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REGULAR ARTICLES

Practices of traditional beef farmers in their production and marketing of cattle in Zambia

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Abstract Understanding the practices of traditional cattle farmers in developing countries is an important factor in the development of appropriate, pro-poor disease control policies, and in formulating regional-specific production incentives that can improve productivity. This paper describes the production, husbandry practices, economics, and constraints of traditional cattle farming in Zambia. A cross-sectional study design was used to obtain data from traditional cattle farmers ($n = 699$) using a structured questionnaire. Data analyses were carried out using SPSS and STATA statistical packages. The results revealed that the majority [65% (95% CI: 59.3–71.1)] of farmers practised a transhumant cattle herding system under communal grazing. In these transhumant herding systems, animal husbandry and management systems were found to be of poor quality, in terms of supplementary feeding, vaccination coverage, deworming, uptake of veterinary services, usage of artificial insemination, and dip tanks all being low or absent. East Coast Fever was the most common disease, affecting 60% (95% CI: 56.4–63.7) of farmers. Cattle sales were low, as farmers only sold a median of two cattle per household per year. Crop farming was found to be the main source of farm income (47%) in agro-pastoralist communities, followed by cattle farming (28%) and other sources (25%). The median cost of production in the surveyed provinces was reported at US$316, while that of revenue from cattle and cattle products sales was estimated at US$885 per herd per year. This translates to an estimated gross margin of US$569, representing 64.3% of revenue.

There is considerable diversity in disease distribution, animal husbandry practices, economics, and challenges in traditional cattle production in different locations of Zambia. Therefore, to improve the productivity of the traditional cattle sub-sector, policy makers and stakeholders in the beef value chain must develop fit-for-purpose policies and interventions that consider these variations.

Keywords Beef value chain · Cattle keeping practices · Traditional cattle farmers · Zambia

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Introduction

Zambia's beef sector encompasses both traditional and commercial sub-sectors. Traditional beef farmers are defined as farmers who mostly keep local breeds of cattle integrated with crop farming on approximately five hectares of land (World Bank 2011). The traditional sector maintains approximately 84% of the cattle population. Commercial beef farmers are defined as farmers who own large herds of mostly exotic breeds of cattle and contribute the remaining 16% (Sinkala et al. 2014). Commercial beef farms are mostly situated along rail lines on large pieces of titled land, while traditional beef farmers are scattered in rural areas, often practising communal grazing on land held in trust by traditional leaders (Muma et al. 2011; Muuka et al. 2012).

The national beef supply relies on the willingness of traditional farmers to sell animals. However, such offtakes typically only take place when financial needs arise and are predominately comprised of cattle that are old or sick, or cows with reproductive problems (Lubungu et al. 2015). FAO data report a significant growth in both cattle numbers (from 2.6 million heads in 2005 to 4.1 million heads in 2014) and beef production (from just over 59,000 tons in 2005 to over 233,000 tons in 2014), fuelled largely by economic growth linked to population growth, urbanisation, and an increase in the middle income class (Steinfeld et al. 2006; World Bank 2011). The rise in beef production and local demand have led to a decline in net imports (based on UN Comtrade data downloaded from 2007 to 2015, see https://comtrade.un.org/data/), although neither exports nor imports have been particularly large historically. However, much of this growth in beef production has come from the commercial sector, with traditional cattle farmers at least partially excluded from these positive developments for a number of reasons (World Bank 2011). In particular, the traditional sector is beset by low average slaughter weights (90–120 kg), poor animal husbandry practices, and a lack of knowledge of husbandry, animal management, and marketing systems (Muma et al. 2009; World Bank 2011; Lubungu et al. 2012). Most animals in the traditional sector reach market weights after 4 to 5 years instead of the standard 2 to 3 years (Du Plessis and Hoffman 2004). A high mortality rate, with a calf mortality rate of 20–30% and an adult mortality rate of 9% further contributes to the low levels of animal productivity among traditional cattle farmers (World Bank 2011). Regionally, neighbouring Namibia and Botswana have higher productivity levels than Zambia (World Bank 2011). These countries are more competitive and have even accessed high-value EU markets (Naziri et al. 2015).

Despite the underdevelopment of the sector, there is great potential for traditional cattle farmers to improve their production due to the wide natural resource base in Zambia (World Bank 2011). The Government of Zambia has targeted livestock as a critical future sustainable source of revenue and as a major component of its export diversification agenda away from copper and towards agriculture (Anonymous 2017). However, addressing these constraints and assisting the government in pushing its diversification agenda require an understanding of current production, husbandry practices, animal management systems, and economics of the traditional beef sub-sector in Zambia. Specifically, what are the factors that limit traditional beef production? What are the production and marketing practices of traditional farmers? Are there regional differences in practices and disease distribution that might influence and compromise improvements in this sector?

Consequently, the objective of this research was to describe traditional cattle production, husbandry practices, economics, and constraints in Zambia. Understanding these drivers will play a key role in helping the Government of Zambia and developing countries in Africa to develop pro-poor animal health policies and disease control plans that take into account these issues as an avenue for improving production and productivity of traditional cattle farmers.

Materials and methods

Study sites and design

The study was a cross-sectional survey with data collection carried out between September 2015 and March 2016 in four of the ten provinces of Zambia namely Southern, Western, Central, and Eastern provinces (Fig. 1). These provinces were chosen, because they constitute the main cattle producing areas of Zambia (Sinkala et al. 2014; Anonymous 2015).

Sample size

Epitools (http://epitools.ausvet.com.au/) were used to calculate the sample size. Given a total population of 300,000 traditional cattle farmers (SNV 2012), a confidence level of 95%, estimated proportion of 50%, and desired precision of 5%, the necessary sample size was calculated at 385 respondents, assuming random sampling. Given a design effect of two for the four clusters to adjust for non-random sampling due to the geographical setup of the study area (Salganik 2006), this resulted in a sample size of 770 traditional cattle farmers. Each sampling unit received an equal number of questionnaires, but provinces, where more districts were purposively selected due to their larger number of cattle farmers, had more sampling units hence recording more respondents than others.

Sampling techniques

In each province, districts with the highest number of cattle farmers were purposively selected from the provinces based on the Department of Veterinary Services' annual report (Anonymous 2015) (Table 1). In each district, the District Veterinary Office (DVO) was approached to provide a list of veterinary camps, which were accessible by road and had a large number of cattle. Veterinary camps are the smallest administrative offices in the district and are manned by veterinary assistants who all report to the District Veterinary Officer (Sitali et al. 2017). These veterinary camps formed a sampling unit for the study. In each veterinary camp, traditional cattle farmers were systematically selected (fixed periodic intervals) from the different veterinary camps and structured questionnaires administered in face-to-face interviews. Farmers were interviewed at abattoirs, cattle markets, district veterinary offices, livestock service centres, and the floodplains where they

