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REGULAR ARTICLES

Constraints to cattle production in a semiarid pastoral system in Kenya

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Abstract Livestock keeping is the mainstay for the pastoral community while also providing social and cultural value. This study ranked main production constraints and cattle diseases that impacted livelihood and estimated herd prevalence, incidence rate, and impact of diseases on production parameters in a semiarid pastoral district of Narok in Kenya. Data collection employed participatory techniques including listing, pairwise ranking, disease incidence scoring, proportional piling, and disease impact matrix scoring and this was disaggregated by gender. Production constraints with high scores for impact on livelihood included scarcity of water (19 %), lack of extension services (15 %), presence of diseases (12 %), lack of market for cattle and their products (10 %), and recurrent cycle of drought (9 %). Diseases with high scores for impact on livelihood were East Coast fever (ECF) (22 %) and foot and mouth disease (FMD) (21 %). High estimated incidence rates were reported for FMD (67 %), trypanosomosis (28 %), and ECF (15 %), while contagious bovine pleuropneumonia (CBPP) had an incidence rate <1 %. Milk yield was affected by FMD, ECF, and trypanosomosis, while ECF was the cause of increased mortality. FMD, ECF, CBPP, and brucellosis caused increased abortion, while effect of gender and location of study was not significant. Despite CBPP being regarded as an important disease affecting cattle production in sub-Sahara Africa, its estimated incidence rate in herds was low. This study indicates what issues should be prioritized by livestock policy for pastoral areas.

Keywords Production constraints · Participatory techniques · Livelihoods · Pastoralism

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Introduction

An estimated 50 % of Kenya's livestock are kept in the arid and semiarid lands (Nyariki et al. 2009). The majority of the 9 million beef cattle are of the East African Zebu breed, and these are kept by pastoralists as a source of meat and milk, draught power, and for sale (Barrett et al. 2005; Kiptarus 2005; Behnke and Centre 2012).

Frequent outbreak of infectious diseases hampers productivity in most cattle production systems in Kenya (Gitau et al. 2001; Wesonga et al. 2010). These diseases result in reduced milk production, loss of weight, delayed maturity age, decreased reproductive rates, and increased mortality rates. They also cause stunted growth and increased preweaning mortality rate in calves (Gitau et al. 2001). Prevalent cattle diseases under pastoral areas in Kenya include foot and mouth disease (FMD), trypanosomosis, East Coast fever (ECF), contagious bovine pleuropneumonia (CBPP), lumpy skin disease (LSD), blackquarter, and malignant catarrhal fever (MCF) (Njanja et al. 2003; Wanyoike 2009). Most of these diseases have varied impact on outputs from different cattle systems. Apart from diseases, other production constraints described for pastoral areas include frequent drought, scarcity of water, poor livestock market infrastructure, and inadequate extension services (Mati et al. 2006; Pavanello 2010; Opiyo et al. 2011).

Despite potential for livestock production under pastoral areas, their contribution to the national economy is seldom

recognized; besides, livestock production under this system faces these varied constraints. The aim of this study was to rank the production constraints and cattle diseases based on their perceived impact on pastoralists' livelihood and to estimate herd prevalence, incidence rates, and impact of diseases on production parameters in the Maasai pastoral area of Kenya. These results will be useful for policy formulation on improvement of cattle husbandry and control of diseases in pastoral areas and consequently, an enhanced livelihood for pastoralist's community that depends on livestock.

Materials and methods

Study area

The study was conducted in Narok County, Kenya, an area of about 15,000 km^2 that lies between 0° 50′ and 2° 05′ S and 35° 58′ and 36° 00′ E and is inhabited by the Maasai community. It receives between 500 and 1,800 mm of rainfall per annum and temperature ranges between 5 and 28 °C (ALRMP 2007).

Selection of study locations

Location was used as the sampling unit in this study and was defined as an administrative area within a division and district. Nine locations were randomly selected from a total of 17 locations in Osupuko and Mau East divisions. The number of locations included in the study was constrained by available resources and distance traveled between locations. Osupuko and Mau East divisions were purposely selected for the study because they had high number of cattle based on advice from the district veterinary officer.

