is of primary importance. From this follow limitations on management practices, on the viability of domestic enterprise, etc which clearly differ from ranching activities focused on meat production. When comparing the efficiency of different production systems, this divergence in goals must be taken into consideration, so that pastoral nomadism is not seen as basically a system of meat production.
- (2) The uncertainty of securing a livelihood in semi-arid areas can be counterbalanced in many ways, such as by social organization, social structures and herd management practices. Various means of spatial redistribution are employed and herds are diversified in several ways.

A pre-requisite for the understanding of pastoral domestic economies is the differentiation between subsistence herds (for immediate milk production) and fallow herds. The latter term is introduced in this book to emphasize some of the basic characteristics of those parts of herds that at first sight seem superfluous to the domestic economy.

- (3) The opportunities of building up large herds solely by means of biological reproduction, are generally more limited than is implied in many references. Our analysis of how herds and flocks can develop over two generations reveal different growth possibilities for cattle, camels, sheep and goats. It also illustrates some of the advantages and drawbacks of substituting large stock for small stock.
- (4) The long-term effects of drought or disease can be better understood with the aid of demographic analysis. Apart from the immediate reduction of herd sizes after a disaster, the number of fertile animals will continue to fluctuate for many years, which will affect herd reproduction and milk production. Particular periods after the culmination of such a disaster can therefore be potentially more dangerous should another catastrophe occur.
- (5) Pastoral household consumption and nutrition have been discussed in detail. We have investigated the opportunities for various species to contribute to household milk, meat and blood requirements, as well as the value of supplementary agricultural produce. Although much social anthropological literature compares different forms of nomadic societies, differences in social organization are insufficiently related to concrete differences in material conditions. In this book we have tried to emphasize the importance of considering factors such as the different ways in which animals can be used as well as for what purposes, differences in labour requirements for watering and other activities, variations in intensity of seasonal shortages and in opportunities for storing pastoral produce etc.

The central theme of this book has therefore been the ecological foundations of pastoral social organization. We have intentionally avoided dwelling at length on pastoral values and have instead concentrated on basic economic requirements. In doing so, we have sometimes been forced to generalize. Such generalizations have only been made about basic economic or institutional conditions that are characteristic for African pastoral nomadism. We have not found it possible, or even necessary, to go deeply into any ethnographic detail or to bring in particular value systems. The generalizations do therefore not apply to all specific ethnographic cases. We do, however, suggest that there is an interrelation between values and ecology, so that a particular value system depends to a certain extent on such basic factors as seasonal fluctuations in food resources or the probability of recurring droughts.

This book has resulted from the need in our individual research to sufficiently grasp the central economic problems of pastoral societies. In the beginning we had hoped that veterinary sources would provide sufficient information. However, they dealt more with the typical (statistical) behaviour of individual animals belonging to particular species or breeds, rather than with the collective off-take from composite herds or flocks containing animals of various age and sex categories. We would like to refer again to Nevil Dyson-Hudson's point of view in 1972 (quoted above in the Introduction):

"Obviously, one can hardly hope for an effective analysis of livestock-oriented groups without some sophisticated grasp of their central concern, viz how to achieve sufficient productivity from the manipulation of available livestock within the available environment so that people may be kept alive from one year to the next. Yet it is a topic most inadequately dealt with by anthropologists . . . An extensive literature exists on cattle in the tropics, but either does not relate directly to the range conditions most relevant to the anthropologist's interests; or where it is applicable, seems frequently to be ignored by him, or to be unknown to him."

We have not, of course, presented any "final solution" to a deeper understanding of aspects that are central in the daily life of a pastoral household.

However, we hope that the methods and results presented here will be of value and help to identify problem areas and central questions for further research. As a compilation and analysis of existing literature, we hope that our work will also be of use to planners working with pastoral societies both under normal conditions as well as when affected by drought and epidemics. Finally, we hope that future research carried out along similar lines will be permeated by an increasing awareness of the validity and quality of the knowledge and experience of the pastoral nomads themselves and a recognition that they, after all, are the experts.

APPENDIX I:
SOME DATA FROM THE SIMULATED GROWTH IN HERDS AND FLOCKS
OF PASTORAL DOMESTIC ANIMALS

In order to provide some more detailed information on the simulated developments of the pastoral herds and flocks of domestic animals, this appendix contains the development of number per female category over some two generations. The data may be of interest to the reader who wants to use the results in some other context. Unfortunately, space does not allow us to present the most detailed information on the year-to-year (for large stock) development of each age-class in any other form than the respective figures.

The various headings in the following tables refer to the examples presented earlier in the text. Thus it is possible to check the conditions guiding each example. Please note that each time period for small stock is half-a-year and that the calculations on disasters in camel herds are based on very little empirical data.

TABLE I.1: The development of a female cattle herd over a period of 30 years according to Example 1

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total Females</u>	<u>Growth Rate</u>
0	136.00	303.00	399.00	1000.00	0.0
1	89.77	303.17	397.12	953.12	0.95312
2	89.35	266.41	395.84	914.50	0.95948
3	89.06	232.38	394.10	878.26	0.96037
4	88.67	199.85	392.51	844.08	0.96108
5	88.31	199.03	361.66	812.04	0.96205
6	81.37	198.25	333.25	774.84	0.95419
7	74.98	192.16	306.13	734.31	0.94769
8	68.88	181.63	280.45	690.96	0.94098
9	63.10	167.19	256.63	646.77	0.93604
10	57.74	153.61	251.35	602.02	0.93081
11	56.55	140.80	242.43	562.53	0.93441
12	54.55	131.87	230.17	528.09	0.93878
13	51.79	125.67	215.00	497.96	0.94293
14	48.38	121.14	197.51	471.54	0.94695
15	44.44	114.97	183.57	444.13	0.94187
16	41.30	107.38	172.22	416.57	0.93796
17	38.75	99.58	162.70	389.98	0.93616
18	36.61	92.48	154.34	365.23	0.93653
19	34.73	86.69	146.42	342.86	0.93875
20	32.94	81.83	137.49	322.63	0.94100
21	30.94	77.52	128.40	303.83	0.94173
22	28.89	73.29	119.77	285.96	0.94119
23	26.95	68.92	112.08	268.76	0.93987
24	25.22	64.46	105.57	252.16	0.93823
25	23.75	60.21	99.65	236.54	0.93806
26	22.42	56.41	93.97	222.07	0.93882
27	21.14	53.06	88.39	208.71	0.93985
28	19.89	50.03	82.90	196.30	0.94052
29	18.65	47.15	77.65	184.60	0.94041
30	17.47	44.35	72.81	173.49	0.93981

TABLE I.2: The development of a female cattle herd over a period of 30 years according to Example 2

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total Females</u>	<u>Growth Rate</u>
0	136.00	303.00	399.00	1000.00	0.0
1	89.77	316.77	397.12	966.72	0.96672
2	89.35	288.04	395.84	936.13	0.96835
3	89.06	261.42	394.10	907.30	0.96921
4	88.67	224.83	403.45	880.00	0.96990
5	90.78	223.90	379.27	856.99	0.97386
6	85.34	225.25	357.17	829.72	0.96818
7	80.36	221.81	336.02	799.22	0.96324
8	75.60	214.41	315.51	765.53	0.95784
9	70.99	201.73	290.49	730.66	0.95445
10	65.36	189.73	287.33	692.83	0.94823
11	64.65	177.10	280.96	658.53	0.95049
12	63.22	168.15	271.63	628.24	0.95400
13	61.12	161.88	259.56	601.25	0.95704
14	58.40	158.24	243.08	578.54	0.96223
15	54.69	152.92	229.95	554.34	0.95818
16	51.74	145.68	219.22	529.24	0.95471
17	49.32	137.80	210.18	504.33	0.95294
18	47.29	130.27	202.25	480.54	0.95283
19	45.51	124.12	195.04	458.67	0.95448
20	43.88	118.93	186.47	438.70	0.95647
21	41.96	114.39	177.41	419.95	0.95726
22	39.92	109.91	168.53	401.89	0.95699
23	37.92	105.20	160.36	384.24	0.95607
24	36.08	100.20	153.48	366.78	0.95458
25	34.53	95.28	147.19	350.02	0.95429
26	33.12	90.79	141.08	334.21	0.95483
27	31.74	86.79	134.97	319.38	0.95565
28	30.37	83.17	128.83	305.42	0.95628
29	28.99	79.68	122.80	292.06	0.95627
30	27.63	76.22	117.13	279.16	0.95581

TABLE I,3: The development of a female cattle herd over a period of 30 years according to Example 3

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	136.00	303.00	399.00	1000.00	0.0
1	159.60	303.17	397.12	1022.95	1.02295
2	158.85	322.27	395.84	1039.86	1.01653
3	158.34	339.92	394.10	1055.08	1.01463
4	157.64	355.28	392.51	1068.48	1.01270
5	157.00	353.82	406.59	1080.46	1.01121
6	162.64	352.44	420.65	1097.70	1.01596
7	168.26	355.99	433.74	1119.03	1.01943
8	173.50	364.24	446.06	1143.80	1.02214
9	178.43	376.52	456.23	1171.02	1.02379
10	182.49	388.25	458.41	1199.67	1.02447
11	183.36	398.79	464.46	1225.39	1.02144
12	185.79	405.92	473.85	1249.59	1.01975
13	189.54	411.32	486.28	1273.40	1.01905
14	194.51	416.73	500.85	1297.89	1.01923
15	200.34	425.17	512.44	1325.81	1.02151
16	204.98	436.13	522.21	1355.46	1.02236
17	208.88	447.62	531.30	1385.56	1.02221
18	212.52	458.23	540.70	1415.31	1.02147
19	216.28	467.25	551.44	1444.42	1.02057
20	220.58	475.67	564.15	1473.57	1.02018
21	225.66	484.42	577.49	1503.78	1.02050
22	231.00	494.29	590.60	1535.40	1.02102
23	236.24	505.31	602.96	1568.33	1.02145
24	241.19	516.99	614.60	1602.18	1.02158
25	245.84	528.54	626.62	1636.24	1.02126
26	250.65	539.57	639.54	1670.45	1.02091
27	255.82	550.30	653.37	1705.08	1.02073
28	261.35	561.24	667.79	1740.52	1.02078
29	267.12	572.83	682.32	1777.09	1.02101
30	272.93	585.14	696.67	1814.76	1.02120

TABLE I.4: The development of a female cattle herd over a period of 30 years according to Example 4

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	136.00	303.00	399.00	1000.00	0.0
1	159.60	316.77	397.12	1036.55	1.03655
2	158.85	350.88	395.84	1068.47	1.03079
3	158.34	382.41	394.10	1097.57	1.02723
4	157.64	399.69	403.45	1123.83	1.02393
5	161.38	398.05	429.82	1152.29	1.02532
6	171.93	400.44	455.50	1189.83	1.03258
7	182.20	412.52	479.58	1235.33	1.03824
8	191.83	433.50	501.82	1287.15	1.04195
9	200.73	458.98	516.43	1343.58	1.04384
10	206.57	483.05	525.45	1400.58	1.04242
11	210.18	503.25	541.86	1454.14	1.03824
12	216.74	518.31	564.72	1506.62	1.03609
13	225.89	531.79	593.14	1560.36	1.03567
14	237.25	548.32	622.05	1618.85	1.03749
15	243.32	571.31	646.20	1684.10	1.04031
16	258.48	598.35	668.16	1753.07	1.04095
17	267.26	625.58	690.25	1823.48	1.04017
18	276.10	650.57	714.56	1894.24	1.03880
19	285.82	673.39	742.81	1965.70	1.03773
20	297.12	696.38	774.52	2039.73	1.03766
21	309.81	721.56	807.24	2118.00	1.03837
22	322.90	750.01	839.52	2200.95	1.03916
23	335.81	781.20	870.83	2288.10	1.03960
24	348.33	813.65	902.32	2378.36	1.03945
25	360.93	845.92	936.02	2470.84	1.03888
26	374.41	877.78	972.57	2565.85	1.03845
27	389.03	910.21	1011.65	2664.30	1.03837
28	404.66	944.45	1052.33	2767.15	1.03860
29	420.93	981.25	1093.71	2874.92	1.03894
30	437.48	1020.37	1135.64	2987.38	1.03912

TABLE I.5: The development of a female cattle herd over a period of 30 years according to Example 5

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	136.00	303.00	560.00	1000.00	0.0
1	224.00	303.17	558.48	1087.35	1.08735
2	223.39	373.79	557.05	1155.92	1.06306
3	222.82	439.47	555.14	1219.11	1.05466
4	222.06	499.45	553.86	1277.07	1.04754
5	221.55	497.99	609.37	1330.61	1.04193
6	243.75	496.62	661.84	1403.90	1.05508
7	264.74	513.48	711.45	1491.34	1.06229
8	284.58	546.43	758.25	1590.96	1.06680
9	303.30	593.28	800.33	1698.61	1.06766
10	320.13	637.54	852.74	1812.08	1.06680
11	341.10	678.67	910.15	1931.57	1.06595
12	364.06	720.92	968.71	2055.34	1.06407
13	387.48	766.53	1027.13	2182.81	1.06202
14	410.85	816.86	1082.82	2313.27	1.05977
15	433.13	868.87	1148.33	2453.06	1.06043
16	459.33	920.29	1222.98	2605.32	1.06207
17	489.19	973.99	1304.47	2770.37	1.06335
18	521.79	1032.79	1390.29	2947.57	1.06396
19	556.12	1099.21	1477.12	3135.43	1.06373
20	590.85	1171.59	1567.79	3333.46	1.06316
21	627.12	1247.47	1664.56	3542.62	1.06275
22	665.82	1326.07	1768.66	3764.26	1.06256
23	707.46	1408.06	1880.41	3999.84	1.06258
24	752.16	1495.26	1998.89	4250.47	1.06266
25	799.55	1588.78	2124.33	4517.12	1.06273
26	849.73	1688.76	2257.61	4800.84	1.06281
27	903.04	1795.09	2399.58	5102.73	1.06288
28	959.83	1907.86	2550.88	5423.86	1.06293
29	1020.35	2027.68	2711.49	5765.13	1.06292
30	1084.60	2155.23	2881.73	6127.54	1.06286

TABLE 1.6: The development of a female cattle herd over a period of 30 years according to Example 6