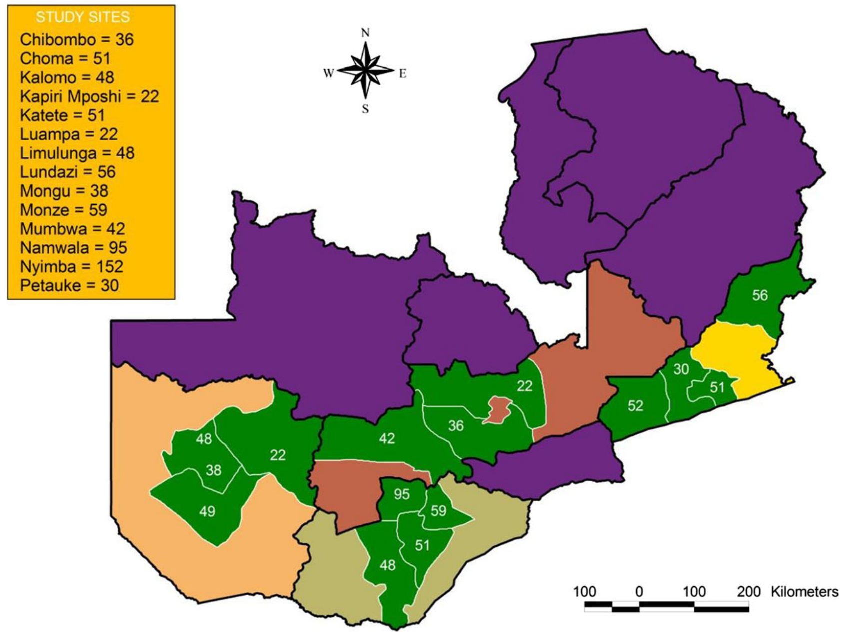

Fig. 1 Map of Zambia showing study areas. Green areas are districts where data were collected in respective provinces demarcated by a thick black line. (Source: developed by authors)

grazed their cattle (pastoralists). This was done, because households are far from each other, which made it practically impossible to visit the farmers at their homes. Systematic random sampling was employed by picking every third farmer (to meet the target number) who brought their cattle to the abattoir, livestock service centre, cattle market, and veterinary office. In the floodplain of Maala veterinary camp where animals graze, there were only a few farmers herding large numbers of cattle, and all of those present (n = 15) were interviewed.

Data collection techniques

A structured questionnaire was developed to capture data on a wide array of variables related to demographics, production, cost structures, and marketing. The questionnaire was pretested in the Namwala district (which has the largest cattle population in Zambia) to assess the clarity, strengths, and weaknesses of the questionnaire and to test whether it would obtain the intended responses. The pilot-testing revealed that some items in the questionnaire were repetitive, and the questionnaire was revised to improve clarity, remove repetitive questions, and reduce ambiguity, after which it was administered. The inclusion criteria for respondents were adult male and female, above 18 years of age, with a minimum of one bovine animal of any age group.

To ensure high-quality data collection, the veterinary assistants in all 30 selected veterinary camps were trained as enumerators by the lead researcher and were observed interviewing at least five farmers in the presence of the lead researcher before they were allowed to conduct interviews on their own. Each questionnaire took an average time of 35 min per respondent. Each enumerator was given 30 hard copies of the questionnaires and instructed to interview a maximum of five traditional cattle farmers per day to avoid rushing over the questionnaire and disturbing their routine work schedule. Informed verbal consent consistent with Norwegian University of Life Science's policy was obtained from all respondents before interviewing them. The interviews were carried out in English, and to those who could not communicate in English, the enumerators translated it to respective local languages, which included Tumbuka, Lozi, Tonga, and Lenje.

Data management and analysis

The questionnaire data were coded and entered manually by the lead researcher into Microsoft Excel® 2007 to standardise them and to make them amenable for further handling and analysis. Questionnaires which were incomplete were removed before data entry. Incomplete questionnaires were those where respondents abandoned halfway through the interview due to other commitments, i.e. where $\geq$ 50% of answers were missing. After an initial data cleanup (checking the codes and respective cells for missing variables and wrong codes) in Microsoft Excel® through the use of the filter function, data were exported to SPSS (version 20, IBM Analytics, Armonk, NY) and STATA (version 12, College Station, TX) for further cleanup, removal of redundant variables, and preliminary analysis using descriptive statistics. Preliminary analysis revealed some errors and missing data in some cells. This necessitated a further cleanup (wrong codes and transposed figures) until the data set was clean and fit for further analyses.

Table 1 Number of respondents in different provinces, districts, and veterinary camps

Province	District	Veterinary camp	Total respondents (n = 699)	%
Southern	Monze (n = 59)	Bwengwa	13	1.86
		Keemba	22	3.15
		Hatontola	15	2.14
		Nakansangwe	9	1.29
	Namwala (n = 95)	Chitongo	38	5.44
		Katantila	42	6.01
		Maala	15	2.15
	Choma (n = 51)	Mapanza	27	3.86
		Mbabala	24	3.43
	Kalomo (n = 48)	Moonde	24	3.43
		Siachitema	24	3.43
Central	Kapiri Mposhi (n = 22)	Chibwe	22	3.15
	Chibombo (n = 36)	Chikumbi	22	3.15
		Mbosha	14	2.00
	Mumbwa (n = 42)	Moono	22	3.15
		Mumbwa Central	20	2.86
Eastern	Nyimba (n = 52)	Chipembe	26	3.72
		Nyimba Central	26	3.72
	Lundazi (n = 56)	Mwase	20	2.86
		Japhet	30	4.29
		Mcheleka	6	0.86
	Katete (n = 51)	Kafumbwe	51	7.29
	Petauke (n = 30)	Kalindawalo	30	4.29
Western	Senanga (n = 49)	Namulundu	33	4.72
		Lukanda	16	2.29
	Mongu (n = 38)	Namushakende	23	3.29
		Siwito	15	2.14
	Limulunga (n = 48)	Limulunga	27	3.86
		Usha	21	3.00
	Luampa (n = 22)	Luampa	22	3.15

The sample size (n) in each district has also been indicated on the map to link this table

Statistical analysis

Tabular and graphical analyses of the data were the starting point for data analyses. Frequency tables of ordinal and nominal variables and descriptive statistical tables for scale variables were generated. In all the descriptive statistics, the province was kept as a strata and demographics, production, cost structures, and the market as subsets. Proportions for categorical and Kruskal-Wallis tests for continuous variables were used to test for statistical differences across the strata using non-overlapping of 95% confidence intervals (CI) and p values ($p \leq 0.05$), respectively. All continuous variables underwent a normality test using histograms. The median was used in place of the mean values of continuous variables that were not normally distributed. The US dollar (US$) was used in calculations of costs and benefits in monetary terms at the exchange rate of US$1 = ZMK10, provided by the Bank of Zambia (www.boz.zm), and consistent with the time period of the survey. Cost structures were tabulated using gross margin analysis and price sensitivity measured using the price elasticity of supply, which is a ratio of percentage change in quantity of cattle sold to a given percentage change in price (Gallet 2010). The price elasticity of supply was calculated using Eq. 1.

$$\frac{\text{Q2-Q1}}{\text{Q1}} \times \frac{\text{P1}}{\text{P2-P1}} \qquad (1)$$

Equation 1: Formula for calculating the price elasticity of supply.

where Q1 = initial quantity, Q2 = final quantity, P1 = initial price, and P2 = final price.

Ethical clearance

Ethical clearance consistent with Norwegian University of Life Sciences policy was obtained from Excellence in Research Ethics and Science (ERES) Converge, reference number "2016-Nov-006".

