ELSEVIER

Agricultural Systems 59 (1999) 1–25

AGRICULTURAL SYSTEMS

The effects of wealth on livestock dynamics among the Datoga pastoralists of Tanzania

Daniela F. Sieff

Institute of Biological Anthropology, University of Oxford, 58 Banbury Road, Oxford, OX2 6QS, UK

Received 5 June 1996; accepted 25 September 1998

Abstract

Data on the dynamics of the cattle and small stock herds belonging to the Datoga are presented. Overall the Datoga are struggling to survive. They have been alienated from more fertile areas, and consequently they are poor and herd productivity is low. This is due to the low reproduction rate of cattle, and the high commercial offtake rate of both cattle and small stock. The high commercial offtake rate is driven by subsistence needs and most income is used to buy grain and veterinary products. However, there is considerable variation between households, and compared to poor households, wealthy households have a comparatively low offtake rate of livestock, in terms of both mortality and sales. Consequently, they are managing to retain their livestock holdings, or in a few cases to increase the size of their herds. However, wealthy households are in the minority, and the majority of households are caught in a declining cycle of poverty, and will eventually be forced to drop out of the pastoral system.

1. Introduction

The Datoga, like many East African pastoralists, have become marginalised within the national economy, and they are struggling to survive and to retain their traditional lifestyle. This paper examines the dynamics of cattle and small stock herds belonging to the Datoga. The production system is based on livestock, and as the Datoga have no ways to supplement their income the livestock performance is crucial. Herd composition, reproductive performance, mortality and commercial offtake are described for each species and the prospects of the herds are explored. As livestock form the basis of the Datoga subsistence system such an analysis is crucial in understanding the prospects and problems faced by these people.

This paper also explores whether livestock dynamics differ according to household wealth and if so why? This is an important issue as poor and wealthy households may have qualitatively different problems in livestock management and family provisioning (Bekure and Grandin, 1991). By looking at the ways in which wealth affects livestock dynamics, this study aims to show which households are particularly vulnerable, and which are relatively robust. It is through such analysis that the families most at risk can be recognised, and those most likely to benefit from development interventions can be identified. In addition the kinds of development initiatives that might be effective can be identified (Bekure and de Leeuw, 1991; Bekure and Grandin, 1991; IIED, 1994; Toulmin, 1994; Perrier, 1994; Sandford, 1994).

0308-521X/99/$—see front matter
PII: S0308-521X(98)00078-X

2. Background

2.1. The study population

The Datoga (also called Datog, Tatog, Tatoga, Tatur or Mang'ati, and a subgroup called Barabaig) are a Nilotic people. In 1978 there were estimated to be between 62 300 and 81 900 Datoga (Kjaerby, 1980). They were concentrated in Arusha, Dodoma, Singida and Shinyanga regions.

Little is known of the early history of the Datoga (Borgerhoff Mulder, 1991, 1992) but during the 18th century they dominated large areas of Northern Tanzania (Kjaerby, 1979). They were displaced from much of this area by the Maasai expansion, sometime between the 16th (Homewood and Rodgers, 1991) and 18th (Fosebrooke, 1948) centuries and then migrated between Lake Manyara, Hanang, Singida and Tabora, Lake Eyasi, Mbulu and Dongabesh. Between 1940 and Tanzanian independence (1961) they settled in Mangola (Tomikawa, 1970, 1979).

Mangola is at the foot of Mt. Oldeani and has a natural spring line running through it with fresh grass all year round. There is also access to the fertile and lush slopes of Oldeani. However, in 1966 Mangola was declared an "*ujamaa*"[1] village and there was a massive influx of other tribes, particularly Iraqw agriculturists from around Mbulu. Farms were established bordering the springs and on the lower slopes of Oldeani, and much of the Datoga grazing land was lost.

The lack of access to grazing around Mangola resulted in many families moving to the Southern end of Lake Eyasi into an area traditionally occupied by the Sukuma. However, cattle raids by the Sukuma and organised bandits on the Datoga in the 1980s forced them along the south-east shore of Lake Eyasi, into the area which they inhabit today (Ndagala, 1991). The Datoga in Udachoteg reported that normally they would not have settled in the Eyasi basin as the area is arid, and tsetse infestation is high. In the past they would have only ventured into this region in years of extreme drought, when all the other grazing had been exhausted. However, they recognise that they have now been alienated from so much of their traditional grazing lands, that like many other pastoral peoples, they are having to eke out a subsistence in marginal land.

2.2. The subsistence system of the Datoga

The Datoga of Eyasi depend on livestock for their subsistence. They herd East African short horn zebu cattle (*Bos indicus*), goats, sheep and donkeys. Cattle make up 80.6% of total livestock units (TLU)[2], goats 9.8% and sheep 9.6%. Agriculture is negligible, although since 1987 many Datoga in this region have tried to grow maize and millet but this is generally unsuccessful (Sieff, 1995).

Cattle have the highest economic and social value of all Datoga livestock. They are named, branded and their pedigrees memorised (Tomikawa, 1972). Small stock have less social importance although they may be of considerable economic importance.

The primary importance of cattle is for their milk production, which provides the staple food during the rainy season and an important source of protein during the dry season. Cattle are slaughtered for food, although this is very rare. More importantly, the meat of animals that die makes a substantial contribution to the diet (Sieff, 1995). Cattle are also sold at local markets; the cash they generate is vital for purchasing grain in the dry season when milk yields are low. Other cattle products used by the Datoga include: (a) dung for building huts; (b) hides for women's clothing, baby carriers, sandals, mats, and leather ropes; (c) horns for vessels for drinking beer; and (d) urine which is used as a cleansing agent, as an enema to treat diarrhoea, and as a softening agent with which to treat leather before it can be made into clothing.

Goats and sheep are valued both as a source of meat, and as a resource that can be sold to provide

[1] The *ujamaa* (KiSwahili; means "unity, or brotherhood") villages were set up under Nyerere's socialist policy. People were brought into villages from distant places and attempts were made to set up farming co-operatives, similar to the kibbutz system in Israel.

[2] One cow = 0.71 TLU, and one goat or sheep = 0.17 TLU. For further discussion on the computation of livestock units, see Sieff (1995).

monetary income. If a family wants to slaughter an animal, small stock are usually slaughtered as opposed to one of the cattle. Small stock that die of disease, or of natural causes are also eaten. Milk from goats and sheep is very rarely consumed, and adults or older children and teenagers never drink it (Sellen, 1995). However, when there is no cow's milk available women will sometimes milk goats to provide food for their infants. Skins from goats and sheep are used for both clothing and mats.

Donkeys are used primarily to transport grain to Datoga households from agricultural centres, 1–3 days walk away. They are also used to transport household belongings when a household moves. In the last five years the Datoga have started to use donkeys to plough the fields.

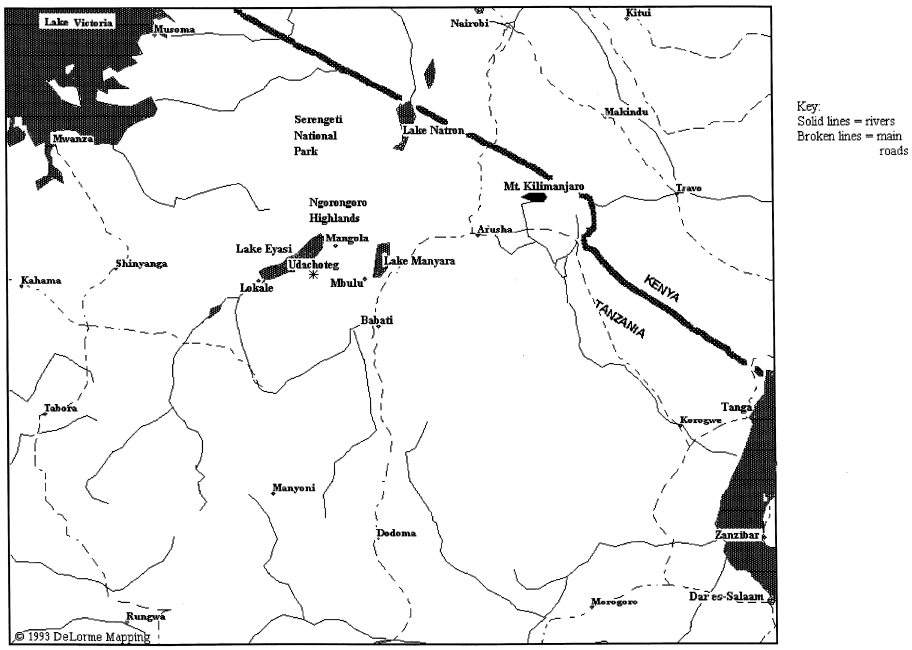
2.3. Household organisation and labour recruitment

Each Datoga homestead (KiSwahili "*boma*"; KiDatoga "*gheda*") is occupied by an independent family unit, and this forms the fundamental social and economic unit among the Datoga. A household generally consists of a married man who is the household head, his wife/wives and their children, although there may be other, more distantly related individuals living in the household. Sometimes a second or "satellite" family lives in the *gheda* of the household owner. Such satellite families are normally poor families who are provisioned by the owner of the *gheda*, and in return they provide labour for the household.