Participatory data collection

Twelve focus group interviews were conducted in these locations. The participants were mobilized through local government administrators and community guides. The total number of participants was 230 with a minimum of 15 participants attending each group interview and these were disaggregated by gender, while in some cases, there were mixed groups. The interviews were guided by a checklist of open-ended questions and both qualitative and quantitative data were collected using published participatory epidemiology techniques: listing, pairwise ranking, proportional piling, disease incidence scoring, disease impact matrix scoring, and probing. This checklist of questions was pretested and adjusted in two locations that were not included in the final study. The guiding questions were: what were the common constraints that were facing cattle husbandry? Which of the listed constraint had greatest impact on household livelihood? Which cattle diseases were commonly encountered in herds? How many households encountered the listed diseases in their herds during the last year? What was the relative incidence rate for the listed diseases in herds? Which of the identified diseases had the greatest impact on household livelihood? How did pastoralists describe the listed cattle diseases using selected clinical signs and their estimated impact on production parameters?

Identification of constraints and diseases that impact on livelihood

The pastoralists used local names to identify constraints or diseases. When they provided syndromes rather than specific names, probing was done using open-ended questions to characterize the constraint. The names of production constraints or diseases and the descriptions obtained from pastoralists were later validated with the local veterinary officer and through literature sources. These production constraints were ranked by participants through pairwise ranking (Catley et al. 2012).

Estimation of disease prevalence and incidence rates in herds

The disease incidence scoring method was used to estimate disease incidence rates in herds. The technique has been used in previous studies (Bedelian et al. 2007; Bett et al. 2009). It included diseases perceived to have been prevalent in herds. This was done with the list of diseases that were identified to impact livelihood through pairwise ranking. A total of 100 stones representing cattle in a herd were used for scoring. Each participant was asked to divide the stones into two piles; one pile representing the proportion of cattle that were ill during the last year and another representing the healthy group. This gave an overall proportion of cattle that were ill from the identified diseases. The pile representing cattle that were ill was further subdivided into piles corresponding to the proportion of cattle that acquired each of the listed diseases. Participants were then asked to give reasons explaining the scores obtained. Additionally, the number of participants who reported the listed diseases in their herds was used to estimate herd prevalence.

Description of cattle diseases in herds

Disease impact matrix scoring was used to estimate the impact of listed diseases on production parameters and to classify diseases by their clinical signs as perceived by pastoralists (Bedelian et al. 2007; Catley et al. 2012). The production parameters assessed included weight loss, mortality, loss in milk yield, and impact on abortion rate. The

clinical signs assessed were severe diarrhea, excessive coughing, loss of appetite, affected animal seeking shade, and sudden death. This was based on how participants perceived the disease to impact on production parameters and extent to which affected cattle manifested the clinical signs. The production parameters and clinical signs were put on the left column of the matrix, while the diseases were put on top of the matrix. The next step involved allocating scores to diseases according to how pastoralist perceived them to impact on each production parameter and how they manifested clinical signs. This was done sequentially focusing on one production parameter and/or clinical sign each time by allocating scores across the disease columns until all the rows of the matrix were filled. The scores allocated for each production parameter or clinical sign were then summed to give an overall score. The results obtained were probed to obtain reasons for the observed pattern.

Data management and analysis

The quantitative data from group interviews were entered into a database developed in Microsoft Excel and the scores for production constraints were standardized by conversion into percentage scores. These percentage scores were analyzed using GenStat 13th edition VSN International statistical package. The Kruskal–Wallis one-way analysis of variance was used for inferential analysis and significance level set at 5 %. The qualitative data were used for triangulation.

Results

Identification and ranking of production constrains to livelihood

The workshops were held with men in Enoosupukia, Suswa, Keekonyokie, Ntulele, and Ongata Naado locations, while those for women were in Keekonyokie, Ntulele, and Ongata Naado. The mixed groups were in Naroosura, Elangata Enterit, Enkutoto, and Ntuka. The main constraints to cattle production included scarcity of water, lack of extension services, presence of diseases, recurrent cycle of drought, and lack of livestock market infrastructure.

Scarcity of water for livestock use was the first ranked constraint to livelihood by all the groups. Participants observed that as a result of water shortage, they would move their cattle to other areas in search for water and pasture when their sources dried up during drought. During this movement to cold and hilly areas, cattle would acquire infectious diseases. Lack of extension services was ranked second overall with a mean score of 15 % (Table 1). It was blamed for the practice of pastoralists keeping large herd sizes that do not benefit them, poor knowledge on management of pasture and water sources, and poor disease control methods. Both men and the mixed groups ranked it second while women ranked it third. The presence of diseases and lack of market for cattle products were ranked third and fourth, respectively. However, participants noted that diseases were readily treated using drugs obtained from drug stockist, but the quality of drugs sold through these stores was regarded as poor. The markets were regarded to be lacking in mechanisms for price setting and brokers were determining prices. The men and women ranked diseases third and fourth, both with a mean score of about 12 %, while lack of market for products was ranked fourth and fifth by men and women, respectively. A significant difference was observed between the mean scores for impact of individual constraints on livelihood (p value$<$ 0.001). The constraints with high scores for impact on livelihood were scarcity of water (Z=5.32), lack of extension services (Z=4.06), presence of diseases (Z=3.68), and lack of markets (Z=3.40). However, the effects of location and gender were not significant.