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	136.00	303.00	560.00	1000.00	0.0
1	280.00	303.17	558.48	1143.35	1.14335
2	279.24	418.59	557.05	1256.57	1.09902
3	278.53	525.81	555.14	1361.16	1.08323
4	277.57	624.31	553.86	1457.44	1.07074
5	276.93	622.49	645.41	1546.53	1.06113
6	322.70	620.78	732.01	1677.18	1.08448
7	366.01	656.26	813.95	1837.90	1.09583
8	406.98	724.51	891.35	2024.54	1.10155
9	445.68	821.18	960.88	2229.42	1.10120
10	480.44	912.58	1053.13	2447.81	1.09796
11	526.57	997.53	1159.02	2684.77	1.09680
12	579.51	1087.07	1271.63	2939.86	1.09501
13	635.81	1187.80	1388.39	3213.66	1.09313
14	694.19	1304.15	1503.94	3505.70	1.09087
15	751.97	1429.37	1641.36	3826.11	1.09140
16	820.68	1557.99	1800.95	4183.02	1.09328
17	900.48	1696.33	1979.41	4579.61	1.09481
18	989.70	1851.27	2172.75	5017.11	1.09553
19	1086.38	2029.56	2374.90	5494.78	1.09521
20	1187.45	2228.50	2593.01	6013.43	1.09439
21	1296.50	2443.02	2833.28	6577.78	1.09385
22	1416.64	2672.35	3099.63	7194.07	1.09369
23	1549.81	2919.53	3393.85	7869.07	1.09383
24	1696.93	3190.91	3714.60	8608.86	1.09401
25	1857.30	3490.81	4063.77	9418.96	1.09410
26	2031.89	3820.70	4445.28	10305.63	1.09414
27	2222.64	4181.48	4863.43	11276.03	1.09416
28	2431.72	4574.93	5322.23	12338.07	1.09419
29	2661.12	5004.92	5823.98	13500.05	1.09418
30	2911.99	5475.98	6371.85	14770.82	1.09413

TABLE I.7: The development of a female cattle herd over a period of 30 years according to Example 7

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	136.00	303.00	560.00	1000.00	0.0
1	280.00	316.77	558.48	1156.95	1.15695
2	279.24	459.24	557.05	1297.22	1.12124
3	278.53	591.54	555.14	1426.88	1.09996
4	277.57	702.35	564.80	1546.42	1.08377
5	282.40	700.30	678.32	1662.73	1.07521
6	339.16	703.30	785.74	1829.88	1.10053
7	392.87	757.68	887.40	2039.63	1.11462
8	443.70	857.29	982.99	2285.67	1.12063
9	491.49	992.17	1072.78	2558.13	1.11920
10	536.39	1119.54	1194.34	2851.92	1.11484
11	597.17	1239.51	1336.17	3174.51	1.11311
12	668.08	1368.99	1489.79	3528.52	1.11152
13	744.90	1518.64	1651.18	3916.58	1.10998
14	825.59	1694.43	1816.55	4340.42	1.10822
15	908.27	1886.55	2014.32	4812.98	1.10888
16	1007.16	2088.30	2245.85	5345.14	1.11057
17	1122.92	2309.32	2507.61	5943.67	1.11198
18	1253.81	2560.64	2794.73	6613.05	1.11262
19	1397.37	2852.30	3101.11	7355.43	1.11226
20	1550.55	3181.16	3438.05	8175.16	1.11144
21	1719.02	3541.07	3815.63	9081.82	1.11090
22	1907.82	3932.66	4240.68	10087.91	1.11078
23	2120.34	4362.82	4716.74	11207.28	1.11096
24	2358.37	4843.25	5243.44	12453.27	1.11118
25	2621.72	5382.32	5825.71	13838.94	1.11127
26	2912.86	5984.00	6471.88	15378.98	1.11128
27	3235.94	6651.73	7191.29	17090.30	1.11128
28	3595.64	7391.18	7992.84	18992.15	1.11128
29	3996.42	8211.96	8883.25	21105.47	1.11127
30	4441.62	9125.22	9870.98	23453.27	1.11124

TABLE I.8: The development of a female cattle herd over a period of 30 years according to Example 8

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	136.00	303.00	510.00	1000.00	0.0
1	178.50	303.17	508.82	1041.85	1.04185
2	178.09	337.39	507.08	1074.22	1.03107
3	177.48	369.37	504.91	1103.67	1.02742
4	176.72	397.99	503.89	1130.26	1.02409
5	176.36	396.64	530.27	1154.80	1.02170
6	185.60	395.37	554.74	1187.52	1.02834
7	194.16	401.96	578.03	1225.95	1.03236
8	202.31	415.44	600.50	1269.39	1.03543
9	210.18	434.72	620.51	1316.21	1.03688
10	217.13	453.00	644.60	1365.36	1.03734
11	225.61	470.10	669.84	1416.27	1.03728
12	234.44	487.49	684.69	1467.64	1.03627
13	239.64	505.68	704.06	1515.51	1.03261
14	246.42	522.24	726.99	1562.10	1.03075
15	254.45	537.65	754.01	1612.29	1.03213
16	263.90	552.71	784.43	1667.05	1.03396
17	274.55	570.94	812.55	1726.20	1.03548
18	284.39	592.04	839.78	1787.55	1.03554
19	293.92	614.38	867.11	1849.85	1.03486
20	303.49	636.69	895.56	1913.17	1.03423
21	313.45	658.24	926.14	1977.99	1.03388
22	324.15	679.92	957.75	2044.95	1.03385
23	335.21	702.51	990.17	2114.26	1.03389
24	346.56	726.21	1024.44	2186.01	1.03394
25	358.56	750.93	1060.04	2260.69	1.03416
26	371.02	776.62	1096.86	2338.47	1.03441
27	383.90	803.37	1134.52	2419.09	1.03447
28	397.08	831.25	1172.82	2502.25	1.03438
29	410.49	860.00	1212.43	2587.80	1.03419
30	424.35	889.44	1253.66	2675.95	1.03407

TABLE I.9: The development of a female camel herd over a period of 40 years according to Example 1

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	66.30	233.50	700.50	1000.00	0.0
1	175.12	233.21	700.50	1108.83	1.10883
2	175.12	309.10	700.50	1184.72	1.06844
3	175.12	384.98	700.50	1260.61	1.06405
4	175.12	460.87	700.50	1336.50	1.06020
5	175.12	536.76	700.50	1412.38	1.05678
6	175.12	612.94	700.21	1488.27	1.05373
7	175.05	612.94	776.10	1564.09	1.05094
8	194.02	612.89	851.98	1658.90	1.06062
9	213.00	626.12	927.87	1766.98	1.06516
10	231.97	652.63	1003.76	1888.35	1.06865
11	250.94	692.42	1079.65	2023.00	1.07130
12	269.91	745.49	1155.53	2170.93	1.07312
13	288.88	811.89	1231.37	2332.14	1.07426
14	307.84	878.29	1320.49	2506.62	1.07481
15	330.12	944.68	1422.89	2697.69	1.07623
16	355.72	1013.39	1538.56	2907.68	1.07784
17	384.64	1086.74	1667.52	3138.90	1.07952
18	416.88	1167.05	1809.76	3393.69	1.08117
19	452.44	1256.65	1965.28	3674.36	1.08270
20	491.32	1357.86	2134.07	3983.25	1.08407
21	533.52	1470.70	2318.74	4322.96	1.08528
22	579.65	1595.16	2445.16	4620.00	1.06871
23	611.29	1731.69	2591.82	4934.80	1.06814
24	647.96	1867.78	2761.05	5276.79	1.06930
25	690.26	2004.64	2955.17	5650.07	1.07074
26	738.79	2143.90	3176.51	6059.20	1.07241
27	794.13	2287.59	3427.38	6509.10	1.07425
28	856.85	2437.70	3710.63	7005.17	1.07621
29	927.66	2609.59	4002.71	7539.96	1.07634
30	1000.68	2805.38	4307.18	8113.24	1.07603
31	1076.80	3022.67	4627.99	8727.46	1.07570
32	1157.00	3259.27	4969.49	9385.76	1.07543
33	1242.37	3513.28	5336.44	10092.09	1.07526
34	1334.11	3783.15	5734.01	10851.27	1.07522
35	1433.50	4067.67	6167.88	11669.05	1.07536
36	1541.97	4370.64	6637.27	12549.89	1.07548
37	1659.32	4696.27	7142.02	13497.61	1.07552
38	1785.51	5047.89	7682.67	14516.07	1.07545
39	1920.67	5428.08	8260.52	15609.27	1.07531
40	2065.13	5838.68	8877.68	16781.49	1.07510

TABLE I.10: The development of a female camel herd over a period of 40 years according to Example 2

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	66.30	233.50	700.50	1000.00	0.0
1	175.12	212.66	640.72	1055.75	1.05575
2	160.18	270.89	602.99	1065.84	1.00956
3	150.75	305.32	576.18	1059.84	0.99437
4	144.05	333.34	551.67	1051.15	0.99180
5	137.92	364.33	524.23	1044.41	0.99359
6	131.06	392.43	499.80	1038.60	0.99444
7	124.95	370.51	523.50	1032.78	0.99439
8	130.88	352.57	541.20	1037.80	1.00485
9	135.30	344.56	555.35	1047.98	1.00982
10	138.84	342.35	567.15	1060.83	1.01226
11	141.79	344.36	576.87	1075.27	1.01361
12	144.22	350.40	584.32	1090.94	1.01458
13	146.08	359.89	590.09	1107.82	1.01547
14	147.52	367.38	599.81	1126.24	1.01662
15	149.95	373.38	613.10	1147.74	1.01908
16	153.28	379.09	627.86	1171.30	1.02053
17	156.96	385.30	642.43	1195.55	1.02070
18	160.61	392.28	655.95	1219.21	1.01979
19	163.99	400.10	668.14	1241.55	1.01832
20	167.03	408.70	678.99	1262.45	1.01683
21	169.75	417.46	687.89	1282.11	1.01557
22	171.97	425.81	688.89	1300.06	1.01399
23	172.22	433.35	694.32	1315.40	1.01180
24	173.58	438.82	703.03	1331.01	1.01187
25	175.76	443.47	714.09	1348.32	1.01301
26	178.52	448.01	726.79	1367.67	1.01435
27	181.70	452.84	740.57	1388.78	1.01544
28	185.14	458.30	754.80	1411.27	1.01620
29	188.70	465.29	767.58	1434.70	1.01660
30	191.89	473.32	779.66	1458.36	1.01649
31	194.92	481.71	791.55	1482.04	1.01624
32	197.89	490.14	803.55	1505.77	1.01601
33	200.89	498.43	815.83	1529.63	1.01584
34	203.96	506.52	828.49	1553.66	1.01571
35	207.12	514.41	841.51	1577.92	1.01561
36	210.38	522.33	854.62	1602.42	1.01552
37	213.66	530.39	867.68	1627.10	1.01540
38	216.92	538.60	880.72	1651.96	1.01528
39	220.18	546.93	893.87	1677.07	1.01519
40	223.47	555.34	907.27	1702.51	1.01517

TABLE I.11: The development of a female flock of sheep over a period of 15 years according to Example 1a

<u>Half- years</u>	<u>New- born</u>	<u>Other lambs</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	140.00	95.00	765.00	1000.00	0.0
1	286.87	98.00	764.28	1149.16	1.14916
2	286.51	200.81	766.57	1253.99	1.09122
3	287.46	200.62	871.67	1359.76	1.08434
4	326.87	201.22	976.58	1504.68	1.10658
5	366.22	228.81	1082.09	1677.12	1.11460
6	405.78	256.35	1215.19	1877.32	1.11937
7	455.70	284.05	1375.83	2115.57	1.12691
8	515.93	318.99	1564.87	2399.79	1.13435
9	586.83	361.15	1788.86	2736.84	1.14045
10	670.82	410.78	2052.01	3133.62	1.14497
11	769.51	469.58	2261.98	3501.06	1.11726
12	848.24	538.65	2530.93	3917.83	1.11904
13	949.10	593.77	2868.36	4411.23	1.12594
14	1075.64	664.37	3233.32	4973.32	1.12742
15	1212.49	752.94	3641.34	5606.77	1.12737
16	1365.50	848.75	4110.23	6324.48	1.12801
17	1541.34	955.85	4639.99	7137.18	1.12850
18	1740.00	1078.94	5234.69	8053.62	1.12840
19	1963.01	1218.00	5902.85	9083.86	1.12792
20	2213.57	1374.11	6651.27	10238.95	1.12716
21	2494.23	1549.50	7486.72	11530.45	1.12614
22	2807.52	1745.96	8442.45	12995.93	1.12710
23	3165.92	1965.26	9524.04	14655.22	1.12768
24	3571.51	2216.14	10736.36	16524.02	1.12752
25	4026.14	2500.06	12103.75	18629.95	1.12745
26	4538.91	2818.29	13647.96	21005.17	1.12749
27	5117.98	3177.24	15387.32	23682.55	1.12746
28	5770.25	3582.59	17346.56	26699.40	1.12739
29	6504.96	4039.17	19555.05	30099.18	1.12733
30	7333.14	4553.47	22044.72	33931.34	1.12732

TABLE I.12: The development of a female flock of sheep over a period of 15 years according to Example 1b

<u>Half- years</u>	<u>New- born</u>	<u>Other lambs</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	140.00	190.00	670.00	1000.00	0.0
1	251.25	193.00	669.28	1113.53	1.11353
2	250.98	273.87	668.57	1193.43	1.07175
3	250.71	351.56	670.85	1273.13	1.06679
4	251.57	351.19	751.02	1353.77	1.06334
5	281.63	351.60	830.99	1464.22	1.08158
6	311.62	373.24	910.78	1595.64	1.08975
7	341.54	415.28	991.16	1747.98	1.09547
8	371.69	457.21	1093.30	1922.20	1.09967
9	409.99	499.26	1216.44	2125.68	1.10586
10	456.16	547.17	1357.51	2360.85	1.11063
11	509.07	606.31	1441.82	2557.19	1.08317
12	540.68	675.66	1553.12	2769.47	1.08301
13	582.42	734.83	1696.94	3014.19	1.08836
14	636.35	786.17	1877.19	3299.71	1.09473
15	703.95	853.14	2058.52	3615.61	1.09573
16	771.95	938.21	2248.08	3958.24	1.09476
17	843.03	1033.12	2454.45	4330.61	1.09407
18	920.42	1130.48	2687.04	4737.94	1.09406
19	1007.64	1234.42	2940.41	5182.46	1.09382
20	1102.65	1349.64	3211.21	5663.50	1.09282
21	1204.21	1477.20	3499.16	6180.57	1.09130
22	1312.19	1614.80	3826.03	6753.01	1.09262
23	1434.76	1761.47	4190.19	7386.42	1.09380
24	1571.32	1922.86	4587.69	8081.87	1.09415
25	1720.38	2104.26	5013.45	8838.09	1.09357
26	1880.05	2304.19	5477.43	9661.66	1.09318
27	2054.03	2520.30	5987.23	10561.56	1.09314
28	2245.21	2753.86	6547.20	11546.27	1.09323
29	2455.20	3009.47	7157.89	12622.56	1.09321
30	2684.21	3290.29	7823.86	13798.35	1.09315