Results

Sociodemographic characteristics

Table 2 summarises the sociodemographic characteristics of the traditional cattle farmers interviewed. The majority of the sample comprised of males with an average age of 48 years (95% CI: 46.7–48.7). The average household size was 9.51 (95% CI: 9.1–9.9). The median cattle herd size of 24 per household structured in a median of 9 males and 15 females (which we refer to as per herd per year throughout the text). However, herd size varied across provinces with Southern and Western recording larger herd sizes than Central and Eastern provinces. Major statistical differences across provinces were noticed in marital status, the level of education, and breed of cattle (non-overlap of CI) (Table 2).

Animal production and management systems

Cattle herding systems

Table 3 compares cattle husbandry practices in each study region. All traditional cattle farmers in Eastern Province practised village resident (permanently in or near the village) cattle herding, while the other three provinces practised both village resident cattle herding and transhumance practices (moving between the village and floodplains) cattle herding systems. A greater prevalence of transhumance practices [65.2%, (95% CI: 59.3–71.1)] was observed in Southern and Western provinces, while in the Central province, village resident herding systems prevailed [90%, (95% CI: 84.1–95.9)].

Supplementary feeding

Only 12.7% (95% CI: 10.3–15.2) of respondents across all provinces practiced supplementary feeding, out of which 23.3% (CI: 15.5–31.1) supplemented with hay, mostly twice a week during the dry hot season (Sept–Nov), at a median cost of US$50 ($n = 25$, range 8–500) per herd per year, while 65% (95% CI: 56.3–73.7) used concentrates mainly in the form of plain maize bran, twice a week during hot, dry season, costing a median of US$86 ($n = 78$, range 4–600) per herd per year (Table 3).

Reasons given by traditional cattle farmers for not supplementing their cattle with feed included the following: 79.4% (95% CI: 76.3–83) reported that feed supplements were unaffordable, 26% (95% CI: 22.4–29) felt that the supplements were inaccessible, 12.1% (95% CI 9.4–14.8) did not see the advantage that comes with extra feeding, and 3.5% (95% CI 1.4–5.4) reported that they have enough grazing land (Table 3).

Cattle breeding systems and purpose of keeping cattle

Natural breeding was the main method of breeding across the study regions. Only Southern Province, with 0.8% (95% CI: 0–1.1) of traditional cattle farmers, used artificial insemination (Table 3). The median cost of natural breeding (cost of maintaining bulls) per bull per year was US$30 ($n = 396$, range 1–500). The median cost of artificial insemination was reported at US$80 ($n = 3$, range 50–86) per herd per year.

The ranking through the use of median values revealed that only Southern Province reported source of income as the main purpose of keeping cattle. However, across the three provinces, the main purpose was draught power for use in cultivation of crops (1), followed by cattle being the source of income (2), source of transport in form of ox-carts (3), source of milk as the main source of protein (4), symbol of status in the village (5), source of meat (6), manure for fertilising crop farms (7), and use of cattle as payment of dowry during marriages (8) (Table 3).

Diseases frequently affecting cattle and treatments used

Table 4 summarises a comparison of diseases reported to be frequently affecting traditional cattle farmers across study regions. The reported disease estimates were based on clinical symptoms by herdsmen. East Coast Fever (ECF) was reported to occur frequently in all provinces apart from Western. It was the most frequently occurring disease overall [60% (95% CI: 56.4–63.7)] in three provinces, reported throughout the year. Its prevalence was significantly lower in Southern Province. However, there was no significant difference between Central and Eastern provinces.

Parvaquone, buparvaquone, and oxytetracycline were the drugs used by traditional cattle farmers to attempt treatment for ECF. The median cost of ECF treatment was US$20 ($n = 394$, range 2–1000) per herd per year. The traditional cattle farmers lost a median of one animal ($n = 196$, range 1–32) per year from ECF valued at US$300 ($n = 193$, range 40–8000).

Own diagnosis based on clinical symptoms was the main [65.2% (95% CI: 61.6–68.8)] method used by traditional cattle farmers to diagnose cattle diseases. This was followed by veterinary assistants [58.7% (95% CI: 55–62.4)], fellow farmers [14.4% (95% CI: 11.8–17.1), and community animal health workers (CAHW) [8.6% (95% CI: 6.4–10.7)].

Table 2 A comparison of the sociodemographic characteristics of cattle farmers, given as mean/median and range for continuous variables, and proportion for categorical variables (at 95% confidence interval)

Variable		Province			
		Southern (*n* = 253)	Western (*n* = 157)	Central (*n* = 100)	Eastern (*n* = 189)
Age (mean 48, 95% CI 46.7–48.7)		44 (22–79)	51 (25–93)	48 (24–85)	50 (22–82)
Household size (mean 9.51, 95% CI 9.1–9.9)		11 (2–38)	9 (1–25)	10 (2–40)	8 (1–27)
Herd size (median 24)		33 (2–600)	36 (14–60)	16 (3–368)	18 (1–128)
Female cattle (median 15)		22 (0–425)	19 (0–380)	10 (1–253)	10 (1–71)
Male cattle (median 9)		10 (1–200)	15 (1–130)	6 (0–115)	7 (1–57)
Sex	Male (*n* = 609, 87.7%)	92.1 (88.8–95.5)	88.4 (83.4–93.5)	90 (84.1–95.9)	78.3 (72.4–84.2)
	Female (*n* = 89, 12.7%)	7.9 (4.6–11.2)	11.5 (6.5–16.6)	10 (4.1–15.9)	21.7 (15.7–27.6)
Marital status	Single (*n* = 28, 4%)	6.4 (3.4–9.4)	3.2 (0.4–6)	3 (0–6.4)	2.1 (0–4.2)
	Married (*n* = 600, 85.4%)	90 (86.3–93.7)	88.5 (83.4–93.5)	82.8 (75.3–90.3)	82.4 (77–87.9)
	Divorced (*n* = 22, 3.1%)	1.2 (0–2.6)	1.3 (0–3.1)	1 (0–3)	**8.5 (4.5–12.5)**
	Widow (*n* = 43, 6.2%)	2.4 (0.5–4.3)	7.1 (3–11.1)	13.1 (6.4–19.8)	6.9 (3.3–10.6)
Education level	None (*n* = 51, 7.3%)	5.2 (2.3–8.1)	5.6 (1.8–9.4)	7.3 (2.1–12.5)	13.3 (8.3–18.3)
	Primary (*n* = 306, 43.8%)	40.2 (33.8–46.6)	49.7 (41.4–57.9)	41.7 (31.7–51.6)	**57.2 (50–64.5)**
	Secondary (*n* = 241, 34.5%)	47.2 (40.7–53.7)	34.3 (26.4–42.1)	44.8 (34.8–54.8)	22.8 (16.6–28.9)
	Tertiary (*n* = 50, 7.2%)	7.4 (4–10.8)	10.5 (5.4–15.5)	6.3 (1.4–11.1)	6.7 (3–10.3)
Breed of cattle	Local (*n* = 398, 56.9%)	12.9 (8.7–17)	72.7 (65.5–79.3)	70 (61–79)	**99.5 (98.4–100)**
	Exotic (*n* = 13, 1.9%)	3.6 (1.3–5.9)	0.7 (0–2)	3 (0–6.4)	0
	Cross (*n* = 276, 39.5%)	**83.5 (78.9–88.2)**	26.7 (19.6–33.8)	27 (18.2–35.8)	0.5 (0–1.6)