Identification and ranking of diseases that constrain livelihood

The men ranked FMD first as a disease greatly impacting livelihood, closely followed by ECF, both with a score of about 25 %. FMD outbreaks were reported to occur twice each year. Participants noted that FMD caused abortion in pregnant cattle, rapid weight loss, loss in milk production, and mortality in calves. However, adult cattle were reported not to suffer mortality. The women ranked ECF first followed by FMD. ECF was reported to cause death in affected cattle but calves were the most affected. It also resulted in loss of milk yield, but this was gradual and animals returned to full production following recovery. According to participants, ECF was the main cause of cattle mortality in the area and the cost for its treatment was high. CBPP was ranked third (11 %) by men; it was, however, ranked only eighth by women and ninth by the mixed groups. This disease was observed not to be common, but when outbreaks occurred, it had high impact. Brucellosis was not perceived to affect cattle production, but participants reported that their household members were on medication for this disease. Its significance was based on its perceived impact to human health. The participants had no knowledge of human exposure factors to brucellosis such as drinking raw milk, handling aborted fetuses and retained placenta with bare hands, and kissing the newborn calves as a cultural practice. However, most households were boiling their milk before consumption. The difference in mean scores for impact of diseases on livelihood was significant (p values$<$0.001). Diseases with higher scores for impact on livelihood were FMD (Z=5.03) and ECF (Z=5.11) (Table 2).

Table 1 Scores for production constraints on livelihood according to pastoralists

Production constraints	Mean %	Median %	Range %	Average rank	*Z*-score	Rank
Scarcity of water	19	19	16–24	231.1	5.32	1
Lack of extension	15	15	0–22	205.3	4.06	2
Cattle diseases	12	11	8–15	197.4	3.68	3
Lack of market	10	10	5–14	191.6	3.40	4
Frequent drought	9	9	0–17	165.3	2.12	5
Poor road infrastructure	8	6	0–21	154.2	1.59	6
Wildlife conflicts	7	3	0–11	128.9	0.36	7
Shortage of pasture	5	0	0–17	111.1	−0.50	8
Cattle breeding	5	0	0–7	115.7	−0.28	9
Insecurity	4	2	0–8	118.6	−0.14	10
Poor quality drugs	3	0	0–16	104.6	−0.82	11
Seasonal flooding	3	0	0–24	96.3	−1.22	12

Estimated herd prevalence and incidence rates for diseases in herds

Cattle diseases with high estimated herd prevalence were FMD (60 %), ECF (57 %), heartwater (39 %), trypanosomosis (37 %), and CBPP (14 %). Of these, FMD (Z=3.64) and ECF (Z=3.16) had significantly high herd prevalence (p value<0.001). However, the effect of location on herd prevalence was not significant (p value=0.41). Diseases with higher estimated incidence rates were FMD, ECF, trypanosomosis, and eye infections (Table 3). There was no significant difference in mean scores for incidence rates between herds and locations, respectively (p value=0.91; p value=0.34). However, the estimated mean incidence rates for diseases were different. Those with higher estimated incidence rates were FMD (Z=10.24), ECF (Z=7.08), and trypanosomosis (Z=3.92).

Description of impact for diseases in herds

Cattle infected with FMD had higher mean score for reduction in appetite followed by ECF (Table 4). Those infected with ECF had higher score for seeking shade followed by CBPP, while sudden death was reported for cattle infected with anthrax and plant poisoning. Excessive coughing was in cattle infected with CBPP and ECF, while severe diarrhea was reported for cattle infected with ECF and trypanosomosis. The participants observed that an FMD outbreak in a herd reduced milk yield by 53 %, while infection by ECF, trypanosomosis, and CBPP resulted in reduced milk yield by 21 %, 12 %, and 7 %, respectively (Table 5). FMD infection also resulted in higher weight loss as compared to ECF and CBPP. The occurrence of ECF and CBPP infections increased mortality by 35 % and 25 %, respectively, while anthrax and plant poisoning both increased mortality by about 11 %. FMD

Table 2 Scores for cattle disease constraints on livelihood according to pastoralists