TABLE I.13: The development of a female flock of goats over a period of 15 years according to Example 2a

<u>Half- years</u>	<u>New- born</u>	<u>Other kids</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	115.00	80.50	804.50	1000.00	0.0
1	402.25	80.50	804.56	1287.30	1.28730
2	402.28	281.57	804.61	1488.46	1.15626
3	402.31	281.59	1005.74	1689.64	1.13516
4	502.87	281.61	1206.89	1991.38	1.17858
5	603.45	352.01	1408.06	2363.52	1.18688
6	704.03	422.41	1679.63	2806.07	1.18724
7	839.81	492.82	2021.59	3354.23	1.19535
8	1010.80	587.87	2433.97	4032.64	1.20225
9	1216.98	707.56	2941.39	4865.93	1.20664
10	1470.70	851.89	3568.45	5891.04	1.21067
11	1784.23	1029.49	4339.84	7153.55	1.21431
12	2169.92	1248.96	5288.83	8707.71	1.21726
13	2644.41	1518.94	6256.21	10419.57	1.19659
14	3128.11	1851.09	7493.56	12472.76	1.19705
15	3746.78	2189.67	9063.04	14999.49	1.20258
16	4531.52	2622.75	10900.70	18054.97	1.20370
17	5450.35	3172.06	13101.04	21723.45	1.20318
18	6550.52	3815.25	15780.28	26146.05	1.20359
19	7890.14	4595.36	19007.66	31483.16	1.20413
20	9503.83	5523.10	22885.46	37912.39	1.20421
21	11442.73	6652.68	27556.68	45652.09	1.20415
22	13778.34	8009.91	33179.87	54968.12	1.20407
23	16539.93	9644.84	39940.82	66175.56	1.20399
24	19970.41	11612.95	48066.71	79650.06	1.20362
25	24033.36	13979.29	57828.58	95841.19	1.20328
26	28914.29	16823.35	69618.19	115355.81	1.20361
27	34809.09	20240.00	83818.75	138867.87	1.20382
28	41909.40	24366.37	100886.69	167162.50	1.20375
29	50443.37	29336.58	121437.81	201217.75	1.20372
30	60718.93	35310.36	146189.06	242218.31	1.20376

TABLE I.14: The development of a female flock of goats over a period of 15 years according to Example 2b

<u>Half- years</u>	<u>New- born</u>	<u>Other kids</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	115.00	161.00	724.00	1000.00	0.0
1	362.00	161.00	724.06	1247.05	1.24705
2	362.03	333.90	724.11	1420.04	1.13871
3	362.06	506.82	724.17	1593.04	1.12183
4	362.08	506.86	897.12	1766.06	1.10861
5	448.56	506.90	1070.10	2025.55	1.14693
6	535.05	567.45	1243.09	2345.59	1.15800
7	621.55	688.53	1416.10	2726.18	1.16226
8	708.05	809.62	1649.65	3167.32	1.16182
9	824.83	930.72	1943.74	3699.29	1.16795
10	971.87	1073.02	2298.32	4343.21	1.17407
11	1149.16	1257.69	2713.46	5120.31	1.17892
12	1356.73	1484.72	3210.34	6051.79	1.18192
13	1605.17	1754.12	3637.25	6996.54	1.15611
14	1818.62	2073.33	4188.24	8080.20	1.15488
15	2094.12	2396.66	4884.52	9375.29	1.16028
16	2442.26	2738.92	5754.68	10935.86	1.16645
17	2877.34	3175.47	6713.72	12766.53	1.16740
18	3356.86	3723.72	7805.07	14885.65	1.16599
19	3902.54	4363.94	9079.57	17346.05	1.16529
20	4539.79	5081.58	10598.07	20219.44	1.16565
21	5299.04	5909.62	12370.50	23579.16	1.16616
22	6185.25	6887.18	14421.96	27494.39	1.16605
23	7210.98	8039.00	16795.40	32045.38	1.16552
24	8397.70	9377.36	19555.02	37330.08	1.16491
25	9777.51	10926.07	22761.07	43464.66	1.16433
26	11380.54	12722.64	26535.72	50638.90	1.16506
27	13267.86	14810.63	30948.22	59026.71	1.16564
28	15474.11	17253.87	36082.90	68810.87	1.16576
29	18041.45	20119.38	42035.14	80195.94	1.16545
30	21017.57	23460.80	48972.84	93451.25	1.16529

TABLE I.15: The development of a female flock of goats over a period of 15 years according to Example 2c

<u>Half- years</u>	<u>New- born</u>	<u>Other kids</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	115.00	80.50	804.50	1000.00	0.0
1	402.25	80.50	679.86	1162.61	1.16261
2	339.93	281.57	635.86	1257.36	1.08150
3	317.93	237.95	801.34	1357.22	1.07942
4	407.67	222.55	926.21	1549.43	1.14162
5	463.10	280.47	1034.99	1778.56	1.14788
6	517.49	324.17	1197.06	2038.73	1.14628
7	598.53	362.25	1396.73	2357.50	1.15636
8	698.36	418.97	1626.92	2744.26	1.16405
9	813.46	488.85	1894.38	3196.70	1.16487
10	947.19	569.42	2198.61	3715.22	1.16221
11	1099.30	663.03	2544.11	4306.45	1.15913
12	1272.05	769.51	2918.26	4959.82	1.15172
13	1459.13	890.44	3360.97	5710.54	1.15136
14	1680.49	1021.39	3894.69	6596.57	1.15516
15	1947.34	1176.34	4505.05	7628.73	1.15647
16	2252.52	1363.14	5205.32	8820.99	1.15628
17	2602.66	1576.77	6020.56	10200.00	1.15633
18	3010.28	1821.86	6963.77	11795.92	1.15646
19	3481.89	2107.20	8050.63	13639.71	1.15631
20	4025.32	2437.32	9305.40	15768.04	1.15604
21	4652.70	2817.72	10755.40	18225.82	1.15587
22	5377.70	3256.89	12431.47	21066.06	1.15584
23	6215.73	3764.39	14369.63	24349.76	1.15588
24	7184.81	4351.02	16611.82	28147.65	1.15597
25	8305.91	5029.37	19204.65	32539.93	1.15604
26	9602.32	5814.13	22201.08	37617.54	1.15604
27	11100.54	6721.62	25664.42	43486.59	1.15602
28	12832.21	7770.38	29668.30	50270.89	1.15601
29	14834.15	8982.55	34296.55	58113.25	1.15600
30	17148.27	10383.90	39646.35	67178.50	1.15599

TABLE I.16: Long-term effects (two generations) on a herd of female cattle from a two-year drought

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	158.58	332.38	468.50	1000.00	0.0
1	0.0	155.73	196.99	360.70	0.36070
2	0.0	83.23	239.98	329.04	0.91223
3	107.99	13.72	280.45	407.38	1.23806
4	98.16	86.39	253.61	453.32	1.11277
5	88.76	158.87	214.62	482.28	1.06390
6	75.12	218.76	175.88	490.61	1.01727
7	61.56	194.05	205.44	482.59	0.98364
8	71.90	166.55	217.47	485.92	1.00690
9	76.12	155.30	224.08	490.44	1.00931
10	78.43	156.98	226.27	498.21	1.01584
11	79.19	169.12	244.86	511.18	1.02604
12	85.70	174.37	273.49	537.19	1.05089
13	95.72	181.75	296.67	574.38	1.06923
14	103.84	195.13	284.77	609.61	1.06133
15	99.67	213.58	278.65	628.60	1.03115
16	97.53	223.22	281.17	636.49	1.01254
17	98.41	224.02	295.18	647.65	1.01753
18	103.31	220.25	317.46	666.03	1.02838
19	111.11	223.35	332.07	692.18	1.03927
20	116.22	233.84	342.78	720.62	1.04108
21	119.97	247.13	352.25	748.32	1.03844
22	123.29	259.33	363.24	775.34	1.03610
23	127.13	268.31	375.72	802.33	1.03481
24	131.50	276.45	387.09	829.41	1.03375
25	135.48	295.10	397.85	856.05	1.03212
26	139.25	294.19	411.61	882.78	1.03123
27	144.07	303.19	427.49	911.55	1.03259
28	149.62	312.60	444.43	943.35	1.03488
29	155.55	323.23	460.65	977.40	1.03609
30	161.23	335.44	475.32	1012.43	1.03584

TABLE I.17: Long-term effects (two generations) on a herd of female cattle from a three-year drought

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	158.58	332.38	468.50	1000.00	0.0
1	0.0	155.73	196.99	360.70	0.36070
2	0.0	53.69	106.35	161.23	0.44700
3	0.0	8.85	139.87	149.43	0.92681
4	62.94	0.0	136.12	200.77	1.34357
5	47.64	50.35	117.80	222.38	1.10761
6	41.23	84.94	99.52	234.42	1.05417
7	34.83	111.98	80.29	236.19	1.00755
8	28.10	91.51	97.47	229.70	0.97253
9	34.11	76.93	97.68	228.57	0.99507
10	34.19	72.30	96.78	226.58	0.99130
11	33.87	72.17	110.01	227.68	1.00483
12	38.50	76.14	120.86	237.84	1.04465
13	42.30	79.66	133.89	256.01	1.07637
14	46.86	85.93	142.66	275.44	1.07592
15	49.93	95.60	130.76	291.37	1.05784
16	45.77	104.08	128.42	297.36	1.02056
17	44.95	106.19	131.24	298.84	1.00496
18	45.93	104.56	139.33	303.78	1.01654
19	48.77	101.86	150.88	312.99	1.03031
20	52.81	104.29	157.00	326.13	1.04198
21	54.95	110.31	162.07	340.03	1.04264
22	56.73	116.99	167.10	353.52	1.03967
23	58.48	122.80	171.67	366.73	1.03738
24	60.08	127.01	177.06	379.40	1.03454
25	61.97	130.83	181.93	391.59	1.03211
26	63.67	134.74	186.92	403.54	1.03053
27	65.42	138.62	194.17	415.84	1.03048
28	67.96	142.59	202.11	429.63	1.03314
29	70.74	147.10	210.18	445.07	1.03596
30	73.56	152.42	217.62	461.44	1.03678

TABLE I.18: Long-term effects (two generations) on a herd of female camels from a two-year drought

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	131.30	325.92	533.26	1000.00	0.0
1	0.0	177.15	136.17	317.24	0.31724
2	0.0	130.77	157.12	291.07	0.91752
3	39.28	91.13	179.87	313.13	1.07578
4	44.97	78.80	206.16	332.59	1.06215
5	51.54	61.04	236.62	351.74	1.05757
6	59.15	79.07	232.38	373.04	1.06057
7	58.09	108.00	220.32	388.76	1.04214
8	55.08	134.00	208.50	399.85	1.02853
9	52.13	140.25	213.46	408.09	1.02061
10	53.36	142.24	219.78	417.67	1.02346
11	54.94	142.91	227.07	427.24	1.02291
12	56.77	141.51	235.16	435.79	1.02002
13	58.79	141.63	239.90	442.69	1.01584
14	59.97	144.05	240.19	446.63	1.00889
15	60.05	148.07	237.50	448.07	1.00323
16	59.37	151.21	232.04	448.12	1.00010
17	58.01	153.01	230.10	448.11	0.99999
18	57.53	153.12	231.56	450.00	1.00421
19	57.89	152.27	235.81	454.54	1.01009
20	58.95	151.35	241.68	461.52	1.01534
21	60.42	151.17	254.06	470.69	1.01987
22	63.51	152.15	265.23	482.63	1.02538
23	66.31	155.57	273.16	495.47	1.02660
24	68.29	160.53	276.02	507.28	1.02384
25	69.00	166.00	278.01	516.86	1.01887
26	69.50	170.89	279.68	524.86	1.01548
27	69.92	175.13	281.35	531.98	1.01357
28	70.34	178.12	284.45	538.73	1.01268
29	71.11	180.04	288.82	545.67	1.01289
30	72.20	181.54	293.90	553.09	1.01359
31	73.48	183.32	298.78	560.98	1.01427
32	74.69	185.54	303.42	569.15	1.01457
33	75.85	188.12	307.90	577.53	1.01473
34	76.97	191.01	312.30	586.14	1.01490
35	78.08	194.04	316.91	595.02	1.01515
36	79.23	197.05	321.92	604.27	1.01553
37	80.48	200.02	327.36	613.91	1.01596
38	81.84	203.04	333.09	623.92	1.01631
39	83.27	206.19	338.87	634.20	1.01648
40	84.72	209.51	344.52	644.61	1.01641

TABLE I.19: Long-term effects (two generations) on a herd of female camels from a three-year drought

<u>Years</u>	<u>Calves</u>	<u>Heifers</u>	<u>Fertile</u>	<u>Total females</u>	<u>Growth Rate</u>
0	131.30	325.92	533.26	1000.00	0.0
1	0.0	177.15	136.17	317.24	0.31724
2	0.0	86.68	46.26	134.30	0.42334
3	0.0	61.93	64.06	126.93	0.94511
4	16.01	36.38	84.94	138.11	1.08806
5	21.24	17.45	110.93	150.28	1.08817
6	27.73	23.61	113.19	165.13	1.09881
7	28.30	38.53	109.35	176.73	1.07021
8	27.34	51.99	105.63	185.46	1.04943
9	26.41	63.91	101.98	192.78	1.03944
10	25.50	68.13	105.00	199.09	1.03278
11	26.25	69.59	109.31	205.63	1.03280
12	27.33	69.00	114.82	211.64	1.02923
13	28.71	68.92	118.46	216.57	1.02331
14	29.61	70.02	119.11	219.23	1.01231
15	29.78	71.85	117.55	219.68	1.00203
16	29.39	73.91	114.26	218.68	0.99544
17	28.56	75.23	109.87	216.96	0.99213
18	27.47	75.51	108.01	215.43	0.99298
19	27.00	74.58	108.42	215.32	0.99946
20	27.10	73.16	110.27	216.95	1.00759
21	27.57	71.93	117.42	220.45	1.01612
22	29.35	71.26	124.54	226.39	1.02698
23	31.14	72.13	129.92	233.50	1.03138
24	32.48	74.41	133.53	240.47	1.02985
25	33.38	77.41	134.78	246.55	1.02526
26	33.69	80.60	135.32	251.35	1.01950
27	33.83	83.50	135.44	255.21	1.01536
28	33.86	85.56	136.30	258.46	1.01273
29	34.07	86.78	137.93	261.57	1.01203
30	34.48	87.54	140.06	264.81	1.01237
31	35.02	88.15	142.45	268.25	1.01299
32	35.61	88.92	144.70	271.88	1.01353
33	36.18	89.93	146.82	275.64	1.01383
34	36.70	91.17	148.81	279.52	1.01409
35	37.20	92.54	150.87	283.56	1.01443
36	37.72	93.93	153.16	287.81	1.01500
37	38.29	95.32	155.73	292.33	1.01571
38	38.93	96.71	158.54	297.12	1.01638
39	39.63	98.17	161.48	302.12	1.01685
40	40.37	99.72	164.40	307.26	1.01700

