doi:10.1111/disa.12060

Livestock mortality in pastoralist herds in Ethiopia and implications for drought response

Andy Catley, Berhanu Admassu, Gezu Bekele, and Dawit Abebe[1]

Participatory epidemiology methods were employed retrospectively in three pastoralist regions of Ethiopia to estimate the specific causes of excess livestock mortality during drought. The results showed that starvation/dehydration accounted for between 61.5 and 100 per cent of excess livestock mortality during drought, whereas disease-related mortality accounted for between 0 and 28.1 per cent of excess mortality. Field observations indicate that, in livestock, disease risks and mortality increase in the immediate post-drought period, during rain. The design of livelihoods-based drought response programmes should include protection of core livestock assets, and it should take account of the specific causes of excess livestock mortality during drought and immediately afterwards. This study shows that, when comparing livestock feed supplementation and veterinary support, relatively more aid should be directed at the former if the objective is to protect core livestock during drought. Veterinary support should consider disease-related mortality in the immediate post-drought period, and tailor inputs accordingly.

Keywords: drought, Ethiopia, excess mortality, livelihoods-based programming, livestock mortality

Introduction

The concept of targeted protection of assets

Humanitarian aid donors, coordinating bodies, and implementing agencies have been responding to drought in pastoralist areas of Africa for many years. Although food aid has dominated typical responses, there has been renewed interest in non-food responses and, in particular, the concept of livelihoods-based programming and the protection of core assets, services, and markets. For example, the *Livestock Emergency Guidelines and Standards* (LEGS, 2009) frames livestock interventions around human livelihood objectives. With regard to asset protection, pastoralists prioritise certain types of livestock in times of drought, and they tend to invest most in protecting productive adult female stock, rather than trying to keep all animals alive at all costs (LEGS, 2009). This is a logical strategy and one that aims to maximise herd growth post drought. The *Livestock Emergency Guidelines and Standards* thus recommends working with pastoralists to target inputs for livestock protection based on existing local strategies.

While some donors or programme coordinators might understand the broad concept of targeted pastoralist livestock protection, two main types of livestock interventions are available to prevent livestock losses: veterinary care; and livestock feeding

Published by John Wiley & Sons Ltd, 9600 Garsington Road, Oxford, OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

support—with the latter including water provision where necessary. The question arises, therefore, as to the most appropriate combination of these two broad inputs to use if the overall goal is to reduce mortality in a targeted subset of a livestock population. For fund managers with a finite budget, the balance of support for these options should depend, at least in part, on the level of mortality caused by livestock diseases during drought compared with mortality owing to starvation/dehydration. For decision-making, information is needed not only on the total mortality in different livestock species during drought, but also on the relative causes of mortality.

Measuring pastoralist livestock mortality

For many years the veterinary literature has included discussion of the particular challenges of measuring livestock mortality in pastoralist areas of Africa (see, for example, de Leeuw, McDermott, and Lebbie, 1995). Among the reported constraints, even during normal, non-drought periods, is an apparent reluctance by herders to provide accurate information on herd size to outsiders. The older veterinary literature explains this behaviour by reference to cultural beliefs that statements about herd size bring bad luck, or that local authorities may use information on herd size to collect taxes (Perry and McCauley, 1984). In addition, as livestock holdings are the main financial asset of pastoralists, herd size is a private and sensitive matter, and comparable to details of a bank balance in other societies and contexts. A further issue concerns the concept of ownership in pastoralist societies where livestock form the basis for complex social arrangements based on gifts or loans to relatives or friends. When combined with the physical remoteness of pastoralist areas and the mobility of herds, these factors explain in part why the baseline livestock population in these areas often is questionable. In turn, mortality estimates that use an invalid denominator are also questionable.

Alternative, but now well-established, approaches to measuring pastoralist livestock mortality are based on participatory epidemiology and, in particular, methods that avoid the absolute measurement of herd size (Catley, Alders, and Wood, 2012). For instance, proportional piling is a method via which informants visualise and compare different causes of mortality without stating the number of animals owned. Results are recorded numerically, and standardisation and repetition of the method allows for some quantification and statistical analysis. When looking specifically at mortality caused by different diseases, the method uses the strong ability of pastoralists to diagnose important livestock diseases based on clinical information. This ability has been verified by more conventional diagnostic and epidemiological measures, such as clinical and pathological examinations by veterinarians, and estimation of positive predictive values of herder diagnoses for specific diseases (Catley, Alders, and Wood, 2012).

During the early stages of drought in pastoralist areas, governmental and non-governmental agencies commonly conduct drought assessments. The assessment reports frequently present statements on livestock mortality as one way of expressing the severity of drought and the need for intervention. Similarly, early warning system reports from pastoralist areas at the onset of drought often refer to livestock mortality. Such reports may express livestock mortality as a proportion, such as 20 per cent mortality, but they tend not to relate these figures to specific time periods or to baseline livestock mortality in normal periods. Other early warning or drought assessment reports avoid mortality figures and, instead, use narrative descriptions of mortality such as 'critical' or 'high', or they describe livestock body condition as 'bad' or 'poor'. Among humanitarian agencies there is no common understanding of these terms. For example, a non-livestock professional might describe cattle as emaciated, whereas a livestock scientist might describe the same animals as demonstrating normal dry season weight loss. Whether reports use numbers or narrative to depict livestock mortality, the assessment methods employed usually are qualitative, and although specific causes of livestock deaths sometimes are stated, these causes are rarely quantified or compared. A further omission from many early warning or drought assessment reports is a description of livestock mortality by species, or recognition that resistance to drought varies by species.