Cattle diseases	Mean %	Median %	Range %	Average rank	*Z*-score	Rank
East Coast fever	22	23	11–36	206.1	5.11	1
Foot and mouth disease	21	20	10–29	204.5	5.03	2
CBPP	8	7	0–19	153.2	2.28	3
Trypanosomosis	7	7	0–17	128.0	0.93	4
Heartwater	7	4	0–15	144.1	1.80	5
Anthrax	6	0	0–19	134.5	1.28	6
Mastitis	5	0	0–14	104.6	−0.32	7
Lumpy skin disease	5	0	0–14	97.5	−0.69	8
Malignant catarrhal dever	5	0	0–15	88.4	−1.18	9
Brucellosis	4	0	0–14	87.8	−1.21	10
Anaplasmosis	4	0	0–14	86.2	−1.30	11
Redwater	3	0	0–11	84.1	−1.41	12
Retained afterbirth	3	0	0–11	84.5	−1.39	13

CBPP contagious bovine pleuropneumonia

Table 3 Estimated incidence rates for cattle diseases in herds as perceived by pastoralists

Cattle diseases	Mean %	Median %	Range %	Average rank	*Z*-score	Rank
Foot and mouth disease	67	80	0–100	709.6	10.24	1
East Coast fever	15	7	0–100	615.6	7.08	2
Trypanosomosis	28	4	0–100	535.7	3.92	2
Heartwater	4	0	0–100	373.6	−1.04	4
Lumpy skin disease	3	0	0–100	340.4	−2.15	5
Anaplasmosis	2	0	0–50	338.7	−1.85	6
Mastitis	1	0	0–30	355.5	−1.55	7
Brucellosis	1	0	0–18	343.7	−1.53	8
Retained afterbirth	1	0	0–25	329.4	−2.37	9
Redwater	1	0	0–20	325.2	−2.66	10
Malignant catarrhal fever	0	0	0–6	355.8	−1.01	11
CBPP	0	0	0–5	337.9	−2.11	12
Anthrax	0	0	0–1	308.7	−2.41	13

CBPP contagious bovine pleuropneumonia

increased abortion rate by 63 %, while CBPP and ECF increased the abortion rate by 15 % and 13 %, respectively. Other diseases that resulted in abortion were brucellosis and trypanosomosis.

Discussion

Participatory techniques used in this study had been successfully used in other epidemiological studies. However, some authors have argued that while these methods provide information on diseases more efficiently, it is valuable to supplement them with diagnostic tests for purposes of triangulation (Wesonga et al. 2010; Catley et al. 2012). Triangulation is defined as the use of two or more methods, data sources, investigators, or theories within the same study (Catley et al. 2012). This is either within- or across-method triangulations. The within method is when a researcher cross-checks information provided by an informant during interview through a rephrased question, while cross triangulation uses two or more different methods to study the same questions (Catley et al. 2012). Nonetheless, this study used more than one technique to identify and describe cattle diseases and other production constraints.

This study identified scarcity of water, lack of extension services, presence of diseases, frequent drought, and lack of markets for livestock and their products as major constraints that impacted pastoralist's livelihood. However, there were other constraints with relatively lower scores for impact on livelihood. The scarcity of water for livestock use under pastoral areas was previously described (Thornton 2010; Opiyo et al. 2011). However, studies on livestock marketing in pastoral areas have been limited to the description of marketing constraints (Barrett et al. 2005; Pavanello 2010). The main sources of water for livestock in this area included open water pans and seasonal streams and rivers and most of these would dry up during drought. According to pastoralists, scarcity of water was the reason for them moving their cattle long distances in search for water and pasture.

Lack of extension services affected pastoralists as they observed that they could not determine optimum stocking levels, plan for proper disease control, and decide on the best criteria for breed selection and on proper management of pasture and water resources. The ideal strategy for provision of extension services under the pastoral system has not been described, but a recent study under a mixed crop–livestock system in western Kenya revealed that group demonstration was the most effective extension strategy due to the low cost of their organization and increased participation by farmers (Ali-Olubandwa et al. 2011).