FOOTNOTES

NOTES TO CHAPTER 1

1. N Dyson-Hudson 1962, pp 793-796
2. Fransen, Khoun and Milford 1970 quoted by Asmarom 1975, p 36
3. Schneider 1965, p 78
4. N Dyson-Hudson 1972, p 23
5. *ibid*, p 11
6. C Widstrand 1975, p 149
7. The issue is thoroughly discussed in the Hunting Report, 1974, on Darfur in Sudan. For other discussions see Le Houérou 1976, Boudet 1975 a and Boudet 1975 b

NOTES TO CHAPTER 2

1. See e g L Mair 1974, p 5
2. The Hunting Report, Annex 3, 1974, p I. 7
3. Williamson and Payne 1965, p 186
4. Evans-Pritchard 1940, p 33
5. Trust Territory 1952, p 119
6. N Dyson-Hudson 1966, p 54
7. Schneider 1957, p 287
8. Joshi et al 1957, p 150
9. *ibid*, p 263
10. *ibid*, p 184
11. Baker 1968, p 217
12. C Widstrand 1972, p 6
13. Calculated from the Hunting Report, Annex 3, 1974; the table on p I. 3
14. R & N Dyson-Hudson 1970, p 112
15. C Widstrand 1972, p 22
16. A Jacobs 1963, p 23
17. Brémaud and Pagot 1962, p 321

18. P Spencer 1973, p 10
19. McKay 1957, p 271
20. Demirören 1974, p 17
21. Brown 1973, p 70
22. C Widstrand 1972, p 6
23. The Hunting Report, Annex 3, 1974, p I.5
24. Brémaud and Pagot 1962, p 32
25. N and R Dyson-Hudson 1970, p 113
26. Gallais 1972, p 355
27. Van Raay 1975, p 44
28. See e g the Hunting Report, Annex 3, 1974, p 4
29. R Bartha 1971, p 138
30. I W Scott 1957 and R Bartha 1971, p 130
31. K Meyn 1970, p 21
32. P Spencer 1965, p 10
33. Kenya Land Commission Evidence, HMSO, London 1933, p 1657 ff
34. This is confirmed by P Spencer; personal communication
35. Mc Kay 1958, p 270
36. N and R Dyson-Hudson 1970, p 111
37. Galukande et al 1962, p 330
38. Joshi 1957, pp 56, 68, 108, 158, 187, 214 and 266
39. Grunnet 1962, p 11
40. Evans-Pritchard 1940, p 34
41. Bartha 1971
42. Demirören 1974, p 17
43. The Hunting Report, Annex 3, 1974, p I.7
44. Demirören 1974, p 45
45. Williamson and Payne 1965, p 174
46. Sjöberg and Persson 1974, p 47
47. Williamson and Payne 1965, p 175
48. The Hunting Report, Annex 3, 1974, p I.5
49. McKay 1957, p 271

50. Demirören 1974, p 17
51. Sjöberg and Persson 1974, p 30
52. Mayn 1970, p 21
53. McKay, loc cit
54. Kenya Ministry of Agriculture 1963
55. L H Brown 1963
56. The Hunting Report, Annex 3, 1974, p I.5
57. Ruthenberg 1971, p 263
58. Williamson and Payne 1974, loc cit
59. McKay 1957, p 270
60. Meyn 1970, p 13
61. Brown, op cit
62. Prole 1967, p 93
63. N and R Dyson-Hudson 1970, p 111
64. Grunnet 1962, p 11
65. A Jacobs 1963, p 21
66. Galukande et al 1962, p 330
67. Joshi et al 1957, p 266
68. The Hunting Report, Annex 3, 1974, p I.6
69. Maris 1954, p 422
70. Joshi et al 1957, p 69
71. ibid, p 187
72. ibid, p 158
73. Williamson and Payne 1965, p 176
74. Demirören 1974, p 17
75. Somali Republic 1961, p 170
76. Grunnet 1962, p 11
77. E Evans-Pritchard 1940, p 34
78. P Spencer 1973, p 10
79. Reid 1930
80. Schinkel 1970, p 249
81. Joshi et al 1957, p 266

82. *ibid*, p 69
83. *ibid*, p 108
84. A more detailed discussion is found in Prole 1967, p 93 and, not limited to nomadic cattle, in Sjöberg and Persson 1974, pp 41-45
85. Gallais 1972, p 357
86. Meyn 1970, p 22
87. Ruthenberg 1971, p 263
88. Shaw and Colville 1950
89. Williamson and Payne 1965, p 211
90. Demirören 1974, p 17
91. The Hunting Report, Annex 3, 1974, p I.10
92. Meyn 1970, p 13
93. Wilson 1963 quoted by Meyn 1970, p 13
94. Williamson and Payne 1965, p 211
95. Grunnet 1962, p 11
96. Prole 1967, p 94
97. Demirören 1974, p 17
98. Bartha, 1971
99. K Meyn 1970, p 22
100. Demirören 1974, p 17
101. The Hunting Report 1974, Annex 3, p I.10
102. Williamson and Payne 1965, pp 210-211
103. Ruthenberg 1971, p 264
104. Deshler 1965, p 160
105. The Hunting Report, Annex 3, 1974
106. *ibid*, p I.3
107. N Dyson-Hudson 1966, p 47
108. Deshler 1965, p 161
109. Demirören 1974, p 17
110. A Jacobs 1963, p 23
111. *ibid*, p 23
112. The class boundary is set to the upper age in the interval

113. In Chapter 2.5 another kind of calculation is made on building up a herd from a few animals.
114. The ratio number of females year i to the number of females year $(i-1)$. Note that this differs from the derivative of the curve for the number of female cattle.
115. Meyn 1970, p 81
116. Allan 1965, p 324
117. *ibid*, p 315
118. Spencer 1965, p 69
119. Demirören 1974, pp 21-22
120. Brémaud and Pagot 1962, p 321
121. Leslie Brown 1973, p 71
122. Widstrand 1972, p 6
123. Prole 1967, pp 93-94
124. Spencer 1965, p 25
125. A Monte Carlo method might be employed here. We hope to simulate this exercise also by computer in the near future. The calf mortality, for example, could then be simulated with a stochastic variable so that one out of five born calves is killed randomly
126. Stenning 1958
127. See P Spencer 1965 for a discussion on this point

NOTES TO CHAPTER 3

1. Spencer 1973
2. See e g Musil 1928, p 349
3. Musil 1928, pp 87-88; Sweet 1965a p 132, Sweet 1965b, p 1139
4. Asad 1970, p 17
5. Leese 1927
6. Yasin and Wahid 1957
7. Born 1965, p 220
8. Lewis 1961, p 73
9. Asad, *loc cit*

10. Spencer 1973, p 12
11. Mares 1954, p 418
12. Williamson and Payne 1965, p 296
13. Musil 1928, p 333
14. Spencer 1973, p 11
15. Sweet 1965b, p 1139
16. Williamson and Payne 1965, p 297
17. Yasin and Wahid 1957
18. Terentjev 1966
19. Mares 1954, p 418
20. Nicolaisen 1963, p 56
21. Spencer 1973, p 11; Asad 1964, p 15; Swift 1973, p 73; Nicolaisen 1963, p 56; Bulliet 1975, p 41; Yasin and Wahid 1957
22. Williamson and Payne 1965, p 297
23. Sweet 1965b, p 1139
24. Blagoveščenski 1963
25. Musil 1928, pp 334 and 537
26. Williamson and Payne 1965, p 297
27. *ibid*, p 296
28. Mares 1954, p 418
29. Lewis 1961, p 85
30. Yasin and Wahid 1957
31. Nicolaisen 1963, p 63
32. See for example Spencer 1973, p 13; Sweet 1965a, p 132 and 1965b, p 1132; Yasin and Wahid 1957; Terentjev 1966; Nicolaisen 1963, p 56; Mares 1954; Aueljbekov 1967; Blagoveščenskij 1963
33. Spencer *loc cit*
34. Mares *loc cit*
35. Bulliet 1975, p 41; Yasin and Wahid 1957
36. See Bulliet 1975, p 285; footnote 27
37. Williamson and Payne 1965, p 298
38. Musil 1928, p 600; Swift 1973 p 73
39. Mares 1954, p 417

40. Aueljbekov 1967
41. Sweet 1965b, p 1139
42. Williamson and Payne 1965, p 298
43. Nicolaisen 1963, p 63
44. Yasin and Wahid 1957
45. Spencer 1973, p 11

NOTES TO CHAPTER 4

1. The Hunting Report, Annex 3, 1974, p 9 and Irons 1972, pp 93-94
2. *ibid* p. I.33
3. Wijeratne 1968, p 43
4. Epstein & Herz 1964, p 242
5. Irons 1972, p 93
6. The Hunting Report, Annex 3, 1974, p 9
7. Williamson and Payne 1965, p 271
8. *ibid* and Asad 1970, p 16
9. Barth 1964, p 6
10. Asad 1970, p 17
11. Mares 1954, p 421
12. The Hunting Report, Annex 3, 1974, p 12:
The notion of flocks is kept for convenience in the Hunting Report, although the animals are allowed to trot around without herding; see *ibid*, p 11
13. Williamson and Payne 1965, p 292; French 1970, p 136
14. Barth 1964, p 7
15. See French 1970, p 102
16. Williamson and Payne 1965, p 290
17. Asad 1970, p 16
18. Williamson and Payne 1965, p 291; Devendra & Burns 1970, p 132
19. Irons 1972, p 94
20. Mares 1954, p 110

21. Williamson and Payne 1965, p 271
22. Ward 1959, p 219
23. Sacker and Trail 1966a, p 392
24. The Hunting Report, Annex 3, 1974, p I.32
25. *ibid*, p I.13
26. Irons 1972, p 94
27. Asad 1970, p 16
28. Williamson and Payne 1965, p 271
29. Asad 1970, p 15. This deviation is used as typical for sheep and goats by Johnson 1969, p 8, influenced by Asad 1964
30. Spencer 1973, p 13
31. Williamson and Payne 1965, p 101
32. Sacker and Trail, 1966a, p 393
33. Ward 1959, p 219
34. The Hunting Report, Annex 3, 1974, p I.32
35. See e g Ward 1959, p 218; Hutchison 1955 qu. by Mason & Maule 1960, p 96
36. Williamson and Payne 1965, p 279
37. Mares in Williamson and Payne 1965, p 428 and Mares 1954, p 421
38. The Hunting Report, Annex 3, 1974, p 20
39. Demirören 1974, p 21; Trust Territory 1952, p 120
40. The Hunting Report, Annex 3, 1974, p I.33
41. *ibid* and Williamson and Payne 1965, p 272
42. Purser and Young 1964, p 322
43. The Hunting Report, Annex 3, 1974, pp 9, 11
44. Sacker and Trail 1966a, p 393
45. Ward 1959, p 220
46. Mares 1954, p 421
47. French 1970, p 102
48. Williamson and Payne 1965, p 289
49. The Hunting Report, Annex 3, 1974, p I.15
50. Irons 1972, p 94

51. Sacker and Trail 1966b, p 50
52. Wijeratne 1968, p 43
53. Epstein and Herz 1964, p 240
54. Williamson and Payne 1965, p 290
55. Asad 1970, p 15 and Spencer 1973, p 13
56. Williamson and Payne *ibid*, French 1970, p 102
57. Sacker and Trail 1966b, p 44
58. Wijeratne 1968, p 43
59. Williamson and Payne 1965, p 290
60. Mares 1954, p 421
61. Swift 1973, p 73
62. Spencer 1973, p 13
63. The Hunting Report, Annex 3, 1974, p I.18: "Although the monthly totals vary considerably a chi squared test shows no significant differences in the monthly totals ($p = 0.01$). " This may be the case for monthly totals but with different class boundaries, e g on a bi-monthly basis, there should be significant changes around the beginning and end of the rainy season.
64. French 1970, p 102
65. Mason & Maule 1960, p 120, quoting Hutchinson 1955 and Rollinson, D. H. L. (personal comm.)
66. Sacker and Trail 1966b, p 44
67. Shanmugasundaram 1957, p 108
68. The Hunting Report, Annex 3, 1974, p I.19
69. *ibid*, p 13
70. Epstein and Herz 1964, p 243
71. Wijeratne 1968, p 43
72. Williamson and Payne 1965, p 290
73. See the Hunting Report, Annex 3, 1974, p 12
74. Sacker and Trail 1966b, p 44
75. Spencer 1973, p 13
76. Sacker and Trail 1966a, p 393
77. Mares 1954, p 421
78. Ruthenberg 1971, p 275

79. Williamson and Payne 1965, p 277
80. Irons 1972, p 94
81. French 1970, pp 184, 197
82. FAO 1972, p 42
83. The Hunting Report, Annex 3, 1974, pp 37-39
84. Ward 1959, p 221
85. French 1938, p 25
86. Sacker and Trail 1966b, p 48; Cf Purser & Young 1964, p 323
87. The Hunting Report, Annex 3, 1974, p I.24
88. Wijeratne 1968, p 43
89. Irons 1972, p 93
90. The Hunting Report, Annex 3, 1974, pp 9, 12
91. The six-month growth rates are 13 % and 9 % respectively
92. The six-month growth rates are 20.4 % and 16.5 % respectively
93. Irons 1972, p 93
94. Demirören 1974, p 21
95. Strangely enough Samburu sheep are considered to prolify better than goats, breeding more quickly; see Spencer 1965, p 3
96. Brémaud and Pagot 1962, p 321