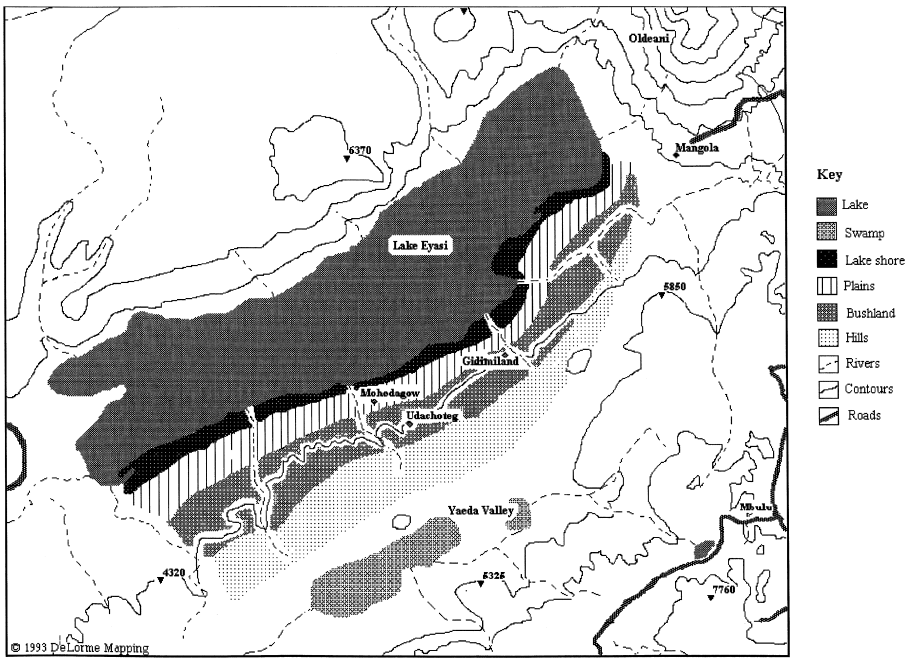
Homesteads consist of several mud huts which are surrounded by a thick fence of acacia thorn. There are separate kraals within the homestead for cattle, calves and small stock. Homesteads are semi-permanent, and families may live in them for several years. However, despite the semi-permanent nature of the homestead the grazing follows a cyclical pattern (Sieff, 1995, 1997).

2.4. The study area

Lake Eyasi (1031 m) lies between 3°00′ and 4°00′ south of the equator, and between 34°50′ and 35°50′ east (Map 1). It is in the Mbulu district at the foot of the Kakesio escarpment which is part of the Great Rift fault systems. The lake is



Map 1.



Map 2.

one of East Africa's largest soda lakes but it is shallow and consequently dry for most of the year. During the rains it fills but even then the lake water is too salty to provide drinking water for either livestock or people. Moreover, the rivers that flow into Lake Eyasi dry up during the dry season, so water is obtained either from natural springs, or from shallow wells that are dug by hand.

The topography of the area is highly variable. There are flat plains (KiDatoga "*muhajega*") next to the lake shore. This is primarily an area of savannah grassland. Then an area of relatively flat bushland (KiDatoga "*darabet*") is sandwiched between the plains and the hills. This area consists of acacia thicket (predominately *Acacia tortilus* – Hawkes et al., 1989) and it is where the villages are situated. Behind the villages to the east are the Mbulu hills which are covered by thick bush (*Acacia brevispicia, Aloe* and giant boababs *Adansonia digitata* – Hawkes et al., 1989). It is here that dry season livestock camps are established. This area is not, however, used during the rainy season due to a high level of tsetse fly infestation (Sieff, 1995).

Rainfall varies from year to year, but averages 363 mm per year[3] between 1990 and 1993. This is low compared to the rainfall in areas where other East African pastoralists herd cattle as part of their herds (Sieff, 1995). Nearly all rain falls between November and April, however the timing varies from year to year, as does the spatial distribution of rain.

Temperatures range between 16°C and 34°C (Dr. Hanby pers. comm.). The temperature is relatively stable throughout the year, although September to March can be deemed a warm season, compared to April to August which is cooler.

2.5. Methodology

Detailed data on livestock dynamics were collected through systematic interviews with 18 households in the village of Udachoteg. A household is defined as an independent decision making unit with regard to the management of livestock and human labour (Dahl and Hjort, 1976). Each

[3] Data collected by Dr. J. Hanby in Mangola.

Table 1
Household Characteristics, and TLU Per Household and Per Capita for Udachoteg and Gidimiland

	Udachoteg and Gidimiland ($n=37$)				Udachoteg ($n=18$)				Gidimiland ($n=19$)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	*Min*	Max
No. married men	44	–	–	–	22	–	–	–	22	–	–	–
No. residents	368	–	–	–	218	–	–	–	150	–	–	–
No. of residents/household	10.0	6.1	3	30	12.1	7.1	3	30	7.9	4.1	3	18
No. of cattle per household	46.1	48.3	0	201	57.7	47.2	7	174	35.2	48.0	0	201
No. of goats per household	23.8	26.8	0	112	22.3	21.1	0	64	25.3	31.8	0	112
No. of sheep per household	23.1	24.6	0	94	26.6	20.0	0	72	19.9	28.4	0	94
No. of donkeys per household	4.9	0.9	0	25	5.6	1.4	0	25	4.4	4.5	0	18
TLU per household	41.6	40.4	2.8	171.4	50.1	37.7	5.0	140	33.6	42.2	2.8	171
No. of cattle per capita	4.3	2.8	0	11.2	4.6	2.0	1.4	7.4	4.1	3.5	0	11.1
No. of goats per capita	2.6	2.8	0	13.8	1.9	2.2	0	9.4	3.1	3.2	0	13.8
No of sheep per capita	2.6	3.3	0	18.5	2.5	1.8	0	6.5	2.7	4.3	0	18.5
No of donkeys per capita	0.5	0.07	0	1.5	0.4	0.3	0	1.2	0.6	0.4	0	1.5
TLU per capita [a]	4.1	2.7	0.3	12.2	4.0	1.7	1.0	7.3	4.1	3.4	0.3	12.2

[a] Borgerhoff Mulder (1992) found that there were 5.7 TLU per reference adult in a survey of four Datoga villages. However, she excluded "satellite" families in her measurement of household members, and her sample included Datoga living in Mangola, and also a village in the Yeada valley whose residents may be wealthier then those living on the shore of Lake Eyasi.

household was interviewed on a monthly basis between May 1992 and April 1993. Rainfall during this period was 355 mm. A further 19 households in Gidimiland were surveyed in a one-off round of questionnaires to establish their livestock holdings. Gidimiland is approximately five miles from Udachoteg, in a similar ecological zone (Map 2). Interviews were carried out in KiSwahili and KiDatoga with the help of a bilingual Datoga field assistant; Momoya Bashgei Merus (see Sieff, 1995 for full methodology). Analyses were carried out using SPSS for windows.

3. Livestock holdings

The 37 households in Udachoteg and Gidimiland owned a total of 1707 cattle, 881 goats and 856 sheep. Table 1 shows that households in Udachoteg have considerably more livestock than

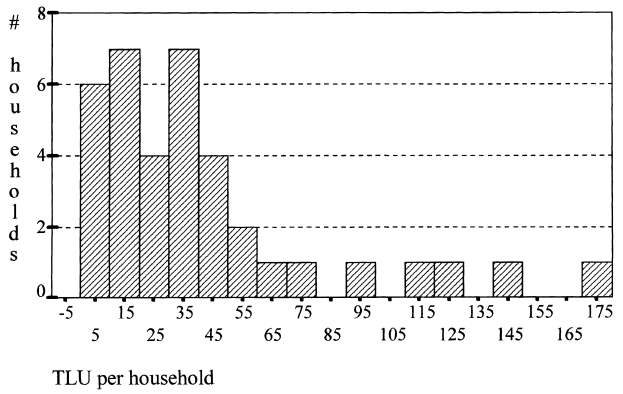


Fig. 1. Histogram of total livestock holdings for 37 Datoga households in Udachoteg and Gidimiland (Udachoteg data collected in March 1993, Gidimiland in December 1993).

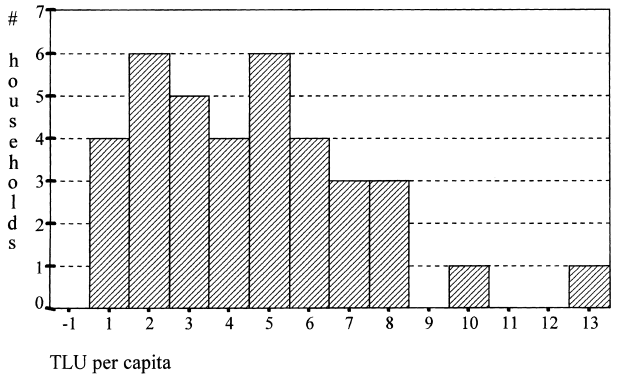


Fig. 2. Histogram of per capita livestock holdings for 37 Datoga households in Udachoteg and Gidimiland (Udachoteg data collected

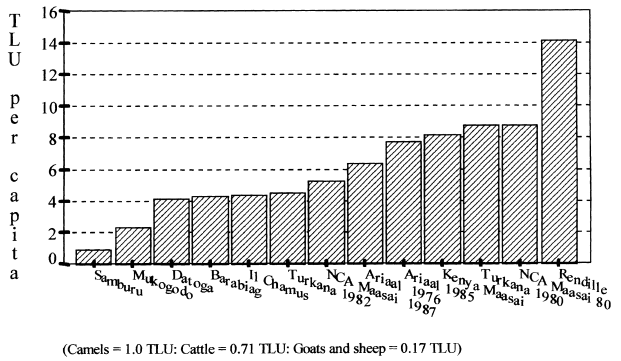


Fig. 3. Livestock holdings (TLU) per capita for East African pastoralist populations. *Source*: Ariaal (Fratkin and Roth, 1990), Barabaig (Lane, 1991), Datoga (this study), Il Chamus (Little, 1985), Maasai of Ngorongoro Conservation Area (NCA) (Homewood and Rodgers, 1991), Maasai of Kenyan group ranches (Nestel, 1986), Mukogodo (Herren, 1990), Rendille (Fratkin and Roth, 1990), Samburu (Sperling, 1987).

those in Gidimiland but interestingly, Udachoteg households have more residents, so the average per capita wealth in Udachoteg and Gidimiland households is almost identical.