Values marked bold have non-overlapping 95% confidence intervals suggesting a statistical difference

Vaccination practices

Table 5 provides a summary of the comparison of vaccination practices across study regions. Countrywide, farmers were most likely to have vaccinated against haemorrhagic septicaemia [46.2% (95% CI: 42.4–50)] and black quarter [64.2% (95% CI: 60.6–67.8)], although annual and twice-annual vaccination rates were noticeably below reported vaccination rates. Significant regional variations were found in vaccination coverage of different diseases. For instance, no farmers in Western or Central provinces reported vaccinating animals against ECF, while the majorities of farmers in Southern and Eastern provinces had vaccinated at least once. Likewise, only farmers in Western province vaccinated against CBPP, while no farmers reported vaccinating in the other three provinces also due to the absence of the disease. Other than for ECF and black quarter (BQ), farmers in Eastern Province rarely if ever vaccinated for major diseases. Vaccination rates in Central Province, other than for BQ, were likewise low for most diseases.

Reasons given for the general poor vaccination coverage were that some farmer's cattle did not suffer from diseases that require vaccination [48.6% (95% CI: 40.1–57)]; vaccines were too expensive [30.1% (95% CI: 22.3–40)]; reliance on the government assuming that once the government vaccinated the animals against FMD, CBPP, or ECF, then the vaccine covered cattle against all diseases [5.2% (95% CI: 3.7–6.8)]; lack of knowledge on the benefits of vaccination [4.8% (95% CI:3.2–6.3)]; vaccines were inaccessible in some areas [11% (95% CI: 5.7–16.4)]; and some farmers believed that vaccines do not work [5.8% (95% CI: 1.8–9.7)].

Among those who vaccinated, the median costs per herd per year of ECF was US$12 (*n* = 330, range 1.5–1200); BQ was US$9 (*n* = 397, range 0.6–500); HS was US$9 (*n* = 298, range 0.4–500); Anthrax US$7.2 (*n* = 73, range 0.8–300); and Brucellosis was US$22.5 (*n* = 8, range 4–50). The government all freely provided FMD and CBPP vaccines.

Helminth management

The majority of traditional cattle farmers [85.5% (95% CI: 82.9–88.1)] practised deworming of cattle in all four provinces. Albendazole was the most used dewormer [74.5% (95% CI: 71–78)] mostly done twice a year [43% (95% CI: 38.8–48)], and some using it once per year [38.6% (95% CI: 34.1–43.2)] in conjunction with Ivermectin [22.2% (95% CI: 19–25.7)] under a twice per year deworming schedule. Other dewormers used included the following: Closantel [11.3% (95% CI: 8.7–13.8)]; Levamisole [5.8% (95% CI: 4.1–7.9)]; Triclabendazole [3.6% (95% CI: 2.1–5.1)]; Oxyclozanide [0.7% (95% CI: 0–1.7)]; Niclosamide [0.6% (95% CI: 0–1.3)]; and Oxfendazole [0.7% (95% CI: 0–1.7)]. Among those who dewormed their cattle, the median cost per herd per year of Albendazole was

Table 3 A comparison of cattle husbandry practices across study regions presented as proportions with their 95% confidence intervals and in some cases the median and range

Variable, sample size and confidence interval (CI)	Province			
	Southern (*n* = 253)	Western (*n* = 157)	Central (*n* = 100)	Eastern (*n* = 189)
Transhumance herding (*n* = 699, 26.1% CI 22.9–29.4)	39.5 (33.5–45.6)	45.5 (37.6–53.4)	**11 (4.8–17.2)**	**0.5 (0–1.6)**
Village resident herding (*n* = 699, 75.8% CI 72.6–79)	65.2 (59.3–71.1)	54.5 (46.6–62)	90 (84.1–95.9)	100 (84.1–95.9)
Interface herding (*n* = 699, 0.3% CI 0–0.7)	**0.7 (0–1.9)**	0	0	0
Supplementation (*n* = 699, 12.7% CI 10.3–15.2)	18.9 (14–23.9)	7 (3–11)	15 (8–22)	20.7 (14.9–26.6)
Hay (*n* = 116, 23.3% CI 15.5–31.1)	28.3 (15–41.6)	0	29.4 (26.8–52)	21.4 (8.7–34.1)
Concentrate (*n* = 120, 65% CI 56.3–73.7)	68.7 (55.4–82.1)	72.7 (44.8–100)	27.8 (6.3–49.3)	74.4 (61.1–87.7)
Reasons for not supplementing cattle with feed				
Feed unaffordable (*n* = 560, 79.4% CI 76.3–83)	79.1 (73.5–84.8)	77 (69.9–84)	89.7 (83–96.5)	77.5 (71–84.4)
Feed inaccessible (*n* = 561, 26% CI 22.4–29)	25.4 (19.3–31.4)	29.3 (21.7–36.9)	30.8 (20.4–41.1)	21.1 (14.4–27.9)
No difference (*n* = 561, 12.1% CI 9.4–14.8)	10 (5.8–14.1)	15.7 (9.7–21.8)	11.5 (4.4–18.7)	12 (6.6–17.3)
Enough grazing (*n* = 26, 3.5% CI 1.4–5.4)	8 (3.9–10)	5 (1.1–8.9)	0	0.9 (0–2.8)
Cattle breeding systems and purpose of keeping cattle				
Natural breeding (*n* = 695, 99.9% CI 99.6–100)	99.6 (98.8–100)	100	100	100
Artificial insemination (*n* = 695, 0.7% CI 0–1.1)	0.8 (0–1.9)	0	0	0
Transport (*n* = 668, median 3)	3	2	2	2
Draught power (*n* = 673, median 1)	2	1	1	1
Source of income (*n* = 624, median 2)	1	3	3	3
Social status (*n* = 627, median 5)	6	6	6	4
Meat (*n* = 602, median 6)	5	5	5	7
Milk (*n* = 628, median 4)	4	4	4	5
Manure (*n* = 270, median 7)	7	7	8	8
Bride price (*n* = 187, median 8)	8	8	7	6

Values marked bold have non-overlapping 95% confidence intervals suggesting a statistical difference

US$10 (*n* = 445, range 0.2–280); Levamisole US$15 (*n* = 35, range 1–650); Ivermectin US$20 (*n* = 135, range 1.5–400); Closantel US$65 (*n* = 68, range 5–900); Niclosamide US$8.75 (*n* = 4, range 5–80); Triclabendazole US$57.5 (*n* = 22, range 3.5–6000); Oxfendazole US$14 (*n* = 4, range 09.5–50); and Nilzan US$17 (*n* = 12, range 5–405).