NOTES TO CHAPTER 5

1. Kenya Ministry of Finance and Planning 1972
2. R and N Dyson-Hudson 1975
3. Prole 1967, p 94
4. Prole 1967, loc cit
5. Jacobs 1963, p 7
6. Ethiopian Government Relief and Rehabilitation Commission 1974, p 47
7. Bondestam 1975, p 63
8. FAO 1972, p 94
9. Quoted by Allan 1967, p 319

10. McKay 1957, p 317
11. Peck 1961, p 3
12. Prole 1967, p 94. See also Swift 1973, p 73
13. Prole 1967, loc cit
14. Brémaud and Pagot 1962, p 323
15. Morgan 1972, p 167
16. FAO 1972, p 94
17. Curasson, G 1942, p 18

NOTES TO CHAPTER 6

1. Kenya Ministry of Finance and Planning 1972
2. This is the case of the Samburu in northern Kenya while the opposite is the rule of the neighbouring Borana
3. Hedlund 1965, p 7
4. Spencer 1965, p 7
5. Elam 1973, p 19
6. See for example Spencer's discussion on the Samburu Morans in Chapters 5 and 6 (Spencer 1965)
7. Hjort 1976

NOTES TO CHAPTER 7

1. Recommended Dietary Allowances 1968
2. Wikberg 1971, pp 90, 114, 116
3. Van Rensburg 1969, p 21; Brown 1973, p 69
4. Brown 1973, p 69
5. McKay 1957, p 321
6. Grunnet 1962, p 11
7. Sweet 1965b, p 1135
8. Brown 1973, p 69
9. Evans-Pritchard 1940, p 23

10. Klima 1970, p 10
11. Brémaud and Pagot 1962, p 318
12. Dyson-Hudson, R and N 1970, p 113
13. Mares 1954, p 423
14. Joshi et al 1957, pp 57, 70 and 266
15. Galukande et al 1960, p 330
16. Lambkin and Lambkin 1960, p 235
17. Marples 1964
18. Alimi 1962
19. Schneider 1957, p 287
20. Dyson-Hudson 1970, p 111-3
21. Most authors have been using kilogrammes, pints, quarts, litres and gallons indiscriminately. We will here assume that 1 kg = 1 litre and give all information stated in these terms. The typical weight for one litre of Swedish milk is 1.03 kg. This weight decreases with fatter milk - Swedish cream weight, for example, is 0.9 kg. With increased amounts of water the specific weight will approach 1.0 kg. The excess over 1 kg comes from solids-not-fat.
22. McKay 1957, pp 271, 321
23. Meyn 1970, p 12
24. Epstein 1955
25. Bartha 1971, p 140
26. Marples 1964
27. Galukande et al 1962, p 330
28. Lampkin and Lampkin 1960, p 235
29. Joshi et al 1957, p 57
30. *ibid*, p 116
31. *ibid*, p 69
32. Klima 1970, p 10
33. Cozzi 1965, p 137
34. Brown 1973, p 71
35. Grunnet 1962, p 10
36. Evans-Pritchard 1940, p 35
37. Joshi et al 1957, p 262

38. *ibid*, p 161
39. *ibid*, p 103
40. *ibid*, p 63
41. Merker 1910, p 163
42. See Schinkel 1970, p 251; Hollis 1905, p 250 and Spencer 1965, pp 4-5
43. Gulliver 1953, p 34
44. Elam 1973
45. Brémaud & Pagot 1962, p 318
46. Evans-Pritchard 1940, p 23
47. Grunnet 1962, p 10
48. Haberland 1963, p 86
49. The Hunting Report, Annex 3, 1974, p I.14
50. Joshi et al 1957, p 187
51. Elam 1973, p 48
52. Bondestam 1974, p 38
53. Smeds 1962, p 51
54. Deshler 1965, p 161
55. Jacobs 1963, p 24
56. Widstrand 1972, p 5
57. Gulliver 1953, p 60
58. Van Raay 1975, pp 49 and 111
59. Dyson Hudson 1970
60. Brown 1973, p 69
61. Widstrand 1976, p 6
62. Van Raay 1975, p 50
63. Stenning 1958, p 103
64. Van Raay 1975, p 149
65. Wilson 1963
66. Ruthenberg 1971, p 263
67. Orr and Gilks 1931
68. Williamson and Payne 1965, p 385

69. McKay 1957, pp 270, 321
70. Luchini 1947
71. Herin 1964
72. Guide Book of Ethiopia 1954
73. Pyke 1970, p 43
74. Deshler 1965, p 162; Widstrand 1972, p 6
75. Brown 1973, p 69
76. Pyke, loc cit
77. Wikberg 1971, p 98
78. Bartha 1971, p 116
79. Kon 1972, p 11
80. ibid, p 8
81. Wikberg 1971, Table 10:4, p 258
82. Kon 1972, pp 1, 8, 9
83. Bondestam 1974, p 38
84. Jacobs 1963, p 25
85. Orr and Gilks 1931, p 29
86. Joshi et al 1957, pp 56, 68, 157, 158
87. Jacobs 1963, p 25
88. Mares 1954, p 472
89. Swift 1973, p 74; Gulliver P and Ph 1953, p 60
90. Fisher and Bender 1970, p 112
91. Pyke 1970, pp 52, 58
92. Elam 1973, pp 28, 34
93. Schneider 1957, p 288, and others
94. Lewis 1963, p 85
95. Gulliver 1955, p 60
96. Spencer 1965, p 2
97. Ruthenberg 1971, p 261
98. Dyson-Hudson 1966, p 43
99. Spencer 1965, p 2
100. Joshi et al 1957, p 263

101. Klima 1970, p 43
102. Spencer 1973, p 9
103. Jacobs 1963, p 21
104. Widstrand 1972, p 9
105. Widstrand 1962, p 9; Jacobs 1963, p 21; Klima 1970, p 43 and others
106. R and N Dyson-Hudson 1970, p 110
107. Schneider 1957, p 289; R Dyson-Hudson 1970, p 110; Van Raay 1975, p 45
108. Gulliver Nomadism ... p 34 cf also Schneider 1957, p 291
109. R and N Dyson-Hudson 1970, p 110, and Schneider 1957, p 289
110. Cf ia Hedlund 1971, p 14; Baker 1968, p 212; 1974, p 6 on Kenya and Uganda; Van Raay 1975, p 45; Joshi et al 1957, p 104; Stenning 1966, p 108, on Northern Nigeria and Thompson and Adloff 1968, p 173 on Somalia
111. See Baker 1968, p 222
112. Cf Bartha 1971, p 70
113. Meyn 1970, p 137
114. Epstein 1955
115. The Hunting Report 1974, Annex 3, p I.13; and Hall 1962
116. Ledger 1966, acc to Meyn 1970, p 138
117. Payne 1963, p 22
118. Meyn 1970, p 162-3
119. Baker 1968, p 222
120. Lewis 1955, p 67
121. McKay 1957, p 270
122. Van Raay 1975, p 44
123. Bartha 1971, p 100
124. Ruthenberg 1971, p 264
125. Morgan 1972, p 167
126. Brémaud and Pagot 1962, p 321
127. The Hunting Report 1974, Annex 3, p I.13
128. Grunnet 1962, p 12
129. Allan 1967, p 303

130. Mann 1954, p 495
131. Jacobs 1963, p 21
132. R and N Dyson-Hudson 1970, p 110
133. Payne 1963, p 22
134. Callow 1949
135. Epstein 1955
136. Wikberg 1971, Table 6.2 p 98
137. See eg Animal Production 1973. Such considerations over the most rational way of using resources seem very often to be done by experts from industrialized countries on behalf of the populations of the third world. Less often they are done in a self-reflecting way.
138. Kon 1972, p 12
139. Evans-Pritchard 1940, p 28
140. Spencer 1965, p 2
141. Elam 1973, p 30 and Ruthenberg 1971, p 264
142. Jacobs 1963, p 21
143. Stenning 1958, p 100
144. Deshler 1965, p 162, and Schneider 1957, p 131; Allan 1967, p 304; Merker 1910, Lewis 1955 and 1969, p 67
145. Gulliver 1953, p 63
146. French 1970, p 185
147. Elam 1973, p 30
148. Dyson-Hudson 1966, pp 44-47
149. Deshler 1965, p 162
150. Cf Schneider 1957, p 287
151. Leakey 1937, p 81
152. Grunnet 1962, p 11
153. *ibid*
154. Dyson-Hudson 1966, p 44
155. Haberland 1963, p 86
156. Brayne Nichols 1954
157. Schneider 1957, p 287
158. Klima 1970, p 12

159. French 1936a, p 110
160. Pyke 1970, p 43; Williamson and Payne 1965, p 411
161. Lewis 1955, p 67
162. Jacobs 1963, p 21
163. Gulliver 1955, p 131
164. Morgan and Shafer 1966, p 10
165. Hunt 1951, p 74
166. Lewis 1955, p 68
167. Asmarom 1975, pp 20 and 34
168. Spencer, personal communication
169. Dyson-Hudson 1966, p 50
170. Allan 1965, p 308
171. Hopen 1958, pp 63-64, acc to Asmarom 1975, p 25
172. Deshler 1965, p 154
173. Huntingford 1969, p 21
174. Morgan 1972, p 164
175. Brown 1973, p 69
176. Murdock 1959, p 335
177. Gulliver 1953, p 63
178. Elam 1973, pp 3-14
179. Gulliver 1953, p 34
180. R and N Dyson-Hudson 1970, p 111
181. Elam 1973, p 14
182. Brémaud and Pagot 1962, p 321
183. Asmarom 1975, p 32
184. Schneider 1970, p 160
185. Flou 1973, p 13
186. Baker 1975
187. Fielder 1973
188. Cf Van Raay 1975, p 44
189. Hedlund 1971, p 14
190. Joshi et al 1957, p 104

191. *ibid*, p 64
192. Morgan 1972, p 167

NOTES TO CHAPTER 8

1. Spencer 1973, pp 56-8 and others
2. Leese, 1927 as quoted by Williamson and Payne 1965, p 299
3. Leupold 1968
4. Spencer 1973, p 12; Mares 1954, p 419
5. Eraskov 1955, see also Ahmediev 1966 and Kuliev 1959
6. Musil 1928, pp 88-9
7. Nicolaisen 1963, p 57
8. Leese 1927
9. Blagoveščenskij 1963
10. Spencer 1973, pp 12-14
11. Lewis 1961, p 74
12. Swift 1973, p 74. Cf Bulliet 1975, p 288
13. Mares 1954, p 472
14. Hunt 1951, p 173
15. Musil 1928, p 89
16. Nicolaisen 1963, p 63
17. Purchase 1943
18. Gulliver P & P 1953, p 62
19. Williamson and Payne 1965, p 298
20. Nicolaisen 1963, p 57
21. Mares in Williamson and Payne 1965, p 426
22. Musil 1928, p 333
23. Mares 1954, pp 419 and 422; Mares in Williamson and Payne 1965, p 426
24. Musil 1928, pp 87-88
25. Klima 1970, p 11
26. Stein 1967, p 51

27. Eraskov 1955
28. Williamson and Payne 1965, p 299
29. Capot-Rey 1962, p 303
30. Musil 1928, pp 88-89
31. Spencer 1973, p 12
32. Morgan 1972, p 166
33. Mason and Maule 1960, p 4
34. Rossetti and Congiu 1955
35. Cozzi 1965, p 130
36. Bondestam 1974, p 38
37. Schinkel 1970, p 72
38. Eraskov 1965
39. Aueljbekov 1967
40. Eraskov 1953, 1955; Kuliev 1959, Tulenbekov 1969
41. Yasin and Wahid 1957, Leupold 1968
42. Yasin and Wahid 1957
43. Nicolaisen 1963, p 63
44. Purchase 1943, quoted by Williamson and Payne 1965, p 386
45. Rosetti and Congiu 1955
46. Eraskov 1953, 1955, 1965; Kuliev 1959 and Terentjev 1966
47. Lewis 1955, p 67
48. Drake-Brockman 1912, p 194
49. Spencer 1973, p 12
50. Kon 1972, p 10
51. Lewis 1961, pp 43 and 85
52. *ibid*, p 74
53. Sweet 1965b, p 1136
54. Musil 1928, p 96
55. Spencer 1973, p 12
56. Mason and Maule 1960, p 6
57. Leese, 1927, quoted by Williamson and Payne 1965, p 295
58. Mason and Maule 1960, p 4

59. Congiu 1953; see also Rosetti and Congiu 1955, Mason and Maule 1960, p 8
60. Mason and Maule, loc cit
61. Cozzi 1965, quoted by Schinkel 1970, p 271
62. Schinkel 1970, pp 71-2
63. Terentjev 1966
64. Williamson and Payne 1965, p 296
65. Yasin and Wahid 1957
66. Musil 1928, p 97
67. Stein 1967, p 52, gives inf. on the Shammar
68. Bhargava et al 1965
69. Aueljbekov 1967
70. Ahmediev 1966
71. Sweet 1965b, p 1136
72. Congiu 1953 and Rossetti and Congiu 1955
73. Kuznecov et al 1970
74. ibid
75. Nasr et al 1965
76. Bartha 1971a, p 133
77. Mann 1954, p 494
78. Stein 1967, p 53; Musil 1928, p 97
79. Musil, loc cit
80. Mann, loc cit
81. For a discussion on the tastiness of different parts of the camel, see Musil 1928, p 96
82. Mason and Maule 1960, p 4
83. Schinkel 1970, p 72
84. Cf Schneider 1957, p 291
85. Gulliver "Nomadism ..." etc, p 34, and 1953, p 63
86. Stein 1967, p 53
87. Musil 1928, pp 95-6
88. Morgan 1972, p 166

89. Yasin and Wahid 1957
90. Musil 1928, p 97
91. Alwan 1968 qu. by Ruthenberg 1971, p 257
92. Johnson 1969, p 10
93. Sweet 1965a, p 135
94. *ibid*, p 142
95. Asad 1970, p 52
96. Lewis 1955, p 67
97. Hunt 1951, p 173
98. See also Lewis 1961, p 57, and Schinkel 1970, p 117, for actual herd sizes
99. Spencer 1973, pp 12-14