The distribution of livestock holdings per household is shown in Fig. 1 and the distribution of livestock holdings per capita is shown in Fig. 2. The majority of households own between 1 and 50 TLUs (mean 41.6 TLUs; SD 40.4; min 2.8; max 171.4), although the distribution is positively skewed with four households owning more than 100 TLUs. The skewness of wealth per capita is less pronounced, and in most households there are between 0 and 8 TLUs per capita (mean 4.1 TLUs per capita; SD 2.7; min 0.3; max 12.2).

It has been estimated that, in order to meet subsistence needs, pastoralists need approximately 5 cattle per person (Kjaerby, 1979; Sperling and Galaty, 1990), or 4.5–4.7 TLUs per person[4] (Pratt and Gwynne, 1970; Dahl and Hjort, 1976). Below this, herders must diversify their production base to provide enough food. The Datoga are one of the poorest pastoral groups in East Africa (Fig. 3), and their average per capita livestock are near the proposed threshold of viability (4.1 TLUs per capita). However, there is considerable variation in per capita livestock holdings across households. Consequently, this paper will examine whether wealth affects the production system of Datoga households.

[4] The estimate of a minimum number of livestock units needed for pastoralists to be viable is highly dependent on the exchange rate between cattle and grain.

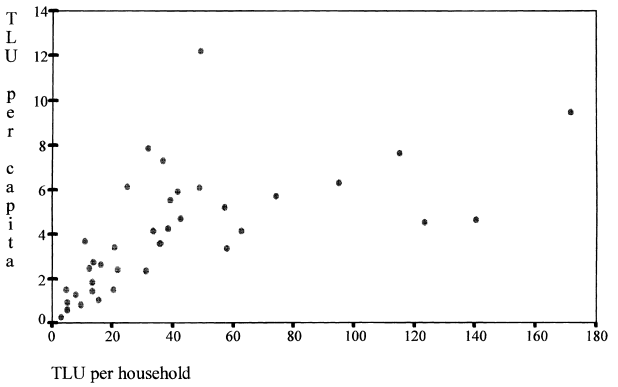


Fig. 4. The relationship between total livestock units per capita and total livestock units per household for 18 households in Udachoteg and 19 in Gidimiland.

3.1. How to measure wealth; wealth per household or wealth per capita?

Before analyses can examine how wealth influences the prospects of Datoga households, it is important to look at how wealth should be measured. There are two main ways to measure the wealth of pastoralist households; the first is to measure the total number of livestock units in a household, and the second is to measure the average TLU per capita for household members.

Some researchers find that these two measures of wealth covary (for example, Grandin, 1988; Kjaerby, 1979). However, they do not have to covary and more importantly they are conceptually distinct. Overall household wealth may be important if production dynamics are affected by economies of scale. For instance, if a small household slaughters an animal, its residents may not be able to eat all the meat before it becomes putrid; however, a large household would be able to consume the entire carcass. In terms of herding strategies the overall herd size may also be important because herders seem to be able to look after a relatively large number of animals without compromising the quality of care given to those animals (Sieff, 1995, 1997). There may also be advantages to being a large, wealthy household that are not measured directly in terms of livestock dynamics and subsistence needs. Wealthier households may have more prestige, resulting in better access to sites for homesteads, more say in village affairs, and more help in times of trouble. In contrast, TLU per capita is an indication of the resources available to household residents in terms of milk, meat and purchasing power. If the viability of households ultimately depend on the daily provisioning of residents, then per capita wealth will be a better indication of a household's prospects than the total number of livestock units owned by them.

The first step in exploring the relationship between household wealth and wealth per capita among the Datoga is to look at the relationship between the variables. Households that are wealthy in terms of total livestock holdings are also wealthy in terms of per capita holdings. Poor households (0–19 TLUs per household; $n=12$) have on average 1.6 TLUs per capita; medium households (20–41 TLUs per household; $n=13$) have 4.41 TLUs per capita; and wealthy households ($\geqslant$42 TLUs per household; $n=12$) have 6.19 TLUs per capita.

Fig. 4 shows that although per capita wealth increases as overall household wealth increases, the relationship is curvilinear. The per capita wealth of individuals in rich households is not proportionally greater than that of poor households. This is because wealthy households have more people in them. Fig. 4 suggests that once households have approximately 5 TLUs available per household resident further increases in household wealth does not lead to further increases in per capita wealth for existing household members;

instead the extra wealth is used to bring new people into the household (primarily new wives, and therefore more children).

Sieff (1995) shows that per capita wealth explains the variation in household subsistence strategies better than total household wealth does, so this paper will focus on per capita wealth, and only refers to total household wealth when it explains aspects of the subsistence system that cannot be understood by measures of per capita wealth.

4. Cattle holdings and dynamics

On average there are 4.6 cattle per capita for household members in Udachoteg (Table 1), of which 70% are female (Table 2). This is typical of pastoralists who bias their herds towards reproductive animals and milk producers. Potential milk producing animals include all adult cows (*nybujiga*) and a subset of "heifers" (*haghweniga*). Among the Eyasi Datoga a cow is classified as a '*haghweniga*' from the age of two until it has weaned its first calf. Together they make up 55% of the cattle population. Most other studies, however, take only mature cows to be potential milk producers and these comprise 38% of Datoga herds.

Herd dynamics are affected by demographic processes such as reproduction, mortality, and commercial offtake. It is possible to see a broad division in these demographic processes; those that add cattle to herds, and those that remove them. Eighty-six percent of cattle come into herds through birth; in contrast only 3% of cattle coming into herds are purchased and 11% are gifts. This suggests that the Datoga do not have surplus cash to invest in livestock, so the successful reproduction of animals is crucial. It is therefore important to examine cattle reproductive rates. The other processes that result in cattle entering the herd (namely receiving a gift, or purchasing cattle), are negligible; these are not discussed here (see Sieff, 1995 for a complete analysis).

There are two principle reasons for cattle to leave herds; death (51.6% of losses) and (b) sale (42.5% of losses). Cattle are also lost through slaughter and by being given away, but as death and sales account for 95.1% of animals leaving the herd only these processes will be discussed below (see Sieff, 1995 for a complete analysis).

4.1. Reproduction performance of cattle in Udachoteg

The annual calving rate is 52%. This is low compared to other populations (see Table 3) and may be more typical of cattle living in "stressed", as opposed to "normal" conditions. The nutritional condition of cattle does affect their fertility, but most evidence centres around dramatic drops in fertility associated with droughts (Dahl and Hjort, 1976; Homewood and Lewis, 1987; Cossins and Upton, 1988). Data for the Datoga were not collected during a year of abnormally low rainfall and moreover, rainfall during the period when the cows were conceiving their calves (July 1991–June 1992) was 308 mm. This is marginally lower than rainfall in an "average" year, but cannot be described as a period of severe drought. However, there is some evidence that in times of low rainfall

Table 2
Sex and Age Composition of the Cattle in the 18 Focal Households in Udachoteg at the Mid-point of the Study, September 1992

Age class	Age in years	Male cattle		Female cattle	
		No. cattle	% of total	No. cattle	% of total
Calves	0–2 yrs	180	15.2	183	15.5
Heifers and sub-adult males	2–3 yrs	82	6.9	203	17.2
Steers/bullocks	2.5 yrs+	48	4.1	–	–
Bulls, cows	3+ yrs	41	3.5	446	37.6
Total		351	29.7	832	70.3

Table 3
Comparative Data for Cattle Demography Among East African Pastoralist Herds

Population	Country	Reference	Calving rate	Calf mortality rate	Adult mortality rate	Commercial offtake rate
Barabaig	Tanzania	(Lane, 1991)	80	39	9	5
Barabaig	Tanzania	(Kjaerby, 1979)	–	–	15	5–7
Baringo district[a]	Kenya	(Homewood and Hurst, 1986)	–	89[b]	45	–
Borana	Ethiopia	(Cossins and Upton, 1987)	75	25	–	–
Il Chamus	Kenya	(Homewood and Lewis, 1987)	>90	–	–	–
East African range	various	(Dahl and Hjort, 1976)	–	10–40	5–10	4–10
Karimojong	Uganda	(Dyson-Hudson and Dyson-Hudson, 1970)	81	–	–	–
Kenyan Maasai	Kenya	(Jacobs, 1965)	66–75	–	–	–
Kenyan Maasai	Kenya	(de Leeuw et al., 1991)	58	6–15	–	–
Kenyan Maasai	Kenya	(Homewood, 1992)	–	–	6	9
Ngorongoro Maasai	Tanzania	(Homewood, 1992)	55–70	23–28[c]	11	8
Tanzanian average	Tanzania	(Raikes, 1981)	–	30	5–10	5–7[d]
Tugen	Kenya	(Homewood and Lewis, 1987)	70	–	–	–
Turkana, in drought	Kenya	(McCabe, 1985)	24	–	–	–
Turkana, post drought	Kenya	(McCabe, 1985)	86	–	–	–
Datoga	**Tanzania**	**This study**	**52**	**26.7**	**11.7**	**19.5**

[a] Il Chamus and Tugen data combined.
[b] Data collected in period of extreme drought.
[c] Data from Homewood and Rodgers (1991).
[d] Data from Sullivan, cited in Lane (1991).

(as opposed to drought) zebu cattle track the environment by reducing their basal metabolic rate and fertility (de Leeuw et al., 1991; Scoones, 1994), so the fact that Eyasi is a very dry environment may explain the low reproductive rate of cows.

One might expect that cows owned by wealthy households would have higher reproductive rates than those owned by poor households, as wealthy households could afford more veterinary care, or might have preferential access to grazing or water resources. However, there is no relationship between the reproductive rates of cattle and any measure of wealth (Sieff, 1995). Further analysis shows that the amount of shillings spent per cow on veterinary care does not influence their reproductive rates (Sieff, 1995). Additionally, the grazing regimes of cattle is similar for both wealthy and poor households (Sieff, 1997).