Tick management

Figure 2 summarises a comparison of tick management practices across study regions. Farmers in Southern and Central provinces practice more dipping than Western and Eastern provinces. Amitraz [81.6% (95% CI: 79.8–85.4)] was the most used acaricide across all study regions apart from Eastern Province where farmers used more of Cypermethrin [18.9% (95% CI: 17.7–22.1)] to control ticks. Dipping/spraying was done weekly during the rainy season [58.6% (95% CI: 54.1–63.1)], and monthly in the dry season [39.4% (95% CI: 22.6–40.8)]. Among those who dipped/sprayed their cattle, the median cost of dipping using Amitraz was US$40 (*n* = 461, range 1–3000) and that of Cypermethrin was US$17.5 (*n* = 107, range 2.5–360) per herd per year.

Farm labour and wages

Less than half of the traditional cattle farmers [42.2% (95% CI: 38.5–45.8)] employed workers to herd cattle with a median of one worker and one family member. The workers earned an average of US$300 (*n* = 159, range 30–4800) per year. Payment was mostly in the form of cattle [48.3% (95% CI: 42.5–54.1)] and cash [49.3% (95% CI: 43.5–55.1)] with one fully-grown animal per year in Southern and after 4 years in Eastern province. Therefore, in total, a worker earned US$300 per year and 1 animal either per year or every 4 years.

Constraints to cattle production

When asked about constraints to cattle production, respondents mentioned high disease burden [77.8% (95% CI: 74.9–81.1)]; lack of improved breeds [58.3% (95% CI: 54.7–62)]; long distances to water points [51.5% (95% CI: 47.8–55.3)]; lack of access to affordable finance [49.6% (95% CI: 45.6–53.4)]; low farm gate prices [43.6% (95% CI: 40–47.4)]; inadequate veterinary and extension services

Table 4 A comparison of the diseases frequently affecting cattle and perceived treatment by farmers presented as proportions with 95% confidence intervals

Diseases frequently affecting cattle (*n* and 95% CI)	Province				Treatment attempted (% use)
	Southern (*n* = 253)	Western (*n* = 157)	Central (*n* = 100)	Eastern (*n* = 189)	
FMD (*n* = 34, 4.9% CI 3.3–6.5)	**6.4 (3.3–9.4)**	**11.8 (6.6–16.9)**	0	0	Oxytetracycline, 1.6%
Anthrax (*n* = 30, 4.3% CI 2.8–5.8)	**1.1 (0–2.5)**	**17.6 (11.6–23.7)**	0	0	Oxytetracycline, 1.6%
CBPP (*n* = 36, 5.2% CI 3.5–6.9)	0	23.5 (16.8–30.3)	0	0	Oxytetracycline, 1.6%
ECF (*n* = 416, 60% CI 56.4–63.7)	**61.5 (55.5–67.5)**	0	92.9 (87.8–98)	88.9 (84.4–93.4)	Parvaqoune, 35.1% Oxytetracycline,12.2%
HS (*n* = 171, 24.7% CI 21.5–27.9)	38.08 (32.1–44.1)	36.6 (28.9–44.3)	17.2 (9.7–24.7)	**1.1 (0–2.5)**	Oxytetracycline,14.3%
BQ (*n* = 362, 52.3% CI 48.6–56)	63.7 (57.8–69.7)	60.8 (53–68.6)	61.6 (52–71.3)	**25.4 (19.2–31.6)**	Penicillin, 25% Oxytetracycline, 21.3%
LSD (*n* = 208, 30% CI 26.6–33.4)	20.6 (15.6–25.7)	28.1 (20.9–35.3)	**63.6 (54.1–73.2)**	26.5 (20.1–32.9)	Penicillin, 18% Oxytetracycline, 4.7%
Heartwater (*n* = 30, 4.3% CI 2.8–5.8)	**9.5 (5.9–13.2)**	2.6 (0–5.2)	2 (0–4.8)	0	Oxytetracycline, 3%
Anaplasmosis (*n* = 54, 7.8% CI 5.7–9.8)	4.8 (2.1–7.4)	**15 (9.3–20.7)**	11.1 (4.9–17.3)	4.2 (1.3–7.1)	Oxytetracycline, 6%
Dermatophilosis (*n* = 12, 1.7% CI 0.7–2.7)	0	**7.8 (3.6–12.1)**	0	0	Oxytetracycline, 0.4%
Mange (*n* = 12, 1.7% CI 0.8–2.7)	0	5.8 (2.1–9.5)	0	1.6 (0–3.4)	Amitraz and Ivomectin, 1.3%
Trypanosomosis (*n* = 7, 1.0% CI 0.3–1.7)	1.6 (0–3.1)	0	2 (0–4.8)	0.5 (0–1.6)	Berenil, 0.9%
Bovine TB (*n* = 12, 1.7% 0.7–2.7)	93.6 (1.3–5.8)	0	0	1.6 (0–3.4)	Nil

Values marked bold have non-overlapping 95% confidence intervals suggesting a statistical difference

FMD foot and mouth disease, *CBPP* contagious bovine pleuropneumonia, *ECF* east coast fever, *HS* haemorrhagic septicaemia, *LSD* lumpy skin disease, *TB* tuberculosis, *BQ* blackleg

[19% (95% CI: 16.1–22)]; lack of quality pastures [4.4% (95% CI: 3.1–5.7)]; and stock theft [5.1% (95% CI: 3.8–6.4)].

Cattle marketing

The majority of traditional cattle farmers [91.1% (95% CI: 89–93.2)] sold cattle during the year, with a median of two cattle being sold per farmer per year in the ratio of two males to zero females, at a median price of US$243 (*n* = 629, range 75–520) per adult animal (Table 6). However, there were more cattle sales in Southern than other provinces.

The reasons for selling cattle were basic home needs [64.5% (95% CI: 60.7–68.2)], school fees [59.4% (95% CI: 55.5–63.2)], investment into other business ventures [19.9% (95% CI: 16.7–23)], culling due to old age and disease [4.7% (95% CI: 3.4–6)], and procurement of farm inputs for crop production [2.2% (95% CI: 1.2–3.4)].

Fluctuations in supply were described with the highest numbers of cattle sold in January, December, April, and August (Fig. 3). Cattle were mostly sold to middlemen [51.5% (95% CI: 47.6–55.4)] and abattoirs [54.9% (95% CI: 51–58.8)].

Almost all [99.5% (95% CI: 98.9–100)] transactions received payment on a cash basis, with [79.8% (95% CI: 76.7–83)] of respondents receiving payment immediately, 19.7% (95% CI: 16.6–22.8) after a few days, and 4.8 (95% CI: 0–10.2) on long-term credit. About [54.7% (95% CI: 50.8–58.6)] of the transactions were farm gate sales, and 43.2% (95% CI: 39.3–47.7) of the farmers reported trekking long distances to the market (abattoirs). More than half [69.3% (95% CI: 65.6–72.9)] of traditional cattle farmers felt that intermediaries pay better prices than abattoirs, while 30.7% (95% CI: 27.1–34.4) think that abattoirs pay better prices than intermediaries. Transactional costs in cattle marketing included transport, with a median cost of US$10 (*n* = 283, range 1–30) per animal; police permit US$2 (*n* = 302, range 0.5–12) per form regardless of the number of cattle; Veterinary livestock movement permit US$0.35 (*n* = 239, range 0.2–5) per animal; village levy US$1 (*n* = 112, range 0.2–8) per animal; and Council levy at US$1 (*n* = 274, range 0.5–8) per animal. The overall median transactional costs were recorded at US$5.49 per sale per year (Table 6).