From an epidemiological perspective, the accurate measurement of livestock mortality in pastoralist areas during drought is especially problematic. Some key potential problems include: limited or unreliable baseline data on livestock populations by species; the possibility that local informants exaggerate mortality to attract aid assistance; and the drought-related movement of livestock to areas where animals cannot be observed or counted easily. For a given location, livestock move into the area, out of the area, or both at the same time depending on conditions in the wider grazing area. This makes it difficult to define the ethnic or geographical boundaries of populations, especially in cross-border areas. Therefore, although a rapid drought assessment might report 50 per cent livestock mortality in a given area, the same report might overlook the movement of 80 per cent of livestock out of the area before the assessment. Assuming these relocated animals find reasonably good grazing and water and do not experience major disease outbreaks, mortality in this group will be similar to normal periods. It follows that, in the overall population in this example, excess livestock mortality is 10 per cent and not 50 per cent, with very different practical and political implications. In addition to this spatial element of a pastoralist livestock mortality assessment is that, in the absence of baseline mortality figures, the concept of excess livestock mortality during drought becomes more difficult to apply. Other challenges are the need for a rapid assessment and the limited value of conventional data collection methods, such as questionnaires, in pastoralist areas (Catley, 1999).

Combined interventions and decision-making

Despite the limitations of early warning systems and drought assessment methods for measuring livestock mortality, donors and programme managers have been making decisions on emergency livestock programmes for drought response for many years. Although we did not conduct an extensive review of these programmes vis-à-vis resource allocation, there were indications that, in relative terms, much of the funding for livestock support was directed towards preventive veterinary care. For example, in drought programmes in Kenya between 2004 and 2006, expenditure on veterinary inputs was 4.5 times that for livestock feed supplementation (Anonymous, 2008).

In the absence of any quantitative information on the relative causes of livestock mortality during drought, an emphasis on one type of livestock input over another seems difficult to justify in terms of preventing mortality. In the case of veterinary vaccination programmes, there is also concern that, when implemented during drought, they can have a very limited impact on livestock mortality, and that, to be effective, they need to implemented in non-drought periods (Catley et al., 2009). For drought response programmes that have included the curative or preventive use of veterinary medicines such as anthelmintics, credible information on impact seems to be very limited; no peer-reviewed papers are available. Alternative but limited information is available from pastoralists on how they chose to protect livestock during drought. For instance, when provided with cash income through the sale of livestock during commercial destocking in Ethiopia, pastoral households spent 30.5 per cent of this revenue on livestock feed and on transport to distant grazing areas, but only 6 per cent of it on veterinary care (Abebe et al., 2008). This expenditure may have related to the availability and the cost of the different services, yet it indicates a very different pattern of expenditure to that seen in many large-scale drought programmes, which focus on veterinary inputs. Furthermore, in the absence of aid programmes, some pastoralists will use supplementary livestock feed during drought, especially for key breeding stock, and feed is acquired through various means (Morton, 2006).

With these issues and experiences in mind, a study was conducted in pastoralist areas of Ethiopia in 2012 that sought to quantify livestock mortality during drought by species, and to examine the relative causes of mortality during drought relative to normal years.

Methodology

The study was based on a comparison of the reasons for livestock leaving herds in 'normal years' and 'drought years'. It involved a re-analysis of field data that was originally collected in 2007 and 2008 for an evaluation of the impact of livestock vaccination on mortality during drought in Ethiopia (Catley et al., 2009). Using a participatory method called proportional piling, informants were asked to explain the reasons why livestock left herds, including gifts and sales, and then to show the relative importance of these reasons. The method was repeated for different livestock species, and for normal and drought years, as defined by informants; the method was repeated in three regions of Ethiopia: Afar; Oromiya; and Somali region. The specific locations were Amibara and Dalifagae districts in Afar, Dire district in Borana, and Filtu district in Somali region.

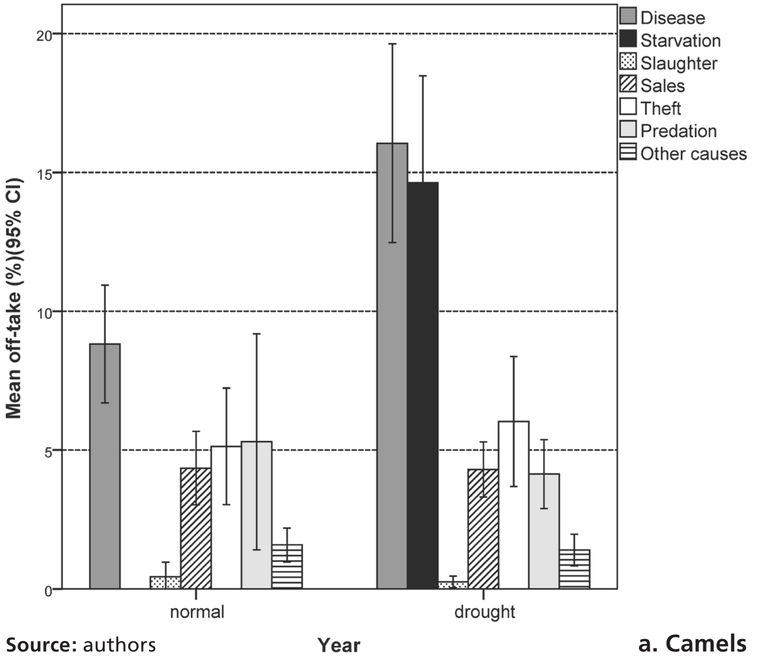
The normal years and drought years identified by pastoralists and used during proportional piling were: Afar—normal year 2002–03, drought year 2001–02; Borana—

normal year 2002–03, drought year 2005–06; and Somali region—normal year 2004–05, drought year 2005–06. There were 60 informants (herds) in Afar, 60 informants (herds) in Borana, and 75 informants (herds) in Somali region. Data were summarised using the Statistical Package for the Social Sciences (SPSS) Version 13. The frequency distribution of the data was tested in SPSS using plots of cumulative expected proportion versus cumulative observed proportion, and a comparison was made with a Normal distribution plot. Where data were judged to be normally distributed, data were summarised using the mean, and normal and drought years were compared using the means and 95 per cent confidence intervals.