Table 4
Reported Causes of Calf Mortality for the 18 Focal Households

Reported cause	No. deaths	Percent of deaths
Accident	7	7.2
Anaplasmosis	7	7.2
Babiosis	10	10.3
Black water fever	1	1.0
Bloody diarrhoea	1	1.0
Cough	1	1.0
Drank too much milk	3	3.1
Foot and mouth	5	5.2
Lack rain / lack grass	13	13.0
Paratuberculosis Johnes	2	2.1
Rain shock	1	1.0
Ringworm	1	1.0
Trypanosomiasis	9	9.3
Stolen by wild animal	7	7.2
Tuberculosis	1	1.0
Unknown	28	28.9

4.2. Cattle miscarriages and still births

There were 40 recorded miscarriages and still births showing that the reproductive potential of Datoga cattle is severely curtailed by pre-natal death. Moreover this figure is likely to be an underestimate. Miscarriages that occur early in pregnancy could easily go undetected by herders. Accepting this, data show that at least 13.6% of pregnancies in cows are unsuccessful, indicating a substantial loss of potential. The Datoga reported that 43% of miscarriages were caused by trypanosomiasis and 3% by foot and mouth diseases. They did not know what caused the remaining miscarriages but brucellosis was a prime suspect and it is commonly known as the "abortion disease".

4.3. Calf mortality

Ninety seven calves (0–24 months) died during the study period. This accounted for 48.7% of all

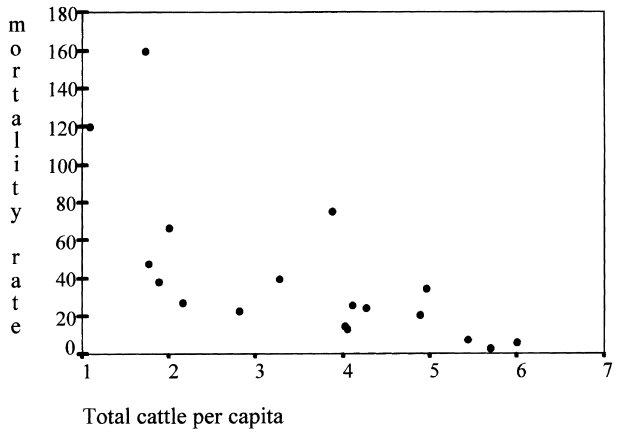


Fig. 5. The relationship between the mortality rate of calves and the number of cattle per capita for 18 focal households in Udachoteg.

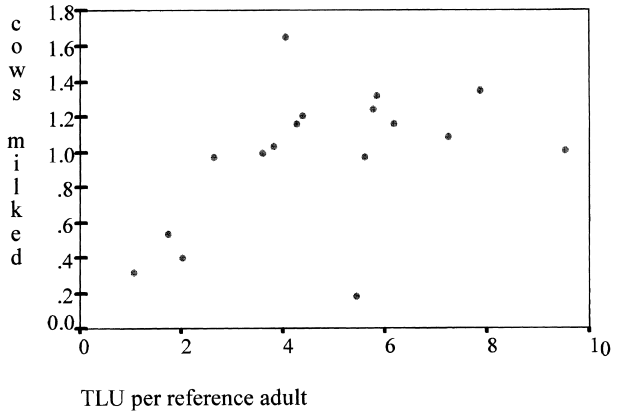


Fig. 6. The relationship between the number of cows milked per day per reference adult and livestock holdings (TLU) per reference adult for 17 households in Udachoteg (April 1992–March 1993).

recorded cattle deaths. Table 4 shows the reported causes of calf deaths. These include tick borne diseases such as anaplasmosis and babiosis, trypanosomiasis, the lack of grass, accidents and being killed by a wild animal.

If the calculation of calf mortality is based on a mid-line figure for the number of calves in a herd then the mortality rate is 26.7%. This is within the range of other East African pastoralists (Table 3) suggesting that although the reproduction rate is low, calves that are born have as good a chance of survival as calves in other East African herds.

The calf mortality rate varies across households and it is significantly lower in households which are wealthy in terms of cattle per capita, compared to poor households (Fig. 5[5]; Spearman's rank for calf mortality versus cattle per capita $= -0.812$, $p = < 0.000$, 2-tailed, $n = 18$)[6]. A possible explanation is that wealthy households milk their cows less hard than poor ones and therefore leave more milk for their calves, like Kenyan Maasai (Grandin, 1988).

An average Datoga household milks 0.98 cows per reference adult[7] per day, and the average milk yield is 0.84 kg per cow per day. It follows that a reference adult has 0.82 kg of milk available per day or 613 Kj. This is within the range of other East African populations (Sieff, 1995). However, there is considerable variation in the amount of milk available to individuals of different households so it is important to explore whether wealthy households are in fact leaving more milk for their calves, whether they are taking more milk for household residents, or whether they have reached a compromise.

Statistical analyses show that households which are wealthy in terms of livestock per reference adult do milk more cows for each reference adult compared to poorer households (Spearman's rank $= 0.532$, $p = 0.028$, 2-tailed, $n = 17$)[8]. However, Fig. 6 suggests that the relationship between wealth per reference adult and the number of cows milked is curvilinear; the number of cattle milked per reference adult per day rises steeply as households become richer, but once they are milking

[5] The calf mortality rate can be greater than 100% as it is calculated by dividing the number of calves that die by the number of calves at the mid-point of the study. At the mid-point there might be 2 calves, but during the entire year other calves would have been born, and if four calves had died in total then mortality would be 200%. (See Homewood and Rodgers, 1991 for subtly different method.)

[6] This is significant even if the two households with substantially higher calf mortality than the rest are excluded (Spearman's rank $= -0.735$, $p = 0.001$, 2-tailed, $n = 16$).

[7] See Sieff (1995) for computation of "reference adult units".

[8] $n = 17$ not 18 because one household was split between two villages so it was impossible to get accurate data on the number of cows being milked in the second household.

about 1 cow per reference adult per day additional wealth does not result in additional cattle being milked. In other words, although wealthy households have more lactating cows available they do not milk every lactating cow at every milking. This suggests that wealthy households are trying to balance the needs of humans and those of calves; once households have what they consider to be an "acceptable" amount of milk available for human consumption they leave the remainder of the milk for the calves, even if there are more cows available that could potentially be milked. This probably explains why the death rate of calves in wealthy households is lower than it is in poor households.

4.4. Adult and sub-adult cattle mortality

During the study 102 adult and sub-adult cattle died, giving an annual mortality rate of 11.7%. This is high, but comparable to the mortality rates of cattle belonging to other East African pastoralists (Table 3). Table 5 shows the main reported causes of death. These include drought, trypanosomiasis, tick borne diseases (anaplasmosis and babiosis), and being lost out herding, or killed by a wild animal.

Table 6 shows the mortality rate for each class of cattle and it is worth noting the high mortality rate in reproductive cows (15.9%). This might be because of the high energy loads associated with pregnancy and lactation. Homewood and Rodgers, 1991 quantified the physical condition of different classes of cattle belonging to the Maasai of the Ngorongoro Conservation Area and they found that adult female cows were in the poorest condition. They suggested that this was because pregnancy and lactation imposed an extra energy load. Scoones (1992) showed that during the 1982–84 and 1987–88 droughts in southern Zimbabwe, mature cows suffered the highest mortality compared to other age–sex classes. The condition of Datoga cattle was not measured, but the high mortality rate of reproductive cows indicates

Table 5
Reported Causes of Death for Adult and Sub-adult Cattle

Cause of death	No. of deaths	Percentage of deaths
Drought	18	17.6
Anaplasmosis	15	14.7
Babiosis	15	14.7
Trypanosomiasis	8	7.8
Lost out herding/killed by wild animal	6	6.0
Paratuberculosis Johnes	5	5.0
Broke a limb	5	5.0
Diarrhoea	3	3.0
Malignant catarrh	3	3.0
Cow died during birth	3	3.0
Due to injection / veterinary care	3	3.0
Suddenly died	2	2.0
Old age	1	1.0
Eye infection	1	1.0
Snake bite	1	1.0
Unknown illness	13	12.7

Table 6
Mortality Rates for Adult and Sub-adult Cattle in Udachoteg Over a Year (in percentages)

Heifers	Cows	Yg. males	Bullocks	Bulls	All females	All males
4.9	15.9	7.3	10.3	9.6	12.5	8.7

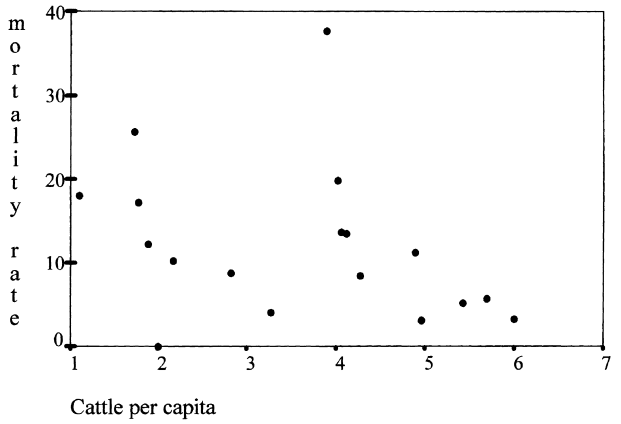


Fig. 7. The relationship between the mortality rate of adult and sub-adult cattle and the number of cattle per capita owned by the household for 18 households in Udachoteg.

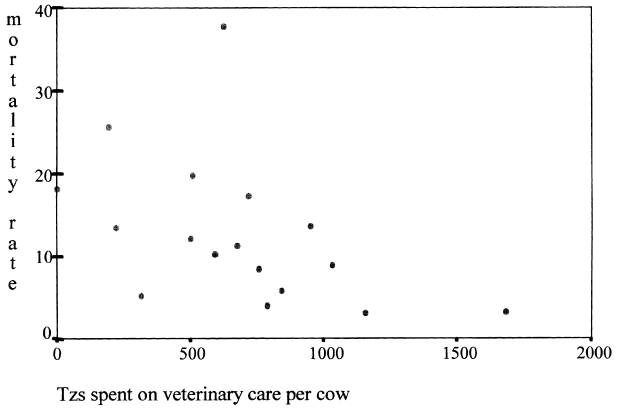


Fig. 8. The relationship between the number of Tanzanian shillings (Tzs) spent buying veterinary products per cow, and the mortality rate of cattle in 17 Datoga households between April 1992 and March 1993.

that their condition is poorer than other age–sex classes of cattle.