Constraints to cattle marketing included low farm gate prices [62.9% (95% CI: 59.2–66.6)], too many levies (transactional costs) to pay [46.3% (95% CI: 42.5–50.1)], lack of access to cattle markets [36.6% (95% CI: 32.9–40.3)] (34.6%), high cost of transportation to markets [39.6% (95% CI: 35.9–43.4)], and poor road infrastructure [22.5% (95% CI: 19.3–25.7)].

Traditional cattle farmers selling behaviour was also not very sensitive to small price changes, although larger price changes would incur more price elastic marketing behaviour.

Table 5 Diseases vaccinated against and the frequency of vaccination presented as proportions with 95% confidence intervals and fractions, respectively

Diseases vaccinated against and frequency		Province				(Overall %, 95% CI)
		Southern (*n* = 253)	Western (*n* = 157)	Central (*n* = 100)	Eastern (*n* = 189)	
Anthrax	Yes	**7.6 (4.3–10.9)**	**58.8 (51–66.7)**	1.2 (0–3.5)	0.5 (0–1.6)	16.5 (13.7–19.4)
Frequency	Once/year	7/253	84/157	1/100	0	12.9 (10.4–15.4)
	Twice/year	11/253	3/157	1/100	1/189	2.1 (1.1–3.2)
CBPP	Yes	0	**85.6 (80–91.2)**	0	0	19.5 (16.5–22.5)
Frequency	Once/year	0	129/157	0	0	18.2 (15.3–21)
FMD	Yes	32.8 (27–38.6)	45.5 (40.3–53.4)	**17.6 (9.5–25.8)**	0	24.7 (21.5–28)
Frequency	Once/year	27/253	67/157	4/100	0	13.7 (11–16.3)
	Twice/year	55/253	1/157	11/100	0	9.6 (7.4–11.8)
ECF	Yes	**66 (60.1–72)**	0	0	**91.9 (88–95.8)**	50.4 (46.6–54.2)
Frequency	Once/year	82/253	0	0	131/189	30.6 (27.2–34)
	Twice/year	83/253	0/157	0/100	39/189	17.5 (14.6–20.3)
Brucellosis	Yes	2.4 (0.5–4.3)	0.6 (0–2)	2.4 (0–5.7)	0	1.3 (0.5–2.2)
Frequency	Once/year	7/253	0/157	2/100	0	1.3 (0.4–2.1)
HS	Yes	**86.4 (82.1–90.7)**	**49.7 (41.7–57.6)**	**22.4 (14.4–31.3)**	0	46.2 (42.4–50)
Frequency	Once/year	117/253	68/157	3/100	0/189	26.9 (23.6–30.2)
	Twice/year	97/253	4/157	16/100	0/189	16.7 (13–19.5)
BQ	Yes	**90.4 (86.7–94.1)**	70 (62.6–77.2)	74.1 (64.6–83.5)	**19.5 (13.7–25.2)**	64.2 (60.6–67.8)
Frequency	Once/year	120/253	98/157	33/100	36/189	40.9 (37.3–44.5)
	Twice/year	104/253	2/157	29/100	0/189	19.2 (16.2.22.1)

Values marked bold have non-overlapping 95% confidence intervals suggesting a statistical difference

At 25% price increment, all of them apart from those sampled from Eastern Province said they would not sell an extra animal. Given a 50% price increase, it was found that a median of one extra animal from those sampled in Western province and two extra cattle in Eastern Province would be sold. Given a 75% price increase, only a median of one extra animal from those sampled in Southern Province, two in Western, and four extra cattle Eastern Province would be sold (Table 6). Thus, only traditional cattle farmers in Eastern and Western provinces showed some level of price sensitivity (i.e. a price elasticity over 1) and only with large hypothetical changes in prices.

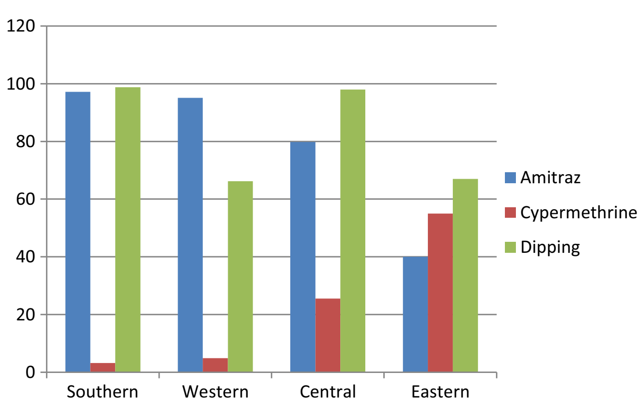

Fig. 2 A comparison of tick management practices across study regions

Market governance

None of the traditional cattle farmers belonged to a beef association or cooperative dealing in beef production and marketing, because they were none existent in all four provinces. About half of the traditional cattle farmers [53.6% (95% CI: 50–57.4)] felt that they had the power to bargain with intermediaries based on body size and condition of cattle. Information dissemination on new developments in the cattle market was reported to occur mostly through intermediaries [58.3% (95% CI: 54.6–62.1)]; processors [18.5% (95% CI: 15.6–21.4)]; fellow traditional cattle farmers [13.6% (95% CI: 11–16.2)]; and veterinary offices [3.3% (95% CI: 1.9–4.6)]. Lack of beef cooperatives [79.5% (95% CI: 76–88.2)] and lack of government support [75.8% (95% CI: 72.5–79)] were major constraints to information dissemination.

Traditional cattle farmer production costs, revenue, and sources of income

Table 7 summarises the cost structure for traditional cattle farmers. Cattle enterprises were more profitable in Southern than the other provinces. The median cost of production for all the provinces was reported at US$316 (denominator for all the

Table 6 A comparison of cattle sales (US$), price sensitivity, and sources of revenue across study regions

Variable	Province				
	Southern (n = 253)	Western (n = 157)	Central (n = 100)	Eastern (n = 189)	p value
Number of cattle sold/year (n = 697, median 2)	4 (0–75)	2 (0–35)	2 (0–12)	2 (0–20)	< 0.001
Male cattle sold/year (n = 692, median 2)	2 (0–70)	2 (0–20)	1 (0–12)	1 (0–16)	< 0.001
Female cattle sold/year (n = 693, median 0)	1 (0–20)	0 (0–15)	0 (0–6)	0 (1–7)	< 0.001
Price/adult animal (n = 629, median 242.5)	290 (90–520)	180 (75–350)	300 (150–480)	200 (80–500)	< 0.001
How many more cattle can you sell @ 25% price increase? (n = 699, median 0)	0 (0–60)	0 (0–30)	0 (0–30)	1 (0–12)	0.014
Elasticity @ 25%	0	0	0	4	
How many more cattle can you sell @ 50% price increase? (n = 699, median 1)	0 (0–80)	1 (0–59)	0 (0–30)	2 (0–25)	< 0.001
Elasticity @ 50%	0	1	0	0	
How many more cattle can you sell @ 75% price increase? (n = 699, median 2)	1 (0–100)	2 (0–59)	0 (0–50)	4 (0–30)	< 0.001
Elasticity @ 75%	1	0	0	1.75	
Average monthly income from all sources per household (n = 635, mean 211.25)	287.76 (8–2000)	153.84 (8–2000)	254.94 (15–1200)	148.32 (7–1000)	< 0.001
% Crop sales (n = 699, 47%)	40 (0–100)	20 (0–100)	65 (5–100)	63 (0–100)	< 0.001
% Cattle sales (n = 627, 28%)	40 (0–100)	30 (0–100)	15 (0–90)	27 (0–100)	< 0.001
% Other sources (n = 699, 25%)	20 (0–100)	50 (0–100)	20 (0–70)	10 (0–95)	< 0.001