The diseases with the greatest impact on livelihood included FMD, ECF, trypanosomosis, and CBPP. These diseases have been previously reported under the pastoral system (Njanja et al. 2003; Wanyoike 2009). Additionally, they occur under other cattle systems where they constrain production (Gitau et al. 2001; Wesonga et al. 2010). Besides their effect on cattle production, diseases also endanger human health especially during outbreak of zoonotic diseases such as Rift Valley fever and brucellosis (Munyua et al. 2010; Muendo et al. 2012). Their occurrence has been blamed on inadequate extension services (Maingi and Njoroge 2010; Wesonga et al. 2010). In response to lack of extension services, pastoralists have adopted coping strategies such as self-medication and use of herbal remedies which effectiveness are unknown. Pastoralists observed that if they were empowered with knowledge on cattle production and disease control, they would apply better mitigation measures whenever disease outbreaks occurred. The impact of these diseases on production was from mortality, reduced milk yield, reduced reproduction rates, delayed maturity

Table 4 Mean scores for clinical signs of prevalent cattle diseases according to pastoralists

Clinical signs	Lost appetite %	Seek shade %	Sudden death %	Coughing %	Diarrhea %
FMD	44	16	0	7	0
CBPP	11	24	11	58	7
East Coast fever	33	50	10	28	63
Trypanosomosis	3	5	0	3	25
Anthrax	2	1	60	0	0
Plant poisoning	0	0	16	0	0
Heartwater	2	1	1	1	1
Blackquarter	0	0	2	0	0
Anaplasmosis	2	2	0	2	2
Brucellosis	0	0	0	0	0

FMD foot and mouth disease, *CBPP* contagious bovine pleuropneumonia

ages, and low weight at maturity. The high impact of ECF was blamed on poor quality acaricides that were sold through local drug stores. ECF is caused by the parasite *Theileria parva* and is widely reported to affect cattle productivity. The economic impact of FMD has been reported to be dependent on the production system involved (Perry et al. 2002), and losses are from reduced milk yield, rapid loss of weight in affected animal, death of calves, and abortions in pregnant cows (Aftosa 2007; El-Hussein and Daboura 2012). However, it is also argued that these impacts are not immediately felt by farmers under the extensive systems (Rushton 2008). Pastoralists observed that CBPP was not common. Participants who could remember it stated that it had serious impact on affected cattle. However, reasons for the low estimated incidence rate were unclear. Nonetheless, cattle were subjected to repeated antibiotic treatment against other diseases that could partly explain why CBPP was rare, since the causative agent is sensitive to oxytetracycline and danofloxacin (Huebschle et al. 2006; Niang et al. 2007). Additionally, a recent survey reported seroprevalence of 1.47 % in the Maasai Mara ecosystem (Mtui-Malamsha 2009). Before, this disease had been ranked as the main constraint to cattle production by pastoralists in sub-Sahara Africa (Tambi et al. 2006; Windsor 2006). Bovine trypanosomosis was observed to be common in herds that were grazed next to game reserves and forests. This is a parasitic disease transmitted by tsetse fly and its control in endemic areas is always directed at eradication of vectors. Its impact on production is through decreased milk yield, weight loss, reduced reproduction rate, and testicular damage in males (Maichomo et al. 2009). The participants had limited knowledge on exposure factors to brucellosis, but these pastoralists engaged in practices that exposed them to infection while family members were on brucellosis treatment. No baseline study has established the prevalence of brucellosis in pastoral herds. One study previously reported the presence of antibodies against *Brucella abortus* in marketed milk from Narok and other areas adjoining Nairobi while another had examined hospital records for patients who were diagnosed with brucellosis in Narok district (Muriuki et al. 1994; Kangethe et al. 2007); however, no study has yet described risk factors for human exposure at farm-level in pastoral areas. Furthermore, a recent study in smallholder systems reported isolation of *Brucella melitensis* and *B. abortus* from milk samples and aborted fetuses from herds with history of recurrent abortions (Muendo et al. 2012).

Table 5 Mean scores for impact of cattle diseases on production parameters according to pastoralists

Production parameters	Milk yield %	Weight loss %	Mortality rate %	Abortion rate %
FMD	53	48	3	63
CBPP	7	13	25	15
East Coast fever	21	27	35	12
Trypanosomosis	12	8	1	2
Anthrax	2	1	11	0
Plant poisoning	0	0	11	0
Heartwater	2	1	3	1
Blackquarter	0	0	0	0
Anaplasmosis	1	0	0	0
MCF	0	0	5	0
Brucellosis	0	0	0	6

FMD foot and mouth disease, *CBPP* contagious bovine pleuropneumonia, *MCF* malignant catarrhal fever

Conclusion and recommendation

This study has described the main constraints to cattle production under the Maasai pastoral system. Diseases with significant impact on livelihood included ECF and FMD. Although participants were aware of the impact of CBPP, its incidence rate in herds was low. It is recommended that

policies on cattle management and disease control in pastoral areas address these prioritized constraints that have significant impact on livelihood.

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Conflict of interest None.

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