There is substantial inter-household variation in the rate of cattle mortality and wealthy households have lower rates of cattle mortality than poorer ones (Fig. 7) (Spearman's rank for cattle mortality versus cattle per capita $= -0.488$, $p = < 0.040$, 2-tailed, $n = 18$). One possible explanation is that wealthy households can afford to spend more money on veterinary care than poor ones. On average wealthy households spend 31% ($\geqslant 3.5$ TLU per capita) of their expenditure on veterinary products whereas poor households (< 3.5 TLU per capita) spend only 18.5% of their total expenditure on veterinary products.

As wealthy households are defined by the number of livestock they own, it is not surprising that they spend a greater percent of their income on veterinary products than poorer ones. They simply have more cattle to care for. A more informative analysis is to look at the relationship between wealth and the average number of shillings spent per animal on veterinary care. On average poor households spend Tzs 599 per cow,[9] whereas wealthy households spend Tzs 769 per animal. A Spearman's correlation between wealth per capita and the Tzs spent on veterinary products per

[9] In this context "cow" means a male or female animal of any age.

Table 7
Reported Number of Tanzanian Shillings Spent on Various Classes of Goods for the 18 Focal Households in Udachoteg Combined

Class of goods	Tzs	Rank	Percent
Food	1 378 578	1	58.2
Veterinary goods	602 778	2	25.0
Clothes	142 980	3	6.0
Livestock	122 400	4	5.2
Tobacco/alcohol	59 000	5	2.5
Adornments (beads etc.)	19 572	6	0.8
Medical supplies	16 076	7	0.7
Household utensils	10 750	8	0.5
Wages for labour	7 800	10	0.2
Other [a]	9 470	9	0.4

[a] The category "other" includes (a) tax , (b) money lost, and (c) any alcohol that was reported.

cow shows a significant positive relationship (Spearman's rank $= -0.505$, $p = < 0.039$, 2-tailed, $n = 17$)[10].

More directly Fig. 8 shows that the mortality rate of adult cattle is negatively related to the number of shillings spent on veterinary care per animal and this is supported by statistical analysis (Spearman's rank for the number of Tzs spent per cow on veterinary care and the mortality rate of adult cattle $= -0.610$, $p = 0.009$, 2-tailed, $n = 18$). This provides strong evidence to suggests that by spending more money on veterinary goods wealthy household directly reduce the death rate of their adult cattle[11].

4.5. Cattle sales and commercial offtake

Many development projects try to encourage pastoralists to sell more livestock. It is commonly thought that pastoralists are over-stocking and that higher rates of commercial offtake will be good for the national economy and for the environment. However, Lane (1991) among others, points out that a high commercial offtake is not necessarily a sign of economic health. In times of drought, cattle sales increase as families are forced to sell their stock to buy grain and other sources of food. Under such conditions pastoralists are forced into a cycle whereby they have to sell female animals, and herds are no longer able to reproduce themselves.

During the study 164 cattle were sold resulting in a commercial offtake rate of 19.5%. This is extremely high compared to other East African pastoralists (Table 3). In order to assess whether the animals are being sold out of increasing commercialisation or because of subsistence stress it is important to look at how much money is coming into Datoga households and how that money is spent.

An average household's annual monetary income is 156 185 Tanzanian shillings (Tzs) or £260 pounds sterling (SD = Tzs 110 981). The sale of cattle generates 81% of this income and the sale of small stock 17%. The remaining income is obtained by (a) trading livestock, (b) buying and re-selling veterinary goods, (c) collecting and selling honey, and (d) collecting the sap of a particular tree and selling it as a medicine against chiggers.

Table 7 shows how this money is spent. The main expense is the purchase of food. Of this money, 90% is used to buy maize, 4.5% to buy millet, and 0.5% to buy sweet potatoes. Veterinary products are the second most important class of goods purchased. Ninety four percent of the money spent on veterinary products is used to buy

[10] $n = 17$ because one household is excluded from the analysis. The household head killed a lion and was given a large number of cattle towards the end of the year. Consequently towards the end of the year he was relatively wealthy and could afford to buy a lot of cattle medicine, however, in the middle of the year (when the livestock holdings were measured) he was one of the poorest households.

[11] There is no relationship between the amount of veterinary products purchased per animal and calf mortality rates.

Table 8
Number and Average Price of Cattle Sold for Each Age and Sex Class of Datoga Cattle

	Age in years	Male cattle			Female cattle		
		No. cattle	% of sales	Average price [a]	No. cattle	% of sales	Average price
Calves	0–2 yrs	3	3.5	9 500	1	1.3	No data
Heifers and sub-adult males	2–3 yrs	34	39.5	11 400	30	38.5	12 042
Steers / bullocks	2.5 yrs+	37	43.0	17 102	–	–	–
Bulls, cows	3+ yrs	12	14.0	36 272	47	60.3	16 807
Total		86	52.4	17 257	78	47.6	14 950

[a] It was not always possible to record the price that an animal was sold for. Consequently, the average price per animal in each class was worked out on a sub-set of all cattle sold. (It was worked out on the following number of cattle: male calves = 2; heifers = 21; adult cows = 38; sub-adult males = 24; bullocks = 34; bulls = 11.)

medicines that treat trypanosomiasis (Samorin, Nividium and Berenil), reaffirming the finding that trypanosomiasis is one of the most important livestock diseases[12]. The other drugs bought are antibiotics (tetracycline, and aquacycline) which are used to treat a range of livestock infections.

Clothes make up the next most important category of expenditure for the Datoga (6.0%) but livestock purchases make up only 5.2% of expenditure. This shows that although the Datoga realise the potential for livestock trading, they do not have spare cash to invest in livestock, once the more pressing needs of purchasing grain and veterinary products have been met.

To conclude: the income generated by livestock sales is primarily used to buy grain and veterinary products. There is little income re-invested in livestock, and no income is stored or deposited in a bank. Consequently, the exceptionally high commercial offtake of cattle is not because of increasing commercialisation, but due to poverty and subsistence stress. The problem may be exacerbated by the lack of potential for cross border selling of livestock to Kenya where prices are higher. The Maasai of Ngorongoro sell many of their cattle in Kenya and higher prices reduce the need to sell so many animals (Homewood pers. comm.). Geographically, the Eyasi Datoga are not in a position to trek their cattle to Kenya so this option is not available.

Examination of the age and sex of cattle sold lends further support to the idea that the Datoga are selling due to extreme poverty. The sale of reproductive female cattle diminishes a herd's reproductive potential, and the sale of young males and heifers results in lower financial returns than if pastoralists could afford to keep these animals until they had reached maturity. Table 8 shows the numbers of cattle sold in each age and sex class, and the average price obtained for these animals.

The proportion of sales that consist of female cattle (47.6%) is extremely high compared to other pastoral societies. Only the Maasai of the Ngorongoro Conservation Area sell such a high percent of females (49%). This is because the livestock to human ratio has declined rapidly over the last 20 years, making the Maasai increasingly dependent on purchased maize (McCabe et al., 1992). Among the Borana of Ethiopia the proportion of female to male cattle sold rises from 25% in normal years, to 43.5% in drought years (Cossins and Upton, 1987).

The proportion of Datoga cattle sold that consist of young males (< 3 years) is also high (43%) compared to other pastoralist groups. Among the Barabaig the average age at which male cattle were sold was 6 years, suggesting that they are not suffering from economic stress (Lane, 1991). Swift (1984) describes how the poorest group of WoDaabe in Nigeria sell a relatively greater number of young males (45%) than the wealthier

[12] The other important livestock diseases are tick borne, but as the chemical treatment of these involves either dips, or expensive sprays little money is spent on combating them and most tick control is carried out by picking ticks off cattle by hand.

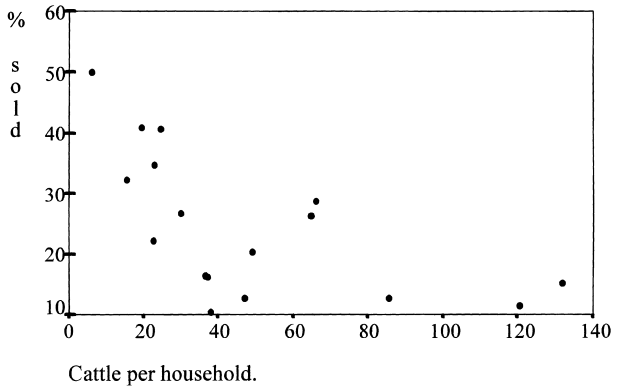


Fig. 9. The relationship between the annual commercial offtake rate of cattle and the total number of cattle owned by the households in Udachoteg ($n=17$).

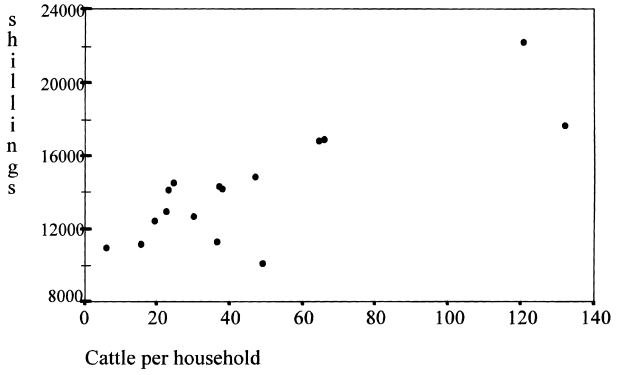


Fig. 10. The relationship between the number of Tanzanian shillings received for each cow (both male and female) and the total number of cattle owned by the household in Udachoteg ($n=16$).

group (18%), and he concludes that the poor group is not maximising its economic return.