Results

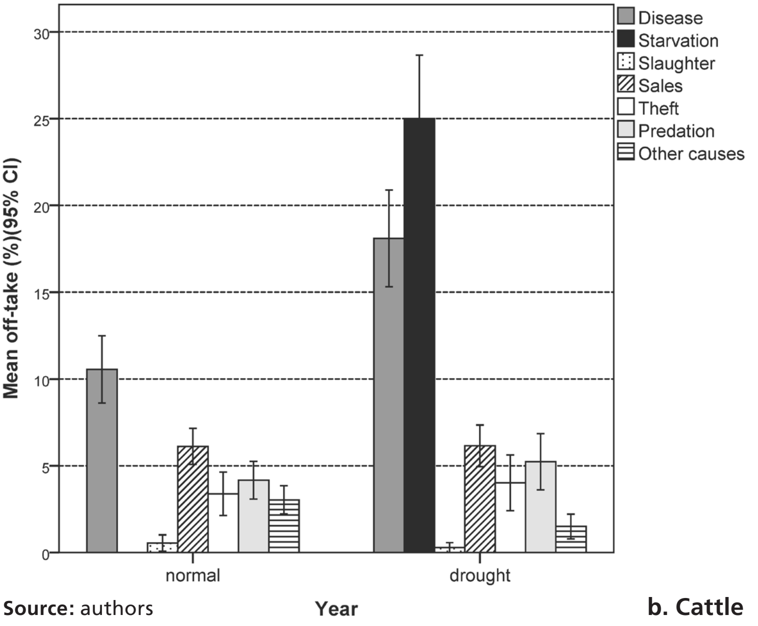
For the purpose of the study we categorised the different types of off-take and losses from pastoralist herds as follows: death due to starvation/thirst; death due to disease; death due to predation (such as by hyenas or jackals); livestock sales; thefts; livestock slaughtered; and other causes (such as gifts of livestock to relatives). These reasons for livestock off-take and losses in normal and drought years are shown in Figures 1–3, by livestock type.

Figure 1. Off-take and losses from Afar pastoralist herds (n=60) in a normal year and drought year