NOTES TO CHAPTER 9

1. See e g R & N Dyson-Hudson 1970, p 109; Asad 1964, p 51
2. Gulliver, P & Ph 1953, p 60
3. Williamson and Payne 1965, p 270
4. *ibid*, or Bishop 1951, Bennett et al 1948, both quoted in Mason and Maule 1960, p 90
5. Demirören 1974, p 20
6. The Hunting Report, Annex 3, 1974, p I.42
7. Mason and Maule 1960, p 86, quoting Chalmers 1954
8. Payne 1963, p 22
9. Williamson and Payne 1965, p 273
10. Mason and Maule 1960, p 95
11. Williamson and Payne 1965, p 271, Epstein 1954
12. Williamson and Payne 1965, p 273
13. French 1970, p 98; Williamson and Payne 1965, p 286
14. French, *loc cit*
15. Chalmers 1954, qu. by Mason and Maule 1960, p 113
16. See Cozzi 1965, Schinkel 1970, p 87, Mason and Maule 1960, p 118, for information generally based on Drake Brockman 1912 and Rossetti & Congiu 1955

17. Sacker and Trail 1966b, p 43
18. Williamson and Payne 1965, pp 285-6
19. Mason and Maule 1960, p 117, quoting Chalmers 1954
20. Williamson and Payne 1965, p 256
21. Payne 1963, p 22
22. Wilson 1958, p 10
23. Callow 1949
24. French 1938
25. Payne 1963, p 22
26. Wikberg 1971, p 98
27. Mason and Maule 1960, p 95
28. Salerno and Congiu 1939 qu. by Mason and Maule 1960, p 105
29. Williamson and Payne 1965, p 272
30. Pyke 1970, pp 20-21
31. Fisher and Bender 1970, pp 100-102
32. Wilson 1958, p 10
33. Platt 1962, p 25
34. French 1970, p 138, Williamson and Payne 1965, p 287, Payne 1963, p 22
35. Spencer 1973, p 13
36. Nicolaisen 1963, p 45
37. Asad 1970, p 54
38. Demirören 1974, p 21
39. Brémaud and Pagot 1962, p 318
40. Payne 1963, p 22
41. Animal Production 1973, p 16
42. Stauffer 1965, p 292
43. Capot-Rey 1963, p 303
44. Nicolaisen 1963, p 45
45. Devendra and Burns 1970, p 11
46. Spencer 1973, p 13
47. Jacobs 1963, p 21

48. Rossetti and Congiu 1955
49. Williamson and Payne 1965, p 286
50. Maher 1945, p 116
51. The Hunting Report 1974, Annex 3, p I.27
52. Brémaud and Pagot 1962, p 318
53. Williamson and Payne 1965, p 286; Devendra and Burns 1970, p 11; Mason and Maule 1960, p 113
54. Mason and Maule 1960, p 113, based on Marchi 1929
55. Mason and Maule 1960, pp 113 and 119, qu. Rossetti and Congiu 1955
56. *ibid*, p 118, quoting Gadola 1947
57. Rossetti and Congiu 1955
58. Williamson and Payne 1965, p 290
59. Epstein and Herz 1962, p 243
60. The Hunting Report 1974, Annex 3, p I.19
61. Demirören 1974, p 21
62. French 1970, p 121
63. Williamson and Payne 1965, p 291
64. *ibid*, p 282. See also Ward 1969 on this issue
65. Mares 1954, p 421
66. Sweet 1965b, p 1136
67. The Hunting Report 1974, Annex 3, pp I.15 - I.20
68. Swift 1973, p 73
69. The Hunting Report, Annex 3, 1974, fig I.3 and fig I.6
70. Lewis 1961, p 58
71. Webster and Wilson 1966
72. Sacker and Trail 1966a, p 46
73. Barth 1962, p 7
74. Maher 1945, p 115
75. Kon 1972, p 9
76. French 1970, pp 106, 116, 125; Dyson-Hudson 1966, p 48
77. Parkash and Jenness 1968
78. French 1970, p 120

79. Rossetti and Congiu 1955
80. Allan 1965, p 304; Forde 1934, p 296
81. Jacobs 1963, p 21
82. Gulliver P and Ph 1953, p 63
83. French 1970, p 195
84. Stauffer 1965, p 291
85. Barth 1962, p 349, 1964, pp 16 and 109
86. Asad 1970, p 52
87. Hunt 1951, p 174
88. Lewis 1961, p 58, see also Lewis 1962
89. For a calculation on the total household economy of the Basseri, see Barth 1962, pp 16-18
90. R & N Dyson-Hudson 1970, p 107
91. Jacobs 1963, p 21
92. Maher 1945, p 118

NOTES TO CHAPTER 10

1. These are given in any edition of "FAO Production Yearbook"; and also presented by Schinkel 1970, p 54, and Williamson and Payne 1965, p 80
2. Somali Republic 1961, pp 163 f, 153, 155, 157
3. Heady, H F 1972, p 688
4. The Hunting Report 1974, Annex 3, p 36
5. Brown 1973, p 69
6. Allan 1965, pp 306-308
7. Ethiopian Government Relief and Rehabilitation Committee 1974
8. S Sandford, personal communication quoted in op cit
9. The Hunting Report 1974, Annex 3, p 36
10. Harrison quoted in Barbour 1961, p 169
11. Asmarom 1975, p 19
12. Nicolaisen 1963, p 56
13. Allan op cit loc cit

14. See Baxter 1966, p 116; Van Raay 1975, p 45; B A Lewis 1972, p 32
15. Cf Asad 1970, p 52 and Jacobs 1963, p 22
16. Spencer 1973, p 14
17. Cf Asmarom Legesse 1975, p 29
18. A warning should be made again, that the calculation for camel herds is based on scarce information and guessing
19. This kind of analysis has been discussed briefly in Hjort 1969
20. Jacobs 1963, p 22
21. Spencer 1973, p 13
22. Asad 1970, p 52
23. B A Lewis 1972, p 32
24. FAO 1972, p 94
25. Devendra and Burns 1960, p 128
26. See Spencer 1973, p 13; Jacobs 1963, p 21; and others
27. Elam 1970, pp 4-6
28. Swift 1973, p 73. The reason is illustrated in Chapter 5 above
29. Jacobs 1963, p 21 and Dyson-Hudson 1966, p 48
30. Baxter 1966, p 121
31. Chenevix-Trench 1964, p 21
32. I M Lewis 1955, p 68
33. Williamson and Payne 1965, p 50
34. French 1956 according to Williamson and Payne 1965, p 51
35. Payne 1963, quoted *ibid*
36. Williamson and Payne 1965, p 217
37. *ibid*, p 208
38. Ruthenberg 1971, p 257
39. Spencer 1973, p 15
40. Baxter 1954
41. Brémaud and Pagot 1962, p 320
42. Van Raay 1975, p 110
43. *ibid*, pp 106-129
44. *ibid*, p 110

45. Williamson and Payne 1965, p 243
46. See e g the Hunting Report 1974, Annex 3, p 54
47. Williamson and Payne 1965, p 208
48. Schmidt-Nielsen 1964. For summaries, see Gauthiers-Pilters 1969, pp 1349-51; Williamson and Payne 1965, p 301 and Bulliet 1975, p 31
49. Williamson and Payne 1965, p 13
50. *ibid*, p 301
51. Cf Webster and Wilson 1967, p 337
52. Ruthenberg 1971, p 256
53. Forde 1934, p 313
54. Asad 1964, p 52
55. I M Lewis 1955, p 67
56. Leese 1927, pp 84-85, 95, 101
57. Chenevix-Trench 1964, p 21
58. Spencer 1973, p 12
59. For more information on camel watering habits, see Gauthiers-Pilters 1969, p 1355-1367
60. I M Lewis 1961, p 72
61. Spencer 1973, p 17
62. Yasin and Wahid 1957, Leupold 1968 and Leese 1927 quoted by Williamson and Payne 1965, p 296
63. Schinkel 1970, p 296
64. Musil 1928, p 286
65. Cf Chenevix-Trench 1964, p 20; Bulliet 1975, p 319; Leupold 1968; Leese 1927
66. Spencer 1973, p 17
67. Williamson and Payne 1965, p 289
68. See e g *ibid*, p 299 and Gauthiers-Pilters 1969
69. Mares 1965, p 427 in Williamson and Payne 1965
70. See Williamson and Payne 1965, p 300
71. Johnson 1969, p 9
72. Williamson and Payne 1965, p 299
73. Cf Spencer 1973, p 8

74. Williamson and Payne 1965, pp 50-51 and Ruthenberg 1971, p 257
75. Manson-Bahr 1968, pp 1044-1051
76. Porter 1965, p 67. See also Heady 1960, pp 110-113
77. Van Raay 1975, p 121
78. Quoted by Allan 1967, p 292
79. Van Raay 1975, p 110
80. See Ph and P Gulliver 1953, p 61; Johnson 1969, p 8; Spencer 1973, p 12; Schinkel 1970, p 69
81. Mares 1965, p 430 in Williamson and Payne 1965
82. Spencer 1973, p 141
83. Cf Bulliet 1975, p 40; Schinkel 1970, p 69; Gauthiers-Pilters 1969
84. Bulliet 1975, p 284
85. Mason and Maule 1960, p 4
86. Rousseau 1943, p 68
87. Asmarom Legesse 1973, pp 15-17 and 1975, p 26
88. Bulliet 1975, p 45
89. Brown 1973, p 70
90. I M Lewis 1961, p 72
91. Spencer 1973, p 12
92. See Musil 1928, pp 347-48; Forde 1934, p 314; Asad 1970, p 16; Spencer 1973, p 13
93. Asad 1970, p 16
94. Gulliver 1953, p 61
95. Ruthenberg 1971, p 256
96. Cunnison 1966, p 69
97. Swift 1973, p 73; Schinkel 1970, p 184 ff and Ruthenberg 1971, p 256
98. Musil 1928, p 547
99. Baxter 1966, p 116
100. See Leitch and Thomson 1944 quoted by Williamson and Payne 1965, p 52; Swift 1973, p 73; I M Lewis 1961, p 59; Devendra and Burns 1970, pp 104-105
101. Asad 1964, p 52
102. Baxter 1966, p 121

103. Spencer 1973, p 18
104. Hunt 1951, p 174 and I M Lewis 1955, p 69
105. Williamson and Payne 1965, p 288
106. Nicolaisen 1963, p 46
107. Spencer 1973, p 13
108. Cf Johnson 1969, p 8
109. Asad 1970, p 16
110. Johnson 1969, p 8
111. Asad 1964, p 51
112. French 1970, p 80
113. Swift 1973, p 73
114. Williamson and Payne 1965, p 275; Devendra and Burns 1970, p 102
115. Spencer 1965, p 6 and 1973 p 18
116. Cf Nicolaisen 1963, p 45 and Brown 1973, p 70
117. Maher 1945
118. For thorough discussions on the diet of goats, see Staples, Hornby and Hornby 1950; Hornby and Van Rensburg 1948; Epstein 1948; and Heady 1972, pp 78-80 (which also includes a bibliography)
119. French 1970, pp 70-92
120. French op cit
121. Asad 1964, p 52
122. Spencer 1973, p 13
123. Spencer *ibid*; Gulliver 1953, p 61
124. Gulliver *ibid*
125. Ph and P Gulliver 1953; Ph Gulliver 1955
126. Hunt 1951, p 174
127. Barth 1962, p 16
128. Williamson and Payne 1965, p 80
129. Spencer 1973, p 18; Dyson-Hudson 1970, p 109
130. Williamson and Payne 1965, p 80
131. See Stenning 1958 and Asad 1970, pp 53-54
132. Spencer 1965, p 11 and Cunnison 1966, pp 68-69
133. Spencer 1973, p 20

134. Asad 1970, p 16
135. Tribe 1950, p 74
136. Swidler 1972, p 74
137. Barth 1964, pp 6, 16
138. Asad 1970, p 52
139. Hunt 1951, p 174
140. R and N Dyson-Hudson 1970, p 107
141. Barth 1964, pp 103 ff
142. However, this analysis has been questioned by A Singer 1969, p 136, Note 1

BIBLIOGRAPHY

- Adloff 1968: See Thompson and Adloff 1968
- Ahmediev A 1966: ("The meat production of camels"). Konevod. Konnyĭ I Sport, 36 (2):12 (Russ)
- Alimi K A 1962: "Environmental & genetic factors affecting milk production" J Dairy sc Vol 45
- Allan W 1967: The African husbandman, Oliver & Boyd, London
- Alwan A S 1968: "Socioeconomic issues of nomad's settlement in the Western Desert of the UAR". Land Reform 1: 28-35
- Animal Production 1973: Report of the Task Force Commissioned by the African Livestock sub-committee of the Consultative Group on International Agricultural Research, March 1973. Complete title: Animal production and research in Tropical Africa
- Asad T 1964: "Seasonal movements of the Kababish Arabs of Northern Kordofan" Sudan Notes and Records 45:45-58
- Asad T 1970: The Kababish Arabs: Power, Authority and Consent in a Nomadic Tribe, London
- Asmarom Legesse 1973: Gada; Three Approaches to the Study of African Society, New York
- Asmarom L 1975: Ecological Stress and Pastoralism in Africa
- Aueljbekov K 1967: (Camel breeding - a profitable field) Konevod. Konnyĭ I Sport 5:6-8 (Russ)
- Baker R 1968: "Problems of the cattle trade in Karamoja, Uganda; an environmental analysis" p 211-226 in Ostafrikanische Studien. Band 8 Wirtschafts- und Sozialgeographischen instituts der Friedrich-Alexander Universität No 49 Nürnberg
- Baker R 1975: "Development and the pastoral peoples of Karamoja: an example of the treatment of symptoms" in: Monod, T (ed) 1975: Pastoral Societies in Tropical Africa OUP for the IAI. Originally presented as a paper to the Symposium on Pastoral Societies in Tropical Africa, Niamey, Niger, Dec 1972; 14 pp
- Baker R 1974: Perceptions of pastoralism Development Studies, Discussion Paper; University of East Anglia
- Barbour K M 1961: The Republic of the Sudan. A regional geography. London
- Barth F 1962: "Nomadism in the mountain and plateau areas of South-west Asia" in: The problems of the arid zone, UNESCO, Paris
- Barth F 1964: Nomads of South Persia, Oslo
- Bartha R 1971: Studien zur Tragen der Zeburinderzucht in den tropen München IFO-institut
- Bartha R 1971a: "Die physiologische Anpassung des Kamels an die besonderen Umweltbedingungen der weiträumigen Trockengebiete" Der Tropenlandwirt 72 (1971) pp 138-148
- Baxter P T W 1954: The Galla of Northern Kenya. Unpublished PhD Thesis, Oxford