Commercial offtake rates in other populations have been found to vary with household wealth (see Sieff, 1995 for a review) so in the following section this relationship is examined for the Datoga[13]. There is a negative correlation between cattle offtake rates and the total number of cattle owned by households (Fig. 9), whereby wealthy households have a lower commercial offtake rate than poor ones (Spearman's rank $=-0.674$, $p=0.003$, $n=17$, 2-tailed). A similar result is obtained when the offtake rates are correlated against cattle per capita as opposed to total household wealth (Spearman's rank $=-0.679$, $p=0.003$, $n=17$, 2-tailed).

One possible explanation might be that wealthy households sell cattle that are in better condition and which fetch higher prices than the cattle sold by poor households. Therefore wealthy households do not have to sell as many animals to obtain the same relative level of income. Fig. 10 shows that as household herd size increases the average price received per cow sold rises. This is supported statistically (Spearman's rank $=0.703$, $p=0.002$, 2-tailed, $n=16$)[14]. However there is no significant relationship between per capita cattle holdings and

[13] For these analyses one poor household is excluded: this household (with only 5 cattle) did not sell any cattle during the year. Instead it got its maize either by buying it with cash raised from collecting and selling wild honey, or by begging gifts of maize from a wealthy, related household.

[14] $n=16$ as one household was left out because it sold no cattle during the year, and a second household was omitted as it was not possible to collect data on the price received for cattle sold in the household.

the average price receive per animal sold (Spearman's rank = 0.403, $p = 0.122$, 2-tailed, $n = 16$).

In conclusion the higher price received in households that have large total herd size may partly explain why such households have a lower offtake rate. The household head has a larger pool of animals from which to choose and can therefore select animals that fetch a higher price. However, households that are wealthy in terms of cattle per capita do not receive a greater price per animal sold than poorer households so we cannot explain their relatively low offtake rates by the amount of money received per sale. Instead, it can be explained by the fact that although wealthy households have more income per capita than poor ones, the relationship is curvilinear (Sieff, 1995). As wealth per capita begins to increase there is a rise in the amount of shillings entering the household on a per capita basis. Once households are obtaining 1000–2000 Tanzanian shillings per capita per year, their level of income does not increase further with greater wealth. In other words, wealthy households have more income than poor ones, but not proportionally more, so they do not have to sell such a large proportion of their herds to meet their monetary needs.

4.6. Net change in number of cattle

In order to discuss the prospects of the Datoga it is necessary to examine the net change in herd size. Overall the average household had 3.5 cattle less at the end of the study than they did at the beginning[15]. There was virtually no change in the number of male cattle so the net change was due to a reduction in the number of female animals. As female cows are the reproducers this does not bode well for the Datoga's future as specialised pastoralists.

The average household's cattle herd decreased by 5.4% over the year of the study. When the percentage change in herd size is correlated with the number of cattle per capita a strong positive relationship is found Spearman's rank = 0.723, $p = 0.001$, 2-tailed, $n = 17$) and wealthy households either show a net gain in herd size or they suffer a smaller net loss in herd size compared to households that have a relatively few cattle per capita.

5. Small stock holdings and dynamics

Small stock comprise 20% of livestock holdings making a substantial contribution to the Datoga's subsistence system. Table 1 shows the overall small stock holdings for 18 focal households in Udachoteg[16]. There is an average of 25 goats and 24 sheep per household[17]. On a per capita basis there are 2.4 goats per person, and 2.2 sheep per person, and a total of 4.6 small stock per person. There are some suggestions that poor households specialise in small stock, compared to wealthier households that specialise in cattle, however there is no evidence for this among the Datoga (Sieff, 1995).

Seventy percent of adult sheep consist of ewes and this is typical of other East African pastoralists, where female sheep make up 70–76% of the flock (de Leeuw et al., 1991; Herren, 1990). Seventy-eight percent of adult goats consist of she-goats. Again this is typical. During the main study the percentage of adult males that were castrated was not recorded; however, a follow up study (December 1993) showed that 11.2% of male goats, and 13.6% of male sheep were castrated.

The main way that goats and sheep enter households is through birth, which is the same pattern recorded for cattle. In fact 96% of small stock entering households are those born within households. Purchases make up 2% of those entering the herds and gifts the remaining 2%.

[15] For this analysis one house was omitted. This is because the household head killed a lion during the year and increased his herd size by 250% from the gifts of cattle that he received for killing the lion (Klima, 1970). As the increase was due to unusual circumstances, he is excluded.

[16] Data on small stock is less accurate then cattle data. The Datoga are less concerned about them, and the high turnover makes it hard to get accurate figures on their dynamics. One wealthy households was so vague that it has been excluded from analyses on small stock dynamics (but included for description of livestock holdings). A second household had no small stock, so it too has been left out of the analyses on small stock dynamics. Consequently, the analysis of small stock dynamics refers to 16 households.

[17] xxx.

Table 9
Comparative Data for Small Stock Demography Among East African Pastoralist Herds

Population	Country	Reference	Reproduction rate		Mortality rate		Commercial offtake rate	
			Goats	Sheep	Goats	Sheep	Goats	Sheep
Borana	Ethiopia	(Cossins and Upton, 1987)	140	90	–	–	–	–
Borana pre-weaning	Ethiopia	(Cossins and Upton, 1987)	–	–	32	45	–	–
Borana post-weaning	Ethiopia	(Cossins and Upton, 1987)	–	–	10	10	–	–
Il Chamus	Kenya	(Homewood and Hurst, 1986 [a])	28	–	10–11	–	13–92	–
Kenyan Maasai pre-weaning	Kenya	(de Leeuw et al., 1991)	–	–	34	18	–	–
Mukogodo	Kenya	(Herren, 1990)	84	108	41	37	8	8
Tugen	Kenya	(Homewood and Hurst, 1986)	42.5	129–225	46–62	137–168	26–34	85–104
Turkana, in drought	Kenya	(McCabe, 1985)	40	50	–	–	–	–
Datoga	**Tanzania**	**This study**	**126**	**127**	**19**	**26**	**34**	**25**

[a] Worked out as 6-monthly rate, not yearly rate.

Table 10
Reported Causes of Small Stock Deaths in Udachoteg

Cause of death	No. goat deaths	No. sheep deaths
Anaplasmosis	1	1
Babiosis	0	4
Diarrhoea	3	12
Trypanosomiasis	3	6
At birth	0	1
Mange	1	0
Suddenly died without signs of illness	1	3
Unknown illness	27	22
Rain shock	3	9
Drought	4	4
Killed by eagle	2	5
Killed by leopard	11	11
Killed by jackal	5	5
Killed by hyena	2	6
Killed by small cat	7	0
Snake bite	0	1
Broke a limb / accident	2	0
Lost out herding	0	10
Old age	2	0

This reinforces the idea that the Datoga do not have surplus cash to invest in livestock, and shows that reproduction rates are crucial to the sustainability of the subsistence system, so the reproduction rate will be discussed below (see Sieff, 1995 for full analysis). Of the animals leaving the herds, death accounts for 43% of the losses, sales 38%, slaughters 15%, and gifts 4%. As death, sales and slaughters are the most important processes, these will be examined below (see Sieff, 1995 for a full analysis).

5.1. Reproductive performance of small stock

During the study 274 goats and 234 sheep were born. Fifty-two percent of both kids and lambs born were male. The annual reproduction rate for goats is 126%, whereas for sheep it is 127%[18]. Compared to other pastoralist groups (Table 9) the reproduction rate of small stock is at the high end of the scale. Although there is considerable variation in the reproduction rate of both goats and sheep across Datoga households, there is no relationship between the reproduction rate of either species and any measure of wealth.

5.2. Small stock mortality

During the course of the study 74 goats and 100 sheep died. This results in a mortality rate of 19% for goats and 26% for sheep which is low compared to other populations (Table 9). The mortality rate of male rams is 15%, versus 18% for she-goats, whereas the mortality rate of both male and female sheep is 20%[19] so there is no sex bias in their mortality.

The Datoga report that diseases caused 47% of goat deaths, and 45% of sheep deaths (Table 10), with diarrhoea and trypanosomiasis being the most important illness for both species. Tick borne diseases are uncommon in small stock. There are no vaccinations or dips available for small stock so they are rarely given any kind of veterinary medicine. Predation is also an important cause of small stock deaths, accounting for 36% of goat deaths and 27% of sheep deaths.

[18] The annual reproduction rate can be over 100% as small stock are capable of giving birth twice a year, and additionally twinning is not uncommon.

[19] These sex-specific mortality rates are lower than the average rates for each species, and must be slight underestimates as there is no way to incorporate the deaths of small stock which died but whose sex was unrecorded into these calculations.

Table 11
Numbers of Small Stock Sold and Average Price in Tanzanian Shillings Received Per Animal Sold

	Goats		Sheep		All small stock	
	No. sold	Av. price	No. sold	Av. price	No. sold	Av. price
Male	63	2300	48	2311	111	2315
Female	24	2278	16	2110	40	2221
All[a]	88	2294	65	2288	153	2292

[a] There was one sheep and one goat sold whose sex was unrecorded. This is why the number of "all" small stock sold is greater than the sum of the males and females.

Table 12
Results of Spearman's Correlation Between Commercial Offtake Rate and Average Price Received Per Small Stock Sold and Measures of Wealth

	Small stock offtake rate		Average price received per small stock sold	
	R	p	R	p
TLU per household	−0.641	0.007 **	−0.153	0.572
TLU per capita	−0.571	0.021 *	−0.241	0.368
No. small stock/household	−0.804	< 0.000 **	−0.097	0.720
No. small stock/capita	−0.556	0.025 *	0.053	0.846
Average price/goat or sheep sold	0.121	0.656	–	–

Statistical analysis shows no relationship between small stock mortality rates and wealth. This is understandable as the Datoga neither milk small stock, nor do they use purchased medicine on their small stock. Without such inputs it is hard to imagine how wealth would affect small stock mortality.