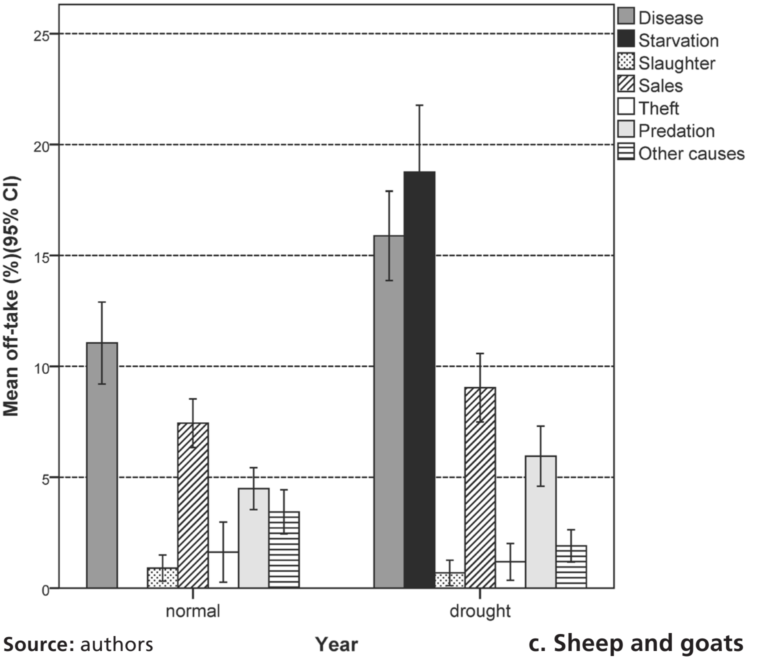
Source: authors

a. Camels



Source: authors

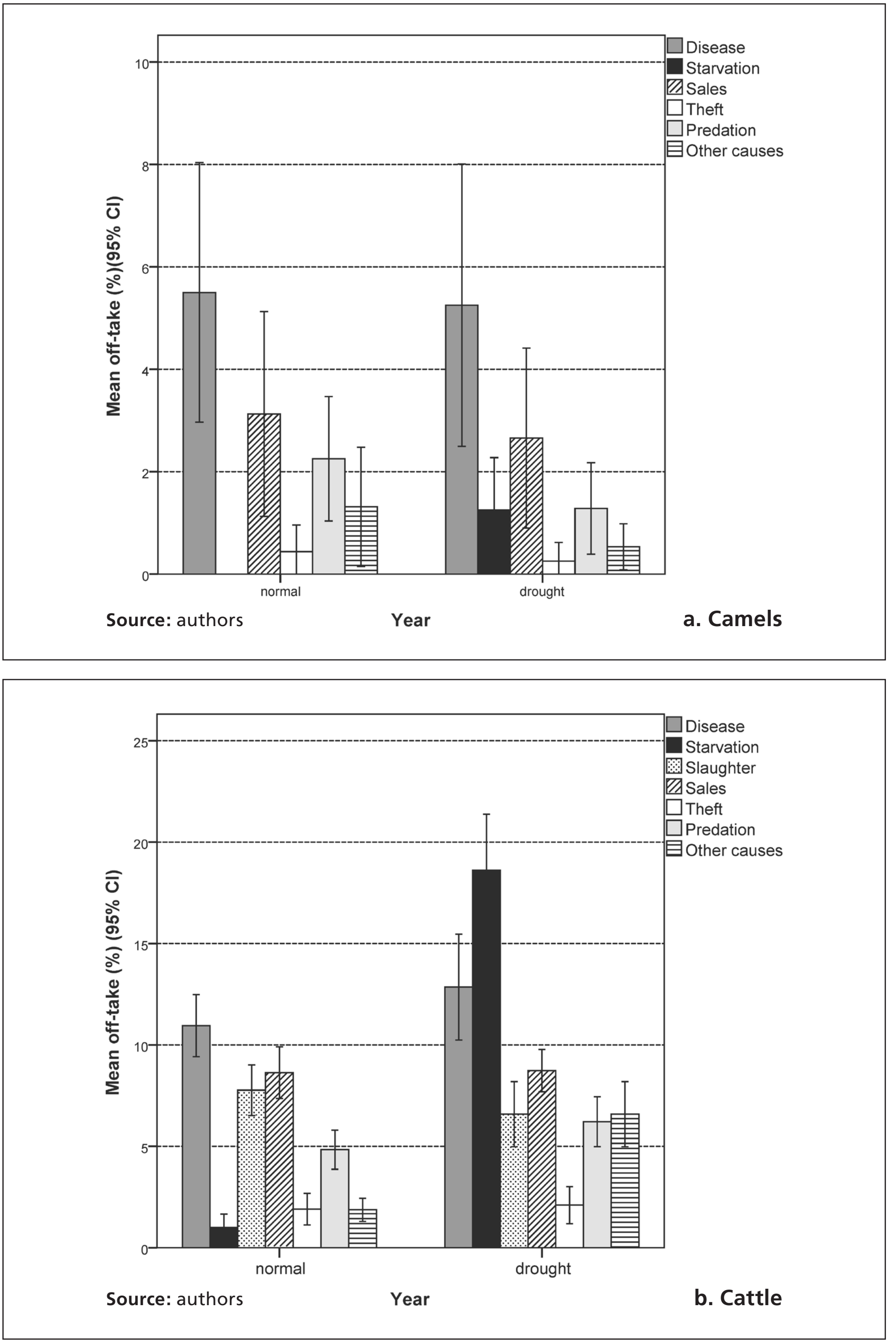
b. Cattle

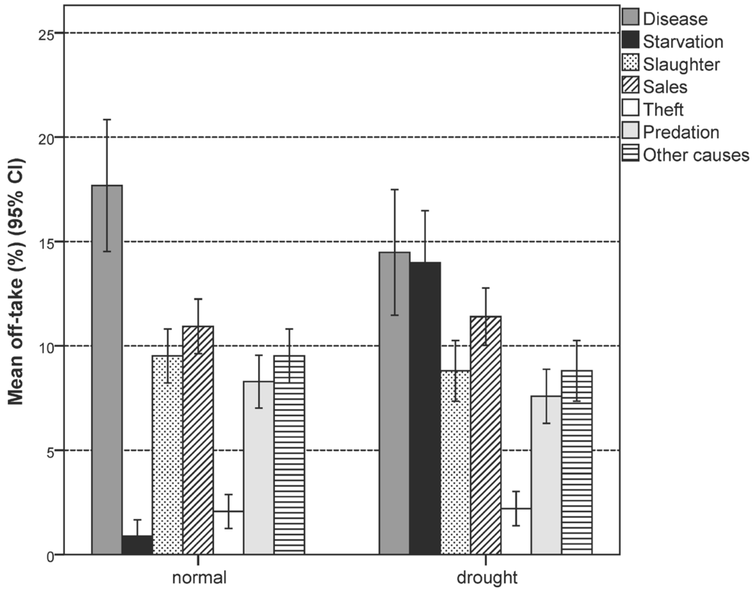


Source: authors

c. Sheep and goats

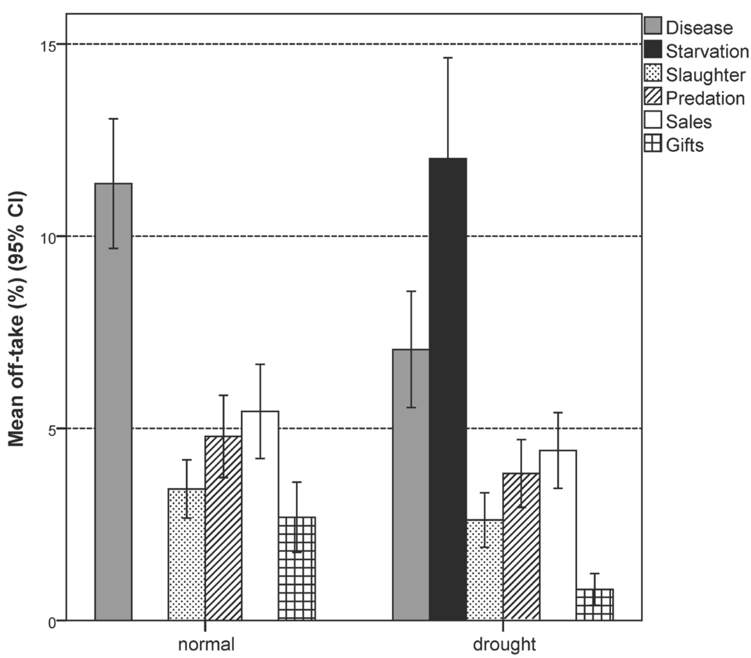
Figure 2. Off-take and losses from Borana pastoralist herds (n=60) in a normal year and drought year



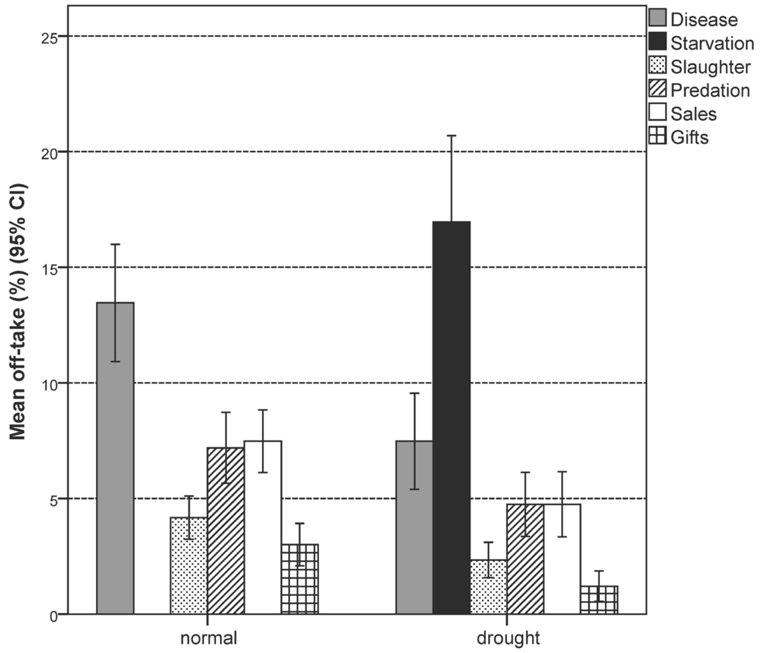


Source: authors **Year** **c. Sheep and goats**

Figure 3. Off-take and losses from Somali herds (n=75) in a normal year and drought year