- Baxter P 1966 and 1970: "Stock management and the diffusion of property rights among the Boran" from Proc of the 3rd International Conference of Ethiopian Studies Addis Ababa Vol III pp 116-27 Haile Selassie University
- Bender A 1970: See Fisher P and Bender A. 1970
- Bennett S C J, John E R and Hewison J W 1948: "Animal Husbandry" in: Agriculture in the Sudan ed J D Tothill pp 633-67 OUP
- Bhargava K K, Sharma V D and Singh M 1965: "A study of birthweight and body measurements of camel (*Camelus dromedarius*)" Indian J vet Sci 35:358-362
- Bisschop J H R 1951: Notes on a Trip to the Sudan Dec 1950 and Jan 1951 Mimeo
- Black 1962: See Galukande, Mahadevan and Black 1962
- Blagoveščenskij V 1963: (Reserves in the production of milk and meat) Konevod konnyĭ Sport 33 (10):8-9 (Russ)
- Bondestam L 1974: Den dömda dalen Lund
- Bondestam L 1975: "Svälten i Etiopien och dess orsaker" Forum for utvicklingsstudier Nr 4-6 pp 49-68
- Born M 1965: Zentralkordofan: Bauern und Nomaden in Savannengebieten des Sudan, Marburg
- Boudet G 1975a: "Pastures and livestock in the Sahel" in: The Sahel: ecological approaches to land use, MAB Technical Notes, Paris; pp 29-34
- Boudet G 1975b: "Improvement of pasture and livestock exploitation in the Sahel: proposals, for management and land use" in: The Sahel: ecological approaches to land use, MAB Technical Notes, Paris; pp 89-98
- Brayne-Nichols 1954: "Notes on Boran (Golbo Boran of Isiolo)" PC NFD 4/1/1 and PC NFD 4/5/1, Kenya National Archives, Nairobi
- Brémaud O and Pagot J 1962: "Grazing lands, nomadism and transhumance in the Sahel" in: The Problems of the arid Zone, Unesco, Paris
- Brown L H 1963: The Development of the semiarid Areas of Kenya, Mimeo
- Brown L H 1973: "Pastoral People and conservation" pp 67-76 in: Conservation for Survival - Ethiopia's choice, Addis Ababa, Haile Selassie Press
- Bulliet R W 1975: The Camel and the Wheel, Harvard U. P. Cambridge Mass.
- Burns 1970: See Devendra C M and Burns 1970
- Callow E H 1949: "Brief Review of the Science of Meat" Brit. J. Nutr 3:375-380
- Capot-Rey R 1962: "The present State of Nomadism in the Sahara" The Problems of the Arid-zone UNESCO, Paris 1962
- Chalmers A W 1954: Notes on the Livestock of the Sudan, MS Thesis
- Chatty & de Carvalho 1974: "Food Problems & Prospects of Pastoralism in the African Scene". 17th annual Meeting of the African Studies Association, Chicago Oct 30-Nov 2
- Chenevix-Trench C 1964: Deserts Dusty Face London
- Colville 1950: See Shaw and Colville 1950
- Congiu S 1939: See Salerno A and Congiu S 1939
- Congiu S 1953: "Indagini sulla macello, sulla distribuzione ponderate e sulle correlazione fra le diverse parte del corpo del dromedario somalo" Zootec e Vet 8:188-191

- Congiu S 1955: See Rossetti G and Congiu S 1955
- Cozzi P 1965: "L' Allevamento del bestiame in Somalia" Riv. di agricoltura subtropicale e tropicale 59, p 4-6. Part I, London
- Cunnison I 1966: Baggara Arabs Oxford, Clarendon Press
- Curasson G 1942: Traité de Pathologie Exotique Vétérinaire et Comparée Vol I, Paris; Deuxième Edition
- Davenport W 1960: Jamaican Fishing: A Game Theory Analysis Yale University Publications in Anthropology No 59, New Haven
- Davies W L 1940: Indian Indigenous Milk Products Calcutta, Thacker & Spink
- De Carvalho E C 1974: "'Traditional' and 'Modern' Patterns of Cattle Raising in South West Angola. A Critical Evaluation of Change from Pastoralism to Ranching" J of Dev.t Areas 8:2, pp 199-226
- De Carvalho 1974a: See Chatty and De Carvalho 1974a
- Demirören A S 1974: The Improvement of Nomadic & Transhumance Animal Production Systems FAO Rome 1974
- Demoz A et al 1975: A Research Proposal of ecostress in Africa, North-Western University
- Deshler W W 1965: "Native Cattle-keeping in Eastern Africa" in Leeds, Vayda (eds): Man, Culture and Animals Washington; pp 153-168
- Devendra C M & Burns 1970: Goat Production in the Tropics Commonwealth Agr. Bureau
- Diamond H 1974: See Hyrenius H and Diamond H 1974
- Drake-Brockman R E 1912: British Somaliland, Hurst & Blacket, London 334 pp
- Dyson-Hudson N 1955: Sanction & Political Structure among the Nilo-Hamitic Tribes of East Africa Thesis for B-litt. Oxford. Unpublished
- Dyson-Hudson N 1962: "Factors inhibiting change in an African Pastoral Society: the Karamojong of Northern Uganda" Transactions of the New York Academy of Sciences, 11 (24); 771-801
- Dyson-Hudson N 1966: Karimojong Politics Oxford Univ Press
- Dyson-Hudson N 1969: "Subsistence herding in Uganda" Sc Amer 220:2, pp 76-89
- Dyson-Hudson N and R 1970: "The Food Production System of a Semi-Nomadic Society, the Karimojong, Uganda" in: P Mc Loughlin (ed): African Food Production Systems, Cases & Theory, Baltimore, London; pp 91-123
- Dyson-Hudson N and R 1975: "Commentary" in: Drought, Famine and Population Movements in Africa, ed: J L Newman, Syracuse University
- Dyson-Hudson R 1960: "Men, women and work in a pastoral society" Natural History, 69:10, pp 42-57
- Edwards L C 1948: "Some notes on the food of goats in a semi-arid area" East African Agricultural Journal April 1948
- Elam Y 1973: The Social and Sexual Roles of Hima Women: A Study of Nomadic Cattle Breeders in Nyabushozi County Ankole, Uganda Manchester Univ Press
- Elbahay G 1965: See Nasr S, Elbahay G and Moursy A W 1965

- Epstein H 1954: "The fat tailed sheep of East Africa" E A Agr J 20, 109
- Epstein H 1955: "The Zebu cattle of East Africa" E A Agr J 23:42-48
- Epstein H and Herz A 1964: "Fertility and birth weights of goats in a sub-tropical environment" J of Agr Sc 62; pp 237-244
- Eraskov S G 1953: "Moloko verbljudic i produkty ego perera botki (Camel's milk and its products)" Koncvodstvo 23 (11):35-37
- Eraskov S G 1955: "Moločnaja produktivnostj verbljudie (The milk production of the camel)" Sborn Dokl 3 vsesojuz Sovešč Moloč Delu, 1955:174-176
- Ethiopia 1954: Guide Book of Ethiopia
- Ethiopian Government Relief and Rehabilitation Commission 1974: Harerghe under Drought: A Survey of the Effects of Drought upon Human Nutrition in Harerghe Province
- Evans-Pritchard E E 1940: The Nuer: A description of the modes of livelihood and political institutions of a Nilotic people OUP London
- FAO 1967: FAO Production Yearbook. Food and Agriculture Organization of the United Nations. Rome
- FAO 1972: Near East Regional Study - Animal husbandry, production and health, fodder production and range management in the Near East and FAO's policies and plans for promoting the animal industry, Rome-Cairo
- Fielder R J 1973: "The Role of cattle in the Ila Economy" African Social Research No 15, June 15, pp 327-361
- Fisher P and Bender A 1970: The Value of Food OUP, London
- Flou B 1973: Brugsret till graes- och vandresourcer i fire østafrikanske kvaegaulersamfund Karimojong, jie, turkana og masai Aarhus
- Forde D 1934: Habitat Economy and Society, London
- French M H 1936a: "The weights of the carcass and of the individual organs in the body of cattle in Kenya colony". Emp J Exp Agric 4 (14) 108
- French M H 1936b: "The development of livestock in Tanganyika Territory. Actual and proportional weights of the various parts of the body of Zebu cattle" Emp J Exp Agric 4(13):17
- French M H 1938: "The growth rates of local and crossbreed sheep" East African Agr J Vol 8
- French M H 1938: "The mutton capabilities of Tanganyika sheep" Annual Report Veterinary Department, Tanganyika
- French M H 1944: "The feeding of goats" E Afr Agric J 10:66-71
- French M H 1970: Some Observations on the Goat FAO, Rome
- Gadola A 1947: Zootecnica Profilassi e igiene zootecnica in Africa orientale. Istituto superiore di sanità fondazione emanuele paterno, Rome 230 pp
- Gallais J 1972: "Les sociétés pastorales Ouest-Africaines face au développement" Cah d'Etudes Afr Vol 12, No 3, pp 353-368
- Galukande, Mahadevan & Black 1962: "Milk production in East African Zebu cattle" Anim. Prod 4; pp 329-336
- Gauthiers-Pilters 1969: "L'Ecologie du dromedaire en moyenne Mauritanie" Bull d'Inst Fondamentale d'Afrique Noire 31:2

- Gilks J L 1931: See Orr J B and Gilks J L 1931
- Groeneveld 1968: "Traditional Farming and Coconut-cattle Schemes in the Tanga Region" In: Smallholder Farming and Smallholder Development in Tanzania, ed H Ruthenberg. Afrika-Studien no 24, IFO-Institut, München
- Grunnet N T 1962: "An ethnographic-ecological survey of the relationships between the Dinka and their cattle" Folk 4; pp 5-20
- Gulliver Ph 1955: Family Herds. A Study of two Pastoral Tribes in East Africa: The Jie and the Turkana. London
- Gulliver Ph 1958: East African Age Group Systems MISR Conference Paper No 83
- Gulliver Ph 1971?: "Nomadism among the pastoral Turkana of Kenya: Its natural and social environment". In Rigby P (ed): Society and social change in Eastern Africa. Nkanga; Makerere inst of soc research (no date)
- Gulliver Ph and P 1953: The Central Nilo-Hamites. Ethnographic survey of Africa. The central Nilo-hamites. London
- Haberland E 1963: "Galla Südäthiopiens" 815 s. Völker Südäthiopiens, BD II
- Hall H T B 1962: "A note on the dressing percentage and percentage of bone in sudanese cattle". Sudan J Vet Sci Anim Husb 3, 46-47
- Heady H 1972: Range management in East Africa, Nairobi, Second edition
- Heady H F 1972: "Ecological consequences of Bedouin settlement in Saudi Arabia" in: The Careless Technology; ecology and international development Eds: M T Farvar and J P Milton, New York; pp 683-693
- Hedlund H 1971: Impact of Group Ranches on a pastoral Society IDS Staff Paper no 100, June 1971
- Heraskov G 1965: ("Camel milk - a valuable food product") Konevod Konnyĭ Sport. 35 (8):14-15
- Herin 1964: "Les races bovines du ruanda urundi" Bull Agric Congo Belge 43, Band VII
- Herskovits M J 1926: "The cattle complex in East Africa" Amer Anthr 28; pp 230-272, 361-380, 494-528, 633-664
- Herz A 1964: See Epstein H and Herz A 1964
- Hewison J W 1948: See Bennett S C J, John E R and Hewison J W 1948
- Hjort A 1969: Spelteorins möjligheter och begränsningar inom socialantropologin Dep of Social Anthropology, Univ of Stockholm (Mimeo)
- Hjort A 1976: "Cattle insurance blocks; an alternative ranching system?" in: Can Desert Encroachment Be Stopped?, ed: A Rapp, SIES, Stockholm (Oct)
- Hollis A C 1905: The Maasai: Their Language and Folklore, Oxford
- Hornby and Van Rensburg 1948: "The Place of Goats in Tanganyika Farming Systems: In Deciduous Bushland Formation" East African Agricultural Journal
- Hornby H E 1942: See Staples R R, Hornby H E and Hornby R M 1942
- Hornby R M 1942: See Staples R R, Hornby H E and Hornby R M 1942
- Hopen C E 1958: The pastoral fulbe family in Gwandu. London, OUP

- Hunt J A 1951: A general survey of the Somaliland protectorate 1944-1950 Hargeisa
- Hunting Technical Services 1974: Development Plan: Southern Darfur Land Use Planning Survey, Ministry of Agriculture, Food and Natural Resources, Sudan; "Annex 3: Animal Resources and Range Ecology"
- 1974: "Annex 5: Social Organisation" Feb 1974
- Hutchison H G 1955: Notes on the farm livestock or Tanganyika unpublished MS
- Hyrenius H and Diamond H 1974: Demometric techniques applied to animal populations, Demographic Research Institute, University of Gothenburg, Sweden; Report 14
- Irons W 1972: "Variation in economic organization: a comparison of the pastoral Yomut and the Basseri" in Irons W and Dyson-Hudson N (eds): Perspectives on nomadism, Leiden; pp 88-104
- Jacobs A 1963: The Pastoral Maasai of Kenya, Illinois; Mimeo
- Jacobs A 1965: "African Pastoralists. Some general remarks" Anthr Quart 38:3, pp 144-153
- Jacobs A 1968: Maasai Marriage and Bridewealth, Society and Law Workshop, University of East Africa
- Jacobs A 1973: Land and contemporary politics among the pastoral Maasai of East Africa, Paper presented at the AAA-meeting, Nov 1973
- Jenness R 1968: See Parkash S and Jenness R 1968
- John E R 1948: See Bennett S C J, John E R and Hewison J W 1948
- Johnson D 1969: The nature of nomadism University of Chicago, Department of Geography, Research Paper No 118
- Johnston H 1902: The Uganda Protectorate. An attempt to give some description of the physical geography botany, zoology, anthropology, languages and history of the territories under British protection in East Central Africa, Vol II, London
- Joshi N R, McLaughlin E A and Phillips R 1957: "Types and Breeds of African Cattle" FAO Agric Stud No 37 Rome
- Kenya Land Commission Evidence 1933: HMSO, London
- Kenya Ministry of Agriculture: A History of the Fluctuation of the Cattle Population in Kajiado Maasailand during the last twenty years, leading to the Disastrous Losses in 1961-62 with Past Policy and Future Development, Mimeo
- Kenya Ministry of Finance and Planning 1972: Results from aerial livestock surveys of Kaputei Division, Samburu District and North Eastern Province, Nairobi
- Klima G J 1970: The Barabaig: East African Cattle-herders Holt, Rinehart & Winston, New York
- Kon S K 1972: "Milk & Milk products in human nutrition" FAO nutrition studies 27
- Kuliev K 1959: Ob ispolzovanii moloka verbljudic ("The utilization of camel's milk") Mol. Promyshlenn 20 (2):28
- Kuznecov V A et al 1970: ("The yield of meat and meat products from the Turkmen one-humped camel") Trudy turkmen. sel'. khoz. inst. 15: 123-125