5.3. Small stock commercial offtake

Over the year 153 small stock were sold. This accounts for 38% of small stock leaving the herds and results in a commercial offtake of 34% for goats and 25% for sheep. Table 11 shows the composition of small stock sales and the average price received for each class of small stock sold. Male animals make up 70% of the sales.

There are few comparative data on the commercial offtake rate of small stock in other East African pastoralists (Table 9). For Tugen and Il Chamus commercial offtake rates of small stock are considerably higher than those of the Datoga; however, the Tugen / Il Chamus data were collected in a period of extreme drought, when herds were dying, and families were in desperate need of cash to purchase food (Homewood and Hurst, 1986). Herren's study of the Mukogodo during an average period in terms of rainfall (Herren, 1990), found a commercial offtake rate of 8% for both sheep and goats. The Datoga commercial offtake rate is substantially higher than that of the Mukogodo. If the Mukogodo are typical of other East African pastoralists then the offtake rate of the Datoga suggests that the subsistence stress which is evident in the sale of their cattle, is also reflected in the high offtake rate of small stock.

There is considerable variation in offtake rates of small stock among Datoga households, and the relationship between commercial offtake rate and wealth shows a similar pattern to that found for Datoga cattle. There is a highly significant negative relationship between the commercial offtake rate of small stock and both the total number of TLUs owned by the household and the number of small stock owned by the household (Table 12). There is also a significant negative relationship between the commercial offtake rate of small stock and both TLU per capita and small stock owned per capita (Table 12). These relationships cannot be explained by wealthier households getting more money per animal sold, as there is no significant relationship between the commercial offtake rate and the average price received per goat and sheep sold (Table 12). Therefore poor households must be selling a greater proportion of their herds, compared to wealthy households, in order to meet their subsistence needs.

5.4. Small stock slaughtered

Slaughtered animals account for 19% of goats leaving the herds and 11% of sheep leaving the flocks. This is considerably greater than cattle where slaughters make up only 3% of animals leaving the herds, suggesting that when the Datoga want to slaughter an animal they will normally choose either a sheep or a goat. This can be understood in nutritional and economic terms; a household can consume a goat or a sheep by

itself whereas the meat of a cow has to be shared between households or else it will go putrid before it is consumed. Sharing meat raises a household's social status but given the poverty level among the Datoga, few households can afford this.

Fifteen out of the 16 households that owned small stock slaughtered them during the study, with between one and eleven animals being slaughtered in each household. There are two main reasons given by the Datoga for slaughtering small stock; first, to celebrate the birth of a baby (35% slaughters) and second, because a family member is ill (32% slaughters). There is no relationship between wealth and the slaughter rate of small stock. This might be explained by the fact that if a baby is born it is considered unlucky not to slaughter an animal so families do not have that option.

5.5. Net change in small stock herds

Overall there is a net gain of small stock among the 16 focal households; the average increase per household is 5 goats and 3 sheep. This translates into goat herds increasing by 20%, whereas sheep flocks increased by 13%. Sixty-two percent of the increase in goats and 64% of the increase in sheep is made up of female animals.

The increase in small stock numbers is not spread evenly across households, but instead there is a significant positive relationship between the increase in small stock herds, and total household wealth (Table 13). In other words households that have greater number of total livestock units per household, and that have a greater number of small stock per household, have a larger positive change in their flock size. There is also a trend for households who have more small stock per capita to have a positive change in their small stock herds. There is no relationship between total per capita wealth and changes in flock size.

Table 13
Results of Spearman's Correlation Between Percent Change in Small Stock Numbers and Wealth

	% change in small stock	
	R	*p*
TLU per household	0.497	0.050*
TLU per capita	0.356	0.176
No. small stock / household	0.500	0.048*
No. small stock / capita	0.479	0.060

For cattle, the relationship between the change in herd size and wealth is different: a large positive increase in herd size is strongly associated with the average cattle per capita in households, rather than with total cattle herd size. It may be that as cattle have such a direct role in providing for the nutritional needs of the Datoga (either through milk or through commercial offtake), the number of people that depend on those cattle is crucial in determining offtake rates. Small stock are not milked, so their relationship with the number of individuals in the household may be less important.

6. Net change in livestock holdings

In this final section the interaction between cattle and small stock will be examined in order to assess the overall trend in total livestock holdings for the families of Udachoteg. There is a net gain of 130 small stock over the year, whereas the same 16[20] households show a net loss of 58 cattle. As 130 small stock are equivalent to 22.1 TLUs, whereas 54 cattle are equivalent to 38.3 TLUs the gain in small stock does not make up for the loss in cattle and at the end of the study year focal households owned on average 16.2 less TLUs than they did at the beginning. Although the net gain in small stock does not make up for the deficit in cattle, it seems that people are biasing the structure of their herds towards small stock, and the bias is not greater in poor households compared to wealthy ones. However, with data available from so few households, for only a year, it would be foolish to make any serious predictions.

On average household livestock holdings decreased by 5% over the year. However, there is considerable variation in the percentage change of livestock holdings over the year (−35% to +32%)

[20] $n=16$ due to the exclusion of the lion killer, and the exclusion of the household that was too vague about its small stock dynamics to collect reliable data.

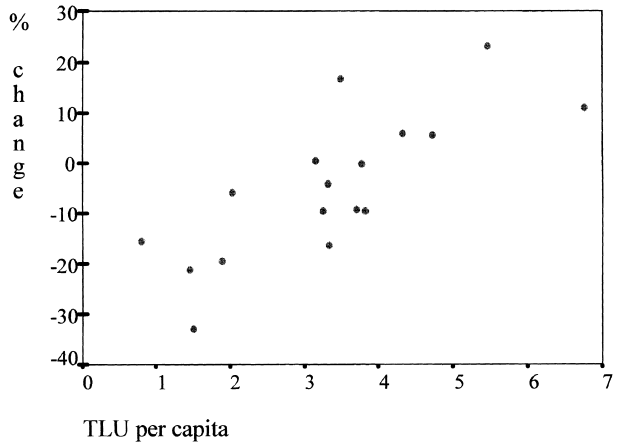


Fig. 11. The relationship between the number of livestock units (TLU) per capita in 17 households in Udachoteg, and percentage change in TLU between April 1992 and March 1993.

and 60% of households became poorer. Consequently it is important to examine the causes of this variation. Fig. 11 clearly shows a positive relationship between wealth and herd dynamics (Spearman's rank = 0.748, $p = 0.001$, $n = 17$, 2-tailed).

In fact, Fig. 11 suggests that there might be three groups. The first group consists of relatively wealthy households, with more than 4 TLUs per capita, whose herds increased in size during the year. The second group is made of middling households, with between 2.5 and 4 TLUs per capita, which appear to either maintain their livestock herds, or only show a small loss. The third group consisting of poor households, with less than 2.5 TLUs per capita, all show a substantial decline in their livestock holdings suggesting that these households are no longer economically viable within the pastoralist sphere. In fact, four of the five households in the very poor group (< 2.5 cattle per capita) have diversified their subsistence strategies. One collects sap from a certain species of tree and sells it at the market as medicine for chiggers. In another household the elder sons not only collect honey to sell, but they built six hives whose honey they harvest. A third household is that of the witch doctor. He holds dances, and often gets paid in maize for his services. The fourth householder farms a substantial area and invested in a donkey drawn plough so that he can increase the area that he farms.

During the study period two households did drop out of the pastoral system. One went directly to Mangola where they had land and concentrated on farming and the other, after trying to supplement their diet with hunting, also went to Mangola. Both these households were extremely poor, suggesting that below a certain threshold individuals can no longer depend only on livestock for their subsistence. If such households cannot supplement their resources then they drop out of the pastoral sector.

7. Summary

The Datoga are poor compared to other pastoralists, and they are struggling to survive as subsistence pastoralists. This strain is reflected in the dynamics of their herds. During the study cattle herds became significantly smaller due to a combination of demographic processes. The mortality rate of both calves and sub-adult and adult cattle are comparable to other East African groups, however the reproduction rate is low, and the commercial offtake rate is extremely high. The negative growth of Datoga cattle herds is therefore a result of both a low reproduction rate and a high commercial offtake rate, rather than because of a high mortality.

It is important to assess how families of different wealth are adapting to the environment, as

pastoralist societies are not homogeneous communities and some families are more at risk than others. There is no relationship between the reproduction rate of cattle and wealth but there is a significant negative relationship between wealth and calf mortality. This is because wealthier households do not milk herds as hard and so more milk is left for calves. There is also a negative relationship between adult and sub-adult cattle mortality and cattle owned per capita. In other words the more cattle per capita in a household the lower the mortality rates are. This is because wealthy households can afford to buy more veterinary products than poor ones. There is a significant negative relationship between commercial offtake of cattle and both the total number of cattle owned by the household and the per capita cattle holdings. In other words wealthy households do not sell as many cattle as poorer ones, partly because wealthy households gain a higher price for each animal sold, and partly because although wealthy households do have more income than poor ones, they do not need proportionally more income.

Unlike cattle, the numbers of small stock did not decline during the study but rather they increased. The reproduction rate of small stock is high compared to other pastoralist groups, and the mortality rate is relatively low. The offtake rate due to slaughter and sales combined is high. Given the extremely high rate of commercial offtake for cattle, it is not surprising that the offtake rate is so high in small stock.

When these demographic indices are correlated with wealth, there is no relationship between either small stock reproduction or mortality and any measure of wealth. There is however, a strong negative correlation between the commercial offtake rate of small stock and both TLU per household and small stock per household. There is a weaker, but still significant negative correlation between the commercial offtake rate and TLU per capita and small stock per capita. From this it can be concluded that poorer households not only have a higher commercial offtake of cattle, but that they also have to sell a higher proportion of their small stock animals than wealthier households.

The overall percent change in small stock herd size is positively correlated with the number of small stock per household, however this result is only just statistically significant, and none of the other measures of wealth are correlated with the percent change in small stock. This is in sharp contrast to the highly significant relationship between the percent change in cattle herds and wealth per capita.