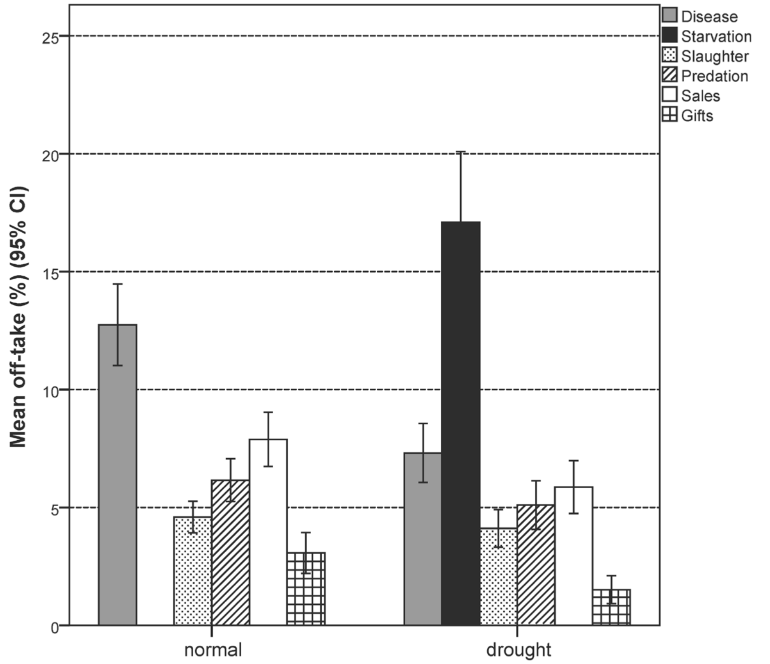


Source: authors **Year** **a. Camels**



Source: authors

b. Cattle



Source: authors

c. Sheep and goats

When viewing Figures 1–3, it is important to note that the aim of the study was not to compare livestock losses and off-take across the three geographically areas, but rather to compare normal and drought years within each area. This approach recognised that, in each area, informants identified different drought years, and the severity of drought varied by year and area.

Livestock losses and sales in normal years

In general, in normal years, the main reasons for livestock leaving herds were losses due to disease, and livestock sales, with disease-related losses exceeding sales. Across the three study areas, disease losses were highest in sheep and goats in Borana (17.7 per cent; see Figure 2c) in a normal year, and lowest in camels in Borana (5.5 per cent; see Figure 2a). Predation, slaughter, and thefts were also important reasons for livestock leaving herds, with variations by area. In normal years, starvation/dehydration was not a cause of losses in Afar or Somali region (see Figures 1–3), and starvation/dehydration accounted for less than one per cent of losses in Borana herds (see Figure 2).

Disease mortality in normal and drought years

Disease mortality increased, decreased, or remained constant in drought years versus normal years, depending on area and livestock species. In Afar, there were increases in disease-related mortality in drought years, and these increases were significant in all four species (see Figure 1). In Borana, disease mortality in camels was similar in normal and drought years (see Figure 2a), but slightly higher in cattle in drought years (see Figure 2b) and slightly lower in sheep and goats (see Figure 2c). None of the disease mortality trends in normal and drought years were statistically significant in Borana. In Somali region, there was significantly lower disease mortality in camels, cattle, and sheep and goats in the drought year versus the normal year (see Figure 3).

Starvation mortality in normal and drought years

In all three areas and in all livestock species, there was a significant increase in livestock losses in drought years due to starvation, relative to normal years (see Figures 1–3). In Afar, starvation was the most important cause of losses in the drought year in cattle, sheep, and goats, and it caused significantly higher mortality than disease in these species (see Figures 1b and 1c). In camels in Afar, disease led to slightly higher losses than starvation in the drought year, but the difference between disease mortality and starvation was not significantly different (see Figure 1a). In Borana, disease mortality in camels in the drought year was significantly higher than starvation (see Figure 2a), whereas in cattle, starvation caused significantly higher losses than disease (see Figure 2b). In sheep and goats in Borana, losses in the drought year due to disease and starvation were similar (see Figure 2c). In Somali region, losses due to starvation in the drought year were significantly higher than losses due to disease, in all four species (see Figure 3).

Excess mortality

In Afar, excess mortality during drought was most evident in cattle (34.9 per cent; derived from Figure 1b) and lowest in camels (20.3 per cent; derived from Figure 1a). In Borana, excess mortality in drought-affected cattle was 20.1 per cent (derived from Figure 2b) and there was no excess mortality in Borana camels in the drought year in question (see Figure 2). In Somali region for the drought year in question, excess mortality was low and it was associated with fewer losses due to livestock diseases (see Figure 3).

Despite these variations by area and species, a common finding was that, when excess mortality was observed during a drought year, starvation/dehydration accounted for between 71.7 and 100 per cent of these losses (see Table 1). In contrast, disease-related excess mortality varied between 0 and 28.1 per cent.

Discussion

Disease as a cause of mortality in drought years: human and livestock diseases

During drought in pastoralist areas, high human mortality often is associated with disease outbreaks in malnourished populations, and outbreaks of disease, such as cholera and measles, are well known in these situations (de Waal, 1989; Taye, Haile Mariam,

Table 1. Starvation/dehydration and mean excess mortality (%) of pastoralist livestock in a drought year

Indicator and livestock species	Area (drought year)		
	Afar (2001)	Borana (2005–06)	Somali region (2005–06)
Excess mortality in drought year:			
Camels	20.3	0	3.0
Sheep and goats	23.3	8.4	6.5
Cattle	34.9	20.1	2.2
Proportion of excess mortality due to starvation/dehydration:			
Camels	71.9	0	100
Sheep and goats	79.3	100	100
Cattle	71.7	87.8	100
Proportion of excess mortality due to disease:			
Camels	28.1	0	0
Sheep and goats	20.7	0	0
Cattle	21.7	9.9	0

Note: excess mortality will vary by area or between drought years, as the severity of drought varies by area and year.