- Lampkin G H and K 1960: "Studies on the production of beef from Zebu cattle in East Africa". J Agr Sc (1960) 55, 2; pp 229-239
- Leakey L S B 1937: Kenya Contrasts and Problems
- Ledger H P 1966: Comparison of shorthorn Zebu and Boran Zebu on high and low nutritional planes. Table presented at the meeting of the East African specialist committee on pastures; May 1966
- Leese A S 1927: A treatise on the one-humped camel. Stamford, Lincs Haynes & sons
- Legesse, see Asmarom
- Le Hourou H 1976: "Rehabilitation of degraded arid zones" in A Rapp (ed): Can Desert Encroachment Be Stopped? SIES, Stockholm (Forthcoming)
- Leupold J 1968: The camel - an important domestic animal of the subtropics. Blue Bk. vet Prof 15. Frankfurt am Main: Abteilung Behring - Prparate, Farbwerke Hoechst AG. Marburg-Kahn: Behringwerke AG Pp 1-6
- Lewis B A 1972: The Murle: Red Chiefs and Black Commoners. Oxford, Clarendon Press
- Lewis I M 1955: Peoples of the horn of Africa-Somali, Afar and Saho Ethn survey of Africa, N E Africa Part 1, London
- Lewis I M 1962: "Marriage and the Family in northern Somaliland" 51 p. Ill. Kampala East African Studies, no 15
- Lewis I M 1961: A Pastoral Democracy; A Study of Pastoralism and Politics among the Northern Somali of the Horn of Africa. OUP, London
- Luchini 1947: "Sulla produzione in latte della bovina Somala" Riv. Agric Subtrop trop 41
- Mahadevan 1962: See Galukande, Mahadevan and Black 1962
- Maher C 1945: "The goat: friend or foe?" East African Agr Journal 1945: 11, pp 115-121
- Mair L 1974: African Societies, Cambridge
- Mann I 1954: "High protein human food from destocking scrub animals" Brit Vet Journ 110; pp 491-499
- Manson-Bahr P 1968: Manson's Tropical Diseases London
- Marchi E 1929: Studi sulla pastorizia della colonia Eritrea istituto agricolo coloniale Italiano; Florence; 2nd ed.
- Mares R G 1954: "Animal husbandry, animal industry and animal disease in the Somaliland Protectorate Pt I, Pt II" Brit Vet J 110:411-423; 470-481
- Mares R G 1959: "The African nomad: East Africa" In: Williamson & Payne 1965: Animal husbandry in the tropics; pp 424-430
- Marples 1964: "An analysis of milk production in the shorthorn Zebu of Entebbe" Trop Agr (Trinidad) 41, 1964
- Mason I L and Maule J P 1960: The indigenous livestock of eastern and southern Africa Commonwealth Agric Bureau, Techn Comm No 14
- Maule J P 1960: See Mason I L and Maule J P 1960
- McKay W M 1957: "Some problems of colonial animal husbandry. The northern frontier province of Kenya, Part I and II" The Brit Vet Journal 113 (1957): 7; pp 268-279 and 316-322

- McLaughlin E A 1957: See Joshi N R, McLaughlin E A and Phillips R 1957
- Merker M 1910: Die Massai, Ethnographische Monographie eines Ostafrikanischen Semitenvolkes, Berlin
- Meyn K 1970: Beef production in East Africa, IFO Institut, München
- Morgan W T W and Shaffer N M 1966: Population of Kenya: Density and distribution, OUP Nairobi & Oxford, 36 p
- Morgan W T W (ed) 1972: East Africa, its peoples and resources, OUP Oxford
- Moursy A W 1965: See Nasr S, Elbahay G and Moursy A W 1965
- Murdock G P 1959: Africa: Its peoples and their culture history, New York
- Musil A 1928: The manners and customs of the Rwala bedouins, New York
- Nasr S, Elbahay G and Moursy A W 1965: "Studies on camel meat. 1. The effect of age and sex on the components of camel meat." J Arab vet med Ass 25:253-258
- Nicolaisen J 1963: Ecology and culture of the pastoral Tuareg Copenhagen
- Orr J B and Gilks J L 1931: "Studies of nutrition: The physique and health of two African tribes" Privy medical research council special report series No 155 London
- Pagot J 1962: See Brémaud O and Pagot J 1962
- Parkash S and Jenness R 1968: "The composition and characteristics of goats milk: a review" Dairy Sci Abstr 30:67-87
- Paulitschke P 1893: Ethnographie Nordost-Afrikas. I. Die materielle Kultur der Danakil, Galla und somäl, Berlin
- Payne 1965: See Williamson and Payne 1965
- Payne W J A 1963: "Relation of animal husbandry to human nutritional needs in East Africa" E A Agr and For J July 1963
- Persson S 1974: See Sjöberg K-E and Persson S 1974
- Phillips R 1957: See Joshi N R, McLaughlin E A and Phillips R 1957
- Platt B S 1962: Tables of representative values of foods commonly used in tropical countries Spec Ref Ser No 302, Medical Research Council London
- Porter J P W 1965: "Environmental potentials and economic opportunities - a background for cultural adaptation" American Anthropologist, 67
- Prole J H B 1967: "Pastoral land use" in Nairobi - City and Region, ed: W T W Morgan OUP; pp 90-97
- Purchase M S 1943: East Afr Agr Journal, 9, 39
- Purser A F and Young G B 1964: "Mortality among twin and single lambs" Anim Prod 1964:321-329
- Pyke M 1970: Man and food, World university library, Weidenfeld & Nicholson, London
- Rapp A 1974: A review of desertization in Africa - water, vegetation and man, SIES, Stockholm
- Rapp A (ed) 1976: Can Desert Encroachment be Stopped? SIES, Stockholm 1976 (forthcoming)
- Recommended dietary allowances 1968: Complete title: Recommended dietary allowances, Food & nutrition board, National Academy of Sciences Washington DC

- Reid 1930: "Some notes on the tribes of the white Nile Province" Sudan Notes and Records 13; 2 pp 149-209
- Rigby P 1971?: "Pastoralism & prejudice. Ideology & rural development in East Africa" Nkanga No 4, undated, Makerere Inst of Soc Research, Kampala
- Rossetti G and Congiu S 1955: "Ricerche zootecnico-veterinarie sugli animali domestici della Somalia" Mogadishu: Ispettorato Veterinario, Amministrazione Fiduciaria Italiana della Somalia
- Rousseau R 1943: "Le Chameau au Senegal" Bull de l'Institut Fondamental d'Afrique Noire 5 (1943) pp 69-79
- Ruthenberg H 1971: Farming systems in the tropics Clarendon Press, Oxford
- Sacker G D and Trail J C M 1966a: "Production characteristics of a flock of East African Blackhead Sheep" East African Agr and Forestry Journal Nairobi; pp 392-398
- Sacker G D and Trail J C M 1966b: "Production characteristics of a herd of East African Mubende Goats" Trop Agriculture, Trinidad 1966:43 pp 43-51
- Salerno A & Congiu S 1939: "Indagini sulle rese al macello, sul peso vivo e sua distribuzione tra le diverse parti del corpo nei bovini dell'altopiano hararino e negli ovini castrati di razza Somala a testa nera. Studio delle correlazioni esistenti tra le diverse parti del corpo" Relaz Monogr Agr-Colon, No 54. Regio Istituto Agronomico per l'Africa Italiana Florence 62 pp
- Sandford G R 1920: An administrative & political history of the Maasai reserve
- Schickele R 1931: Die Weidewirtschaft in den Trockengebieten der Erde, Probleme Weltwirtschaft Bd 53, Jena
- Schinkel H G 1970: Haltung, Zucht und Pflege des Viehs bei den nomaden Ost- und Nordostafrikas Akademie-Verlag, Berlin
- Schmidt-Nielsen K 1964: Desert animals: physiological problems of heat and water Oxford, Clarendon press
- Schneider K 1957: "The subsistence role of cattle among the Pokot of East Africa" Amer Anthr 59; pp 278-299
- Schneider H K 1970: The Wahi Wanyaturu: Economics in an African Society Aldine, Chicago
- Scott I W 1957: Herd Vastage - Calf Vastage - A Fertility Survey. Sydney N S W Division of Dairying. Department of Agriculture. 3rd ed.
- Schaffer N M 1966: See Morgan W T W and Schaffer N M 1966
- Shanmugasundaram K S 1957: "Birth rate among goats" Ind Vet J 34:107-117
- Sharma V D 1965: See Bhargava K K, Sharma V D and Singh M 1965
- Shaw and Colville 1950: Report of Nigerian livestock mission London, H M Stationery Office
- Singer A 1969: Some problems of adaptive nomadic pastoralism in Western Iran Thesis for Bachelor of Letters, University of Oxford, unpublished
- Singh M 1965: See Bhargava K K, Sharma V D and Singh M 1965

- Sjöberg K-E and Persson S 1974: Cattle production in Africa, College of Agriculture, Sweden
- Smeds H 1962: Food production and nutrition in Ethiopia. Mimeo
- Somali Republic 1961: Interriver economic exploration, The Somali Republic Int Coop Administration, Washington DC
- Spencer P 1965: The Samburu: A study of gerontocracy in a nomadic tribe University of California
- Spencer P 1973: Nomads in alliance, Symbiosis and growth among the Rendille and Samburu of Kenya Oxford
- Staples R R, Hornby H E and Hornby R M 1942: "A study of the comparative Effects of Goats and Cattle on a mixed grass-bush pasture" East African Agricultural Journal 8:62
- Stauffer T R 1965: "The economics of nomadism in Iran" Middle East Journal XIX; pp 284-302
- Stein L 1967: Die Sammar-Gerba: Beduinen im Übergang vom Nomadismus zur sesshaftigkeit 167 s. Berlin. (Veröffentlichungen des Museums für Völkerkunde zu Leipzig, H17)
- Stenning D 1957: "Transhumance, migratory drift, migration: patterns of pastoral Fulani nomadism" JRAI 87:57-73. Also in Offenberg S and P (eds) 1960: Cultures and Societies of Africa New York, Random House; pp 139-159
- Stenning D 1958: "Household viability among the pastoral Fulani" in: The Developmental cycle in domestic groups, ed: J Goody, Cambridge 1958
- Sweet L 1965a: "Camel Pastoralism in North Arabia and the Minimal Camping Unit" in Leeds & Vayda (eds): Man, culture & animals Washington; pp 129-152
- Sweet L 1965b: "Camel raiding of North Arabian Bedouin: a mechanism of ecological adaptation" Amer Anthr 67:1132-1150
- Swidler W W 1972: "Some Demographic Factors Regulating the Formation of Flocks and Camps among the Brahni of Baluchistan" in: Dyson-Hudson, Irons (eds): Perspectives on Nomadism, Leiden
- Swift J 1973: "Disaster and a Sahelian nomad economy" In Dalby & Church (eds): Drought in Africa Centre for African studies
- Swift J 1974: "The 'causes' of the Sahel disaster". Seminar on points of controversy in the study of drought in Africa, Sept 1974; Int Afr Inst, London (mimeo)
- Tarantino G B 1934: "L'Allevamento ovino nella Somalia Italiana" Critica Zootechnica 11:114-22
- Terentjev S 1966: "(Improvement of the Kalmyk breed of camel)" Konevod Konnyi Sport 36 (12):19-20
- The Hunting Report 1974: See Hunting Technical Services 1974
- Thompson and Adloff 1968: Djibouti and the Horn of Africa, Stamford
- Tothill J D 1948: Agriculture in the Sudan, London OUP
- Trail J C M 1966a: See Sacker G D and Trail J C M 1966a
- Trail J C M 1966b: See Sacker G D and Trail J C M 1966b
- Tribe D E 1950: "Influence of pregnancy and social facilitation on the behaviour of grazing sheep" Nature, No 166

- Tulenbekov I M 1969: ("The effect of milking frequency on lactational performance of camels") Sb Referat nauch Rab Kazakh gos pedagog Inst No 13:292-296 (Russ)
- United Nations 1962: The trust territory of Somaliland under Italian administration; UN Technical Assistance Programme, New York
- Wahid A 1957: See Yasin S A and Wahid A 1957
- Van Raay H G T 1975: Rural planning in a savanna region Rotterdam University Press
- Van Rensburg 1948: See Hornby and Van Rensburg 1948
- Van Rensburg H J 1969: Management and Utilization of Pastures FAO Pasture & Fodder Crop Studies No 3 Rome
- Ward H K 1959: "Some observations on the indigenous ewe" Rhod Agr J 56:6, pp 218-223
- Webster C C & Wilson P N 1966: Agriculture in the tropics London, Longmans Green & Co Ltd
- Widstrand C 1972: On Pokot Group Ranches, Livestock Marketing, Pastoral Values, Planners and a Variety of Topics Vaguely Related, Kapenguria (Mimeo)
- Widstrand C G 1975: "The rationale of nomad economy" Ambio Vol IV No 4
- Wijeratne W V S 1968: "The production traits of a nondescript breed of South Indian meat goats" Trop Agr, Trinidad, 45:39-45
- Wikberg E 1971: Näringslära, Stockholm
- Williamson and Payne 1965: Animal Husbandry, London
- Wilson F 1958: "The effect of plane of nutrition on the growth and development of the East African dwarf goat: II Age and composition in female kids" J Agric Sci, Cambr 51 pp 4-21
- Wilson F 1963: "Calvings and calf mortality in Ankole longhorned cattle" E A Agr Journal, Oct
- Wilson P N 1966: See Webster C C and Wilson P N 1966
- Yasin S A and Wahid A 1957: "Pakistan camels - a preliminary survey" Agric Pakist 8:289-297
- Young G B 1964: See Purser A F and Young G B 1964

STOCKHOLM STUDIES IN SOCIAL ANTHROPOLOGY

1. *Caymanian Politics: Structure and Style in a Changing Island Society* by Ulf Hannerz
\$ 5.00, £ 2.40
2. *Having Herds: pastoral herd growth and household economy* by Gudrun Dahl and Anders Hjort Skr 45:-, \$ 10.00

Available from
Department of Social Anthropology
University of Stockholm
Fack
S-104 05 Stockholm 50
Sweden

ISBN 91-85284-02-5