In conclusion, the relationships between small stock dynamics and wealth are not as obvious as the relationships between cattle dynamics and wealth. It may be that as small stock make up only a small proportion of the Datoga's total livestock holdings they are less concerned about manipulating their small stock herds. Alternatively, it might be that the data collected on small stock are less accurate than data collected on cattle as they are less culturally important.

In terms of the overall change in livestock holdings the net gain in small stock does not compensate for the net loss in cattle. However, there is substantial variation between households. Poor households become poorer and are unlikely to remain viable as pastoralists. Households of medium wealth retain their livestock holdings or show only a small loss, indicating that these households manage to cope in an average year, but would probably be pushed into a vicious cycle of impoverishment during a bad year, and rich households get wealthier. As the sample size is small it is hard to determine an exact level of wealth, above which Datoga households can remain as viable pastoral units, however, these data provide evidence for the hypothesis that differences between households, in terms of wealth, become exacerbated over time rather than evened out, particularly in such marginal conditions.

Acknowledgements

First and foremost I would like to thank the families of Udachoteg. They welcomed me to their homes, fed me, and spent endless hours answering my questions with patience and good humour. I would also like to thank Momoya Bashgei Merus, Bryan "Mort" Priestley, Jeanette Hanby, David

Bygott, Mama Ramadani and Daniel Sellen for help during fieldwork. Without their support, advice and friendship this project would not have been possible. Monique Borgerhoff Mulder introduced me to the Datoga, and to field work methods, and supervised this project from its inception to its conclusion. It has benefited greatly from her input. During analysis I had many fruitful discussions with Professor Ainsworth Harrison, Gerry Brush, Katherine Homewood, Charles Lane, Heidi Marriot, Danielle Flynn, Mary Ryan and Kirsten Johnson. The Tanzanian Commission on Science and Technology kindly gave me permission to carry out the research, and I am grateful to Mr. Nguli and the late Mrs. Ligunda for their help, and to Professor C. Kamazura for his support. Funding for the research was provided by the Leakey Foundation, the Wenner-Gren Foundation and the Boise Fund.

References

Bekure, S., de Leeuw, P.N., 1991. The potential for improving the livestock production and welfare of the pastoral Maasai. In: S. Bekure, P.N. de Leeuw, B.E. Grandin, P.J.H. Neate (Eds.), Maasai herding: An analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp. 141–154.

Bekure, S., Grandin, S., 1991. Introduction. In: S. Bekure, P.N. de Leeuw, B.E. Grandin, P.J.H. Neate (Eds.), Maasai herding: An analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp. 1–5.

Borgerhoff Mulder, M., 1991. Datoga pastoralists of Tanzania. National Geographic Research and Exploration 7(2), 166–187.

Borgerhoff Mulder, M., 1992. Demography of pastoralists: preliminary data on the Datoga of Tanzania. Human Ecology 20(4), 383–405.

Cossins, N.J., Upton, M., 1987. The Boran pastoral system of Southern Ethiopia. Agricultural Systems 25, 199–218.

Cossins, N.J., Upton, M., 1988. The impact of climatic variation of the Borana pastoral system. Agricultural Systems 27, 117–278.

Dahl, G., Hjort, A., 1976. Having herds: Pastoral growth and household economy. Department of Social Anthropology, University of Stockholm.

de Leeuw, P.N., Semenye, P.P., Peacock, C.P., Grandin, B.E. 1991. Productivity of cattle and small stock. In: S. Bekure, P.N. de Leeuw, B.E. Grandin, P.J.H. Neate (Eds.), Maasai herding: An analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp. 83–101.

Dyson-Hudson, R., Dyson-Hudson, N., 1970. The food production system of a semi-nomadic society: The Karimojong, Uganda. In: P.F.M. McLoughlin (Ed.), African food production systems. The Johns Hopkins Press, Baltimore, pp. 92–123.

Fosebrooke, H., 1948. An administrative survey of the Maasai social system. Tanganyika Notes and Records 26, 1–51.

Fratkin, E., Roth, E.A., 1990. Drought and economic differentiation among the Ariaal pastoralists of Kenya. Human Ecology 18(4), 385–402.

Grandin, B.E. 1988. Wealth and pastoral diary production: A case study from Maasailand. Human Ecology 16(1), 1–21.

Hawkes, K., O'Connell, J.F., Blurton Jones, N.G., 1989. Hardworking Hadza grandmothers. In: V. Standen, R.A. Foley (Ed.), Comparative Socioecology; The behavioural ecology of humans and other mammals. Blackwell Scientific Publications, Oxford, pp. 341–366.

Herren, U.J., 1990. Socioeconomic stratification and small stock production in Mukogodo Division, Kenya. Research in Economic Anthropology 12, 111–148.

Homewood, K., 1992. Development and the ecology of Maasai food and nutrition. Ecology of food and nutrition 29(1), 61–81.

Homewood, K., Hurst, A., 1986. Comparative ecology of pastoral livestock in Baringo, Kenya. Pastoral Development Network 21(b), 1–41.

Homewood, K., Lewis, J., 1987. Impact of drought on pastoral livestock in Baringo, Kenya. Journal of Applied Ecology 24, 615–632.

Homewood, K.M., Rodgers, W.A. 1991. Masaailand ecology: Pastoralist development and wildlife conservation in Ngorongoro, Tanzania. Cambridge University Press, Cambridge.

IIED, 1994. Whose Eden? An overview of community approaches to wildlife management. Report to the Overseas Development Administration of the British Government..

Jacobs, A.H., 1965. The traditional political organisation of the pastoral Maasai. Ph.D., Nuffield College.

Kjaerby, K., 1979. The development of agro-pastoralism among the Barabaig in Hanang District. University of Dar es Salaam, Tanzania.

Kjaerby, F., 1980. The problem of livestock development and villagization among the Barabaig in Hanang District. BRALUP Research report No. 40 (New Series), University of Dare es Salaam.

Klima, G., 1970. The Barabaig: East African cattle herders. Holt, Rinehart and Winston, New York.

Lane, C., 1991. Alienation of Barabaig pasture land: Policy implications for pastoral development in Tanzania. Ph.D., IDS, University of Sussex.

Little, P.D., 1985. Social differentiation and pastoralist sedentarization in Northern Kenya. Africa 1985, 243–261.

McCabe, J.T., 1985. Livestock management among the Turkana: A social and ecological analysis of herding in an East African pastoral population. Ph.D. Thesis, State University of New York at Binghampton.

McCabe, J.T., Perkin, S., Schofield, C., 1992. Can conservation and development be coupled among pastoral people? An examination of the Maasai of Ngorongoro Conservation Area, Tanzania. Human Organisation 51(4), 353–366.

Ndagala, D.K., 1991. The unmaking of the Datoga: Decreasing resources and increasing conflict in rural Tanzania. Nomadic Peoples 28, 71–82.

Nestel, P., 1986. A society in transition: Developmental and seasonal influences on the nutrition of Maasai women and children. Food and Nutrition Bulletin 8, 2–14.

Perrier, G., 1994. New directions in range management planning in Africa. In: I. Scoones (Ed.), Living with uncertainty: New directions in pastoral development in Africa. Intermediate Technology Publications, London, pp. 47–57.

Pratt, D.J., Gwynne, M.D., 1977. Rangeland management and ecology in East Africa. Hodder and Stoughton, London.

Raikes, P.L., 1981. Livestock development and policy in East Africa. Scandinavian Institute of African Studies, Uppsala.

Sandford, S., 1994. Improving the efficiency of opportunism: new directions for pastoral development. In: I. Scoones (Ed.), Living with uncertainty: New directions in pastoral development in Africa. Intermediate Technology Publications, London, pp. 174–182.

Scoones, I., 1992. Coping with drought: Responses of herders and livestock in contrasting savanna environments in southern Zimbabwe. Human Ecology 20(3), 293–314.

Scoones, I., 1994. New directions in pastoral development in Africa. In: I. Scoones (Ed.), Living with uncertainty: New directions in pastoral development in Africa. Intermediate Technology Publications, London, pp. 1–36.

Sellen, D., 1995. The Socio-ecology of child growth among Datoga pastoralists. Ph.D., University of California at Davis.

Sieff, D.F., 1995. The effects of resource availability on the subsistence strategies of Datoga pastoralists of north west Tanzania. Ph.D. Thesis, Institute of Biological Anthropology, University of Oxford.

Sieff, D.F., 1997. The herding strategies of the Datoga pastoralists of Tanzania; Is household labour a limiting factor? Human Ecology 25(4), 519–544.

Sperling, L., 1987. Wage employment among Samburu pastoralists of North-central Kenya. Research in Economic Anthropology 9, 167–190.

Sperling, L., Galaty, J.G., 1990. Cattle, culture and economy: Dynamics in East African pastoralism. In: J.G. Galaty, D.L. Johnston (Eds.), The world of pastoralism: Herding systems in comparative perspective. Belhaven Press, London, pp. 69–98.

Swift, J. ed., 1984. Pastoral development in central Niger: Report of the Niger Range and Livestock Project. Republique du Niger, Ministere du Development Rural, Service de l'Elevage, and United States Agency for International Development, IDS, Brighton, UK.

Tomikawa, M., 1970. The distribution and migrations of the Datoga tribe – The sociological distinction of the Datoga society in the Mangola area. Kyoto University African Studies 5, 1–46.

Tomikawa, M., 1979. The migrations and inter-tribal relations of the pastoral Datoga. Senri Ethnological Studies 5, 1–46.

Tomikawa, M., 1972. Cattle brands of the Datoga – Human relations in the Datoga pastoral society in East Africa. Kyoto University African Studies 7, 1–35.

Toulmin, C., 1994. Tracking through drought: options for destocking and restocking. In: I. Scoones (Ed.), Living with uncertainty: New directions in pastoral development in Africa. Intermediate Technology Publications, London, pp. 95–115.