Source: authors.

and Murray, 2010). The main risk factors for measles outbreaks are overcrowding, poor nutrient intake, and weak vaccination programmes (Checchi et al., 2007), and all three of these factors are typical in drought situations in the Horn of Africa, when, for example, pastoralists move to towns to seek assistance. For cholera, poor sanitation and contaminated water are additional risk factors and, again, are seen in pastoralist areas during drought. It follows that humanitarian agencies already support disease prevention and treatment in human populations alongside other forms of immediate, life-saving assistance such as therapeutic feeding. Regarding livestock, drought results in debilitated animals and concentrations of animals around water points or diminishing grazing resources. Among the various livestock diseases affecting pastoralist livestock, botulism is linked with droughts and can result in high mortality (Bollig, 2006). Botulism is reported to affect pastoral livestock in Ethiopia, but vaccination against it is not conducted. Similarly, hungry livestock during drought are at risk of being poisoned by plants as they consume plants that normally would be avoided. Livestock feed supplementation may be an indirect way of reducing this risk.

Apart from the impacts of botulism and plant poisoning, there is limited evidence in the literature to show that disease-related mortality increases in livestock in drought relative to the long dry season(s) in normal years. Figures 1–3 paint a mixed picture in terms of total disease impacts: for instance, relatively high impacts in Afar region in the drought year relative to the normal year (see Figure 1), but an opposite trend in Somali region (see Figure 3). With regard to excess mortality during drought, the results demonstrate that the maximum net effect of disease on livestock mortality during drought relative to a normal year was only seven per cent, pertaining to cattle and camels in Afar (see Figure 1). However, in Somali region, disease-related mortality declined during the drought year by up to six per cent (see Figure 3).

Using published literature, it is possible to analyse possible livestock disease impacts during drought on a disease-by-disease basis, but, owing to the wide range of diseases affecting livestock, and species variation in disease occurrence, such an evaluation is beyond the scope of this paper. To illustrate the complexity of understanding these impacts, though, in a normal year, diseases such as foot-and-mouth disease show a marked seasonal pattern in pastoralist areas, with incidence peaking in the dry season (Rufael et al., 2008). Yet, there appears to be no published literature indicating that the impact of this disease increases during drought relative to a normal dry season. Other important livestock health problems are most evident during wet conditions, including various internal and external parasitic diseases. Hence, the incidence of some diseases decreases during dry periods.

For humanitarian generalists who may view livestock disease impacts as comparable to human disease impacts, a further consideration is that, compared to outbreaks of measles in children, which can cause high mortality in pastoralist areas during drought (see, for example, Salama et al., 2001), in livestock there seem to be few diseases that are now comparable in terms of excess mortality during droughts. Of the various important livestock diseases, rinderpest used to cause high mortality in cattle, but it has been eradicated globally. It could be argued that other diseases, such as goat plague (also called Peste des petits ruminants), sheep and goat pox, Nairobi sheep disease, and contagious caprine pleuropneumonia (CCPP), are still present in Africa, and that outbreaks can lead to high mortality in small ruminants in pastoralist areas. However, although these diseases certainly affect pastoralist livelihoods, they seem not to be strongly associated with drought. For instance, goat plague is associated with market-based movements or the migration of goats (Baron, Parida, and Oura, 2011), but such movements may occur in pastoralist areas during both normal and drought periods—some researchers suggest that the specific risk factors in pastoralist areas are not well understood (Kihu et al., 2010). Similarly, studies in pastoralist areas of Ethiopia indicate that drought is not a risk factor for the spread of CCPP (Regassa, Netsere, and Tsertse, 2010; Bekele et al., 2011), whereas in pastoralist areas of Tanzania, goat movements in general and wet periods were important risk factors (Swai and Nesele, 2010). The main risk factor for Nairobi sheep disease is exposure of naïve animals to the tick vector *Rhipicephalus pulchellus* and the populations of this tick species increase during wetter months, not during drought (Pegram, 1976; Pegram, Hoogstraal, and Wassef, 1981).

Some drought-specific mortality figures are available from pastoralist areas of Ethiopia (Catley et al., 2009). For example, the highest disease-related mortalities in cattle were caused by contagious bovine pleuropneumonia and anthrax, but mortality in drought years was only 3.8 and 2.5 per cent, respectively (Catley et al., 2009). In sheep and goats in the same areas, the highest disease-related mortality in drought years was caused by CCPP, but at only a modest level of 4.4 per cent. Looking specifically at water-borne diseases, livestock congregate around water sources during drought and these sources may become increasingly contaminated. However, there is no clear livestock equivalent of cholera in people, in terms of mortality. As a general rule, after weaning, the types of livestock kept by pastoralists are not very susceptible to water- or food-borne bacterial diseases, relative to people. Overall, for non-livestock specialists, it may seem logical to associate drought with increased livestock disease. Yet, the situation is far more complex owing to variations in the epidemiology of different livestock diseases in pastoralist areas—some diseases are far more prevalent in wetter conditions, not during drought.

Although we did not estimate livestock disease impacts in the immediate post-drought period, our field experience indicates that mortality due to disease can increase substantially during the first few weeks of rain after drought. Further research is needed to understand better the specific diseases that occur at this time, although it seems feasible that parasitic and vector-borne disease prevalence and mortality will rise during or following heavy rainfall. If so, veterinary care as 'drought response' might focus less on preventing or treating diseases during drought, and more on disease prevention in the post-drought period.