costs), while that of revenue from cattle and cattle products sales was estimated at US$885 per herd per year. This translates to the estimated gross margin of US$569, representing 64.3% of the revenue. However, the main source of income for traditional cattle farmers across all provinces was crop farming (47%), followed by cattle farming (28%) and 25% from other sources which included rent, shop for groceries, piece work, small livestock, fishing, timber trading, and small businesses such as selling charcoal and bricks (Table 6). The average monthly income from all sources was reported at US$211.

Discussion

Assessing the state of the Zambian traditional cattle industry, husbandry practices, economics, and limitations will identify key policy leverage points on which to develop more effective interventions for the traditional cattle sector. This study highlighted the significant variation in cattle herding systems, husbandry practices, animal management, and marketing systems in different study regions in Zambia. This diversity influences the types of policies that are suitable in different regions and suggests that a "one-size-fits-all" approach would be inappropriate to improve the sector.

The importance of cattle production among traditional cattle farmers varied in all the study regions. Apart from Southern Province, rain-fed crop farming is the predominant economic activity in all agro-pastoralist communities. Therefore, draught power is the most important reason for keeping cattle in these communities, so that they can produce more crops. Overall, cattle farming was the second source of income for traditional cattle farmers. This is consistent with the finding of Grace et al. (2009) who observed that animal traction was the main purpose of keeping cattle in the cotton zone of West Africa. This finding has an implication on improving the productivity of the traditional beef sub-sector. For instance, farmers from the regions where cattle keeping is the most important activity (Southern Province) were found to be more likely to invest in animal health and practice good animal husbandry practices compared to those where it is not. This could also be the reason why traditional cattle farmers seem to be less concerned with productivity and so thus would be willing to keep low productive cattle in their herds. Moll (2005) argues that there seems to be a divergent perspective

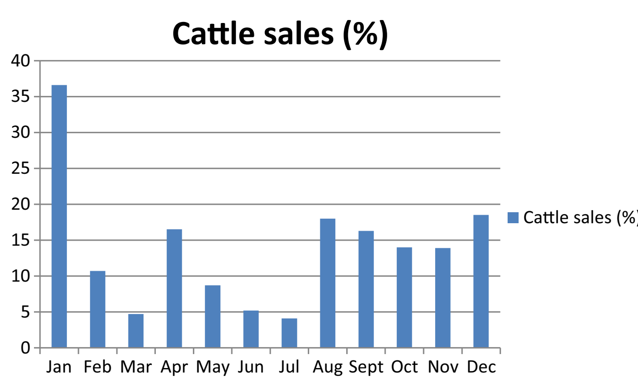

Fig. 3 Cattle sale patterns (seasonality)

Table 7 A comparison of the costs and revenue structures of traditional cattle farmers across provinces

Reported cost of rearing cattle (ZMK)	Province			
	Southern (n = 253)	Western (n = 157)	Central (n = 100)	Eastern (n = 189)
Feeding costs (median, 15.54)	39.55	5.50	12.08	19.00
Breeding costs (median, 32.57)	48.89	34.59	16.57	30.56
Treatment costs (median, 45.59)	55.25	35.94	56.11	25.04
Vaccination costs (median, 13.77)	66.73	12.57	10.64	14.97
Deworming costs (median, 28.58)	94.24	37.13	20.04	8.61
Dipping costs (median, 36.15)	130.01	14.24	58.05	14.05
Labour costs (median, 134.99)	122.61	159.31	147.37	12.34
Transactional costs (median, 5.49)	11.06	4.05	6.93	3.58
Total costs per household per year (median, 315.56)	568.34	303.33	327.79	128.15
Revenue streams (ZMK)				
Cattle sales (median, 827.54)	1974.50	787.58	867.50	744.71
Offal (median, 19.51)	34.98	24.06	14.95	2.65
Calf sales (median, 11.08)	20.16	45.75	0	0
Manure sales (median, 0.36)	7.11	12.22	0	0
Milk (median, 31.84)	4.35	0	15.89	2.02
Total revenue per household per year (median, 884.98)	2034.70	869.61	900.34	749.98
Gross margin per household per year (median, 569.42)	1466.36	566.28	572.55	621.83

between traditional cattle farmers and policy makers, where the latter are interested in improving productivity, and the former are not. This hampers the development of effective livestock policies. From these findings, we argue that a solution to effective policies should consider the variation in mindsets associated with keeping cattle in different agro-economic zones and provide suitable investment opportunities that we have suggested in the concluding remarks.

That cattle take secondary importance in income generation is also a major challenge in developing pro-poor disease control approaches (reducing vulnerability) without changing the perception and mindset that farmers can make more money if they engage in beef enterprise. Survey results revealed that traditional farmers reported high disease burden as one of the major hindrances to cattle production. Two key diseases of National Economic Importance, FMD and CBPP (Hamoonga et al. 2014; Sinkala et al. 2014), and two management diseases, Anthrax and ECF (Muuka et al. 2014; Sitali et al. 2017), were all reported in this study with significant regional variation. Currently, the government only provides ECF immunisation in Southern and Eastern provinces where the disease is endemic (Mubamba et al. 2011). However, these results demonstrate that the prevalence in Central Province where the disease was initially absent (Makungu and Mwacalimba 2014) is equally high. Therefore, our findings imply that similar immunisation programs must be initiated in Central Province. However, the findings demonstrated low uptake of vaccination practices in study regions. This could be due to lack of incentives to vaccinate cattle. To improve uptake of husbandry practices and veterinary/extension services, improving the institutional environment characterised by functioning, accessible markets for products, production factors, finance, and insurance is needed.

Despite increasing numbers of ECF cases, there is little effort by the government, because ECF is listed as a management disease (occurring due to poor management), and thus the responsibility of the farmer to manage it. Despite the importance of ECF cited by farmers, government efforts have focused more on diseases of national economic importance, with FMD topping the list due to the overall impact on trade. However, farmers do not recognise FMD to be an important disease, because it does not have much impact on production, as the disease comes periodically with high morbidity but low mortalities (Hamoonga et al. 2014). Some authors argue that FMD control is not pro-poor, as it benefits commercial interests that are involved in international trade (Perry and Grace 2009). Thus, concentrating more on FMD while neglecting ECF control in a developing country with limited potential for export in the near future is not necessarily a good strategy for improving cattle productivity (Perry and Rich 2007).