At the institutional level it has been suggested that livestock development and veterinary programmes have been adversely affected by a decline in donor funding (Roeder, 2012). If so, government veterinarians and those working for agencies such as the Food and Agriculture Organization of the United Nations may try to access funding for livestock disease control from humanitarian sources during droughts. While this indicates a professional commitment to try to reduce animal disease impacts using whatever funding may be available, our study supports the wider use of feed supplementation and water provision as a drought response to protect livestock, as well as more strategic veterinary care in the immediate post-drought period. The only study available on the effect of veterinary vaccination on mortality during drought shows no impact (Catley et al., 2009), and there seems to be no peer-reviewed evaluations available on other types of drought-related veterinary inputs in pastoralist areas of Africa. Clearly, if international aid donors are seeking to protect or develop pastoralist livestock using veterinary programmes, the best approach is to support well-designed disease control or eradication programmes as a long-term development investment and not as ad hoc, short-term emergency programmes. The exception to this general recommendation is the case of some complex emergencies where back-to-back cycles of humanitarian funding for veterinary inputs have evolved into successful long-term programmes. A good example of this is the eradication of rinderpest in South Sudan during the 1990s (Leyland, 1996). The results in Figures 1–3 clearly show that mortality due to disease is the most important cause of preventable livestock losses in pastoralist areas during normal years.

Towards a balanced livelihoods and livestock approach

The results showing that most excess livestock mortality during drought in pastoralist areas of Ethiopia is due to starvation not disease (see Figures 1–3; Table 1) agree with other recent studies in pastoralist areas of Ethiopia and Kenya (McPeak, Little, and Doss, 2012). However, it is important to note also that livestock disease is still an important cause of mortality, and therefore the challenge for drought response is to achieve a reasonable balance of support for both livestock feed and veterinary inputs.

The *Livestock Emergency Guidelines and Standards* (LEGS, 2009) provides guidance on the design of livestock feed and water projects during drought, and there is a growing body of evidence to support supplementary feeding of selected types of livestock during drought. For instance, the provision of relatively basic livestock feeds, such as hay and wheat bran, to cattle in feed centres in pastoralist areas of Ethiopia, managed by local people, significantly reduced cattle mortality and had a benefit–cost ratio of up to 1.9:1 (Bekele and Abera, 2008). More recently, in 2011, the Milk Matters project in Ethiopia tested livestock interventions that were designed with pastoralists with the objective of enhancing animal milk supply to children during the end of the dry season, when most acute malnutrition in children is evident. Combined livestock feed inputs and basic preventive veterinary care resulted in dramatic increases in the supply of cow and goat milk to children, with related improvements in nutritional status relative to control groups (Sadler et al., 2012).

These experiences indicate that a more balanced livelihoods approach to drought would extend relatively greater support to supplementary livestock feeding than is currently the case, and that it would limit veterinary support to approaches such as veterinary voucher schemes rather than mass vaccination programmes, as recommended by the *Livestock Emergency Guidelines and Standards* (LEGS, 2009). Voucher schemes provide opportunities for livestock owners to select the kinds of treatment or prevention they want, from local service providers. Consequently, the approach allows flexibility and some household-level decision-making, while also supporting private sector para-veterinary workers (LEGS, 2009). As indicated above, further research is needed to understand disease-related mortality in the immediate post-drought period, but experience to date indicates that this is a higher risk period in terms of disease relative to drought itself.

Improving the measurement of livestock mortality

At present, measures of livestock mortality in many drought assessment or early warning reports from pastoralist areas of the Horn of Africa are of limited value. Concerns about the validity of the mortality estimates can lead to debate among humanitarian actors rather than action, and can prompt inappropriate or delayed responses. In Ethiopia, the agencies that implement drought programmes are, in general, the same agencies that implement development programmes. Indeed, a long-term presence on the ground often is used to support a proposal for emergency funds. Despite this long-term presence, though, very limited baseline information is available on pastoralist livestock populations, overall mortality, or specific causes of mortality in 'normal' or 'drought' years. When applied systematically and supported by basic veterinary diagnostics, participatory epidemiological approaches provide relatively reliable and valid data on the specific causes of mortality by livestock species, age group, and season. These methods can also be used to map livestock movements and to quantify the proportions of herds or populations that move to different locations in normal years and drought years. The best time to collect this information with pastoralists is during non-drought years. An inherent aspect of participatory epidemiology is review of secondary data, including analysis of previous studies that present livestock mortality data.

With this kind of baseline information to hand, the measurement of livestock mortality during rapid drought assessments could become far more valid. Critically, drought assessments should include estimates of the proportion of livestock, by species, that have already migrated out of the assessment area. In cross-border areas, this points to the need for collaboration between governments, United Nations agencies, donors, and non-governmental organisations in neighbouring countries. Ultimately, better understanding of livestock mortality during normal and drought years could also support drought cycle management, by enabling each stage of the drought cycle to be defined more clearly using specific measures and triggers.

Conclusion

Although the measurement of livestock mortality during drought in pastoralist areas currently is weak, participatory epidemiology approaches and methods are available to improve the reliability and validity of mortality estimates. During drought, far more livestock deaths are due to starvation/dehydration than to disease, indicating that responses that aim to protect core livestock assets should focus more on supplementary feeding and water provision. Although disease outbreaks are a major cause of increased mortality in human populations during drought, the same levels of disease-related mortality are not evident in livestock populations. Field observations suggest that post-drought rains lead to increased disease-related livestock mortality, indicating a particular need for veterinary care at the end of drought. However, this approach needs further investigation using participatory epidemiology.

Acknowledgements

This study was funded by the United States Agency for International Development under a grant to Tufts University for the Pastoralist Livelihoods Initiative (PLI) Policy Project. The authors are grateful to Dr Bayou Abera, Dr Gezahegn Eshete, Dr Tesfaye Rufael, and Dr. Tesfaye Haile, all of whom assisted with the original collection of field data for the study.

Correspondence

Andy Catley, Feinstein International Center, Tufts University Africa Regional Office, P.O. Box 1078, Addis Ababa, Ethiopia. E-mail: andrew.catley@tufts.edu

Endnotes

1 Andy Catley is Research Director at the Feinstein International Center, Tufts University Africa Regional Office, Ethiopia; Berhanu Admassu is a Senior Researcher at the Feinstein International Center, Tufts University Africa Regional Office, Ethiopia; Gezu Bekele is an independent consultant based in Ethiopia; and Dawit Abebe is a Senior Researcher at the Feinstein International Center, Tufts University Africa Regional Office, Ethiopia.

References

Abebe, D. et al. (2008) 'Livelihoods impact and benefit–cost estimation of a commercial de-stocking relief intervention in Moyale district, southern Ethiopia'. *Disasters*. 32(2). pp. 167–189.

Anonymous (2008) *Functional Analysis of Drought Management Structures at the District Level – Study for the EC-funded DMI, Final Report*. European Commission, Nairobi.

Baron, M.D., S. Parida, and C.A.L. Oura (2011) 'Peste des petits ruminants: a suitable candidate for eradication' *Veterinary Record*. 169(1). pp. 16–21.

Bekele, G. and T. Abera (2008) *Livelihoods-based Drought Response in Ethiopia: Impact Assessment of Livestock Feed Supplementation*. Feinstein International Center, Tufts University, Addis Ababa.

Bekele, T., Y. Asfaw, B. Gebre-Egziabeher, and G. Abebe (2011) 'Seroprevalence of contagious caprine pleuropneumonia in Borana and Guji lowlands, southern Ethiopia'. *Ethiopian Veterinary Journal*. 15(2). pp. 69–76.

Bollig, M. (2006) *Risk Management in a Hazardous Environment: A Comparative Study of Two Pastoral Societies.* Springer Science+Business Media, New York, NY.

Catley, A. (1999) *Methods on the Move: A Review of Veterinary Uses of Participatory Approaches Methods Focussing on Dryland Africa.* International Institute for Environment and Development, London.

Catley, A. et al. (2009) 'Impact of drought-related livestock vaccination in pastoralist areas of Ethiopia'. *Disasters.* 33(4). pp. 665–685.

Catley, A., R.G. Alders, and J.L.N Wood (2012) 'Participatory epidemiology: approaches, methods, experiences'. *The Veterinary Journal.* 191(2). pp. 151–160.

Checchi, F., M. Gayer, R. Freeman Grais, and E.J. Mills (2007) *Public Health in Crisis-affected Populations: A Practical Guide for Decision-makers.* Humanitarian Practice Network Paper. 61. Overseas Development Institute, London.

de Leeuw, P.N., J.J. McDermott, and S.H.B. Lebbie (1995) 'Monitoring of livestock health and production in sub Saharan Africa'. *Preventive Veterinary Medicine.* 25(2). pp. 195–212.

de Waal, A. (1989) *Famine that Kills: Darfur, Sudan, 1984–1985.* Clarendon Press, Oxford.

Kihu, S.M., C.G. Gitau, L.C. Bebora, J.M. Njenga, and G.G. Wairire (2010) 'Risk factors and socio-economic effects associated with spread of peste des petits ruminants in Turkana district, Kenya'. Paper presented at the Second RUFORUM Biennial Meeting, Entebbe, Uganda, 20–24 September 2010.

LEGS (Livestock Emergency Guidelines and Standards) (2009) *Livestock Emergency Guidelines and Standards.* Practical Action Publishing, Rugby.

Leyland, T. (1996) 'The case for a community-based approach, with reference to southern Sudan'. In Food and Agriculture Organization of the United Nations (ed.) *The World without Rinderpest. FAO Animal Health and Production Paper.* 129. Food and Agriculture Organization of the United Nations, Rome. pp. 109–120.

McPeak, J., P.D. Little, and C.R. Doss (2012) *Risk and Social Change in an African Rural Economy: Livelihoods in Pastoralist Communities.* Routledge, London.

Morton, J. (2006) 'Pastoralist coping strategies and emergency livestock market intervention'. In J.G. McPeak and P.D. Little (eds.) *Pastoral Livestock Marketing in Eastern Africa.* ITDG Publishing, Rugby. pp. 227–246.

Pegram, R.G. (1976) 'Ticks (Acarina, Ixodoidea) of the northern regions of the Somali Democratic Republic'. *Bulletin of Entomological Research.* 66. pp. 345–363.

Pegram, R.G., H. Hoogstraal, and H. Wassef (1981) 'Ticks (Acari: Ixodoidea) of Ethiopia. I. Distribution, ecology and host relationships of species infesting livestock'. *Bulletin of Entomological Research.* 71. pp. 339–359.

Perry, B.D. and E.H. McCauley (1984) 'Owner interview surveys as the basis for estimating animal productivity and disease impact in developing countries'. Proceedings of the Society for Veterinary Epidemiology and Preventive Medicine, Edinburgh, United Kingdom, 10–11 July 1984. pp. 54–62.

Regassa, F., M. Netsere, and T. Tsertse (2010) 'Seroprevalence of contagious caprine pleuropneumonia in goats at selected woredas of Afar Region'. *Ethiopian Veterinary Journal.* 14(1). pp. 83–89.

Roeder, P. (2012) 'Making a global impact: challenges for the future' *Veterinary Record.* 169(26). pp. 671–674.

Rufael, T., A. Catley, A. Bogale, M. Sahle, and Y. Shiferaw (2008) 'Foot and mouth disease in the Borana pastoral system, southern Ethiopia and implications for livelihoods and international trade'. *Tropical Animal Health and Production.* 40(1). pp. 29–38.

Sadler, K. et al. (2012) *Milk Matters: The Impact of Dry Season Livestock Support on Milk Supply and Child Nutrition in Somali Region, Ethiopia.* Feinstein International Center, Tufts University, Medford, MA.

Salama, P. et al. (2001) 'Malnutrition, measles, mortality, and the humanitarian response during a famine in Ethiopia'. *Journal of the American Medical Association.* 286(5). pp. 563–571.

Swai, E.S. and M.O. Neselle (2010) 'Using participatory epidemiology tools to investigate contagious caprine pleuropneumonia (CCPP) in Maasai flocks, northern Tanzania'. *International Journal of Animal and Veterinary Advances.* 2(4). pp. 141–147.

Taye, A., D. Haile Mariam, and V. Murray (2010) 'Interim report: review of evidence of the health impact of famine in Ethiopia'. *Perspectives in Public Health.* 130(5). pp. 222–226.