Our study found that own disease diagnosis based on symptoms was the most common method of diagnosing disease across the study regions, and thus traditional cattle farmers would attempt treatment using antibiotics regardless of the diagnosis. This signifies the low uptake of veterinary services by traditional cattle farmers. This is in agreement with Chilonda and Van Huylenbroeck (2001) who highlighted low uptake of veterinary services to be one of the major challenges to disease control. A study by Grace et al. (2009) in West Africa also found similar results, which shows that the practice is common not only in Zambia but Africa in general. This is probably due to lack of accessibility and availability of veterinary and extension services in rural areas, or where veterinary services are accessible, lack of transport, or indeed the prohibitive cost of veterinary farm visits (World Bank 2011). This finding also relates back to the lack of commercial orientation towards cattle production in different regions where even if veterinary/extension services were available, farmers would still opt for cheaper options (own diagnosis). We believe that this practice promotes spread of infectious diseases, because by the time the relevant authorities establish a correct diagnosis, the disease would have already spread to other farmers in communal grazing areas. This is particularly problematic for diseases of epidemic characteristics and compromises disease control efforts at a national level.

Lack of access to disease diagnostic facilities is a big challenge for traditional cattle farmers in remote areas of Zambia and other low-income countries hence depending on own diagnosis based on clinical symptoms which may not be accurate (McNerney 2015). Even veterinary assistants in these rural areas do not have access to diagnostic services and simply depend on clinical symptoms to diagnose disease. Diagnostic laboratories in Zambia are poorly resourced and sparsely distributed. To improve access to diagnostics, further research must investigate the possibility of using tests that do not require laboratory support, including rapid tests for use at the point-of-care in rural areas where traditional cattle producers are found.

There was also variation in the economics of the traditional cattle sub-sector across study regions. There were more cattle sales in Southern than the other provinces even though crop sales contributed equally to annual household income. The major source of income for traditional cattle farmers in Western Province was neither cattle nor crops sales, but other sources. This is because the Zambezi floodplain, where most of the cattle in Western Province are kept, is marginally suitable for crop production (Moll 2005). However, crop and cattle sales together contribute half of the annual household income in Western province. More than half of the farmers reported low farm gate prices to be one of the constraints to cattle marketing, but the study findings for price sensitivity analysis revealed that cattle price increase alone (as an incentive) does not currently drive the desire to sell more cattle. Only traditional cattle farmers in Eastern Province were relatively responsive to cattle price changes, and mainly to large changes in price. Interestingly, farmers in Southern Province are not as price responsive as farmers in other regions despite their greater market orientation. This is because culturally, keeping large cattle herds is more important for social status in Southern compared to Eastern province in Zambia (Randolph et al. 2007). These findings on marketing behaviour could be due to a lack of investment opportunities and a lack of a culture of banking and investment. However, with regard to the poor culture of banking among traditional cattle farmers, Molle et al. (2007) argues that in unstable economies of developing countries, the value of money is quickly lost through inflation as opposed keeping money through cattle. However, this does not hold under poor husbandry practices where the risk of animal death from disease and undernutrition is high. Thus, cattle are a source of savings, but an imperfect one.

The most common source of study bias in low-income countries is geographical sampling bias due to poor road infrastructure in rural areas where the target population resides (Syfert et al. 2013). In the study, the sample population was for the entire country, but sampling was only conducted in four regions. As stated earlier, this was because the four study regions hold 90% of the traditional cattle farmers in Zambia (Sinkala et al. 2014), which meant that the study was representative of the country even though excluding the 10% from other regions could be a source of bias. There were some traditional cattle farmers who could not be accessible by road. This could also be the source of bias due to the geographical distribution of farmers. Furthermore, a significant number of questionnaires ($n = 55$) were removed due to incompleteness which could have probably led to the skewness of data. The study attempted to reduce biases through systematic random sampling and to double the sample size (design effect). A simple systematic random sampling together with doubling the sample size effectively reduces geographical sampling biases even though it is costly (Salganik 2006; Fourcade et al. 2014).

A major limitation of the study was that estimates of disease prevalence were based on the clinical symptoms by traditional cattle farmers, which we did not compare with veterinary diagnoses. However, the estimates gave us an idea of the current situation and provided a basis for comparison in the study regions. Further research studies must make this comparison to come up with accurate disease prevalence in respective regions.

In conclusion, our results reveal considerable diversity in disease distribution, animal husbandry practices, economics, and challenges in cattle production and marketing in different locations of Zambia. This variation suggests that policy makers need to develop cost-effective, fit-for-purpose interventions that are grounded within their regional context. For instance, in Southern and to some extent Eastern Province where cattle play a major role in income generation, traditional cattle farmers can be more easily organised in groups to improve market coordination with other downstream actors, increasing farm income but also raising incentives to control disease and use better animal husbandry practices. Group sales via cooperatives could also facilitate linkages with formal financial institutions that will allow farmers to save/insure/grow their wealth in a less risky fashion. Due to the proximity to high-value markets in Lusaka and Copperbelt provinces, cattle marketing is less of a problem in Central province, but such areas have a high prevalence of ECF. Thus, to improve productivity in Central Province, vaccination against ECF must be initiated as in Eastern and Southern provinces, with greater attention given to its national control. Western province has a comparative advantage in livestock due to the vast Zambezi floodplain, but other businesses like timber trading and fishing seem to take preference in income generation. Improved awareness, veterinary/extension services, and market access could all help in seeing this region achieve its potential.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

Anonymous, 2015. Government Republic of Zambia. Department of Veterinary Services Annual Report. Ministry of Fisheries and Livestock., (Lusaka)

Anonymous, 2017. Government Republic of Zambia. Seventh National Development Plan 2017–2021. Ministry of National Development Planning, (Lusaka)

Chilonda, P. and Van Huylenbroeck, G., 2001. Attitude towards and uptake of veterinary services by small-scale cattle farmers in Eastern province, Zambia, Outlook on Agriculture, 30, 213–218

Du Plessis, I. and Hoffman, L.C., 2004. Effect of chronological age of beef steers of different maturity types on their growth and carcass characteristics when finished on natural pastures in the arid subtropics of South Africa. South African Journal of Animal Sciences, 34, 1–12

Fourcade, Y., Engler, J.O., Rödder, D., Secondi, J. and Brooks, T., 2014. Mapping species distributions with MAXENT using a geographically biased sample of presence data: a performance assessment of methods for correcting sampling bias. PLoS ONE, 9, e97122

Gallet, C.A., 2010. Meat meets meta: a quantitative review of the price elasticity of meat. American Journal of Agricultural Economics, 92, 258–272

Grace, D., Randolph, T., Affognon, H., Dramane, D., Diall, O. and Clausen, P.-H., 2009. Characterisation and validation of farmers' knowledge and practice of cattle trypanosomosis management in the cotton zone of West Africa. Acta Tropica, 111, 137–143

Hamoonga, R., Stevenson, M.A., Allepuz, A., Carpenter, T.E. and Sinkala, Y., 2014. Risk factors for foot-and-mouth disease in Zambia, 1981–2012. Preventive Veterinary Medicine, 114, 64–71

Lubungu, M., Chapoto, A. and Tembo, G., 2012. Smallholder farmers participation in livestock markets: the case of Zambian farmers., Lusaka. http://fsg.afre.msu.edu/zambia/WP66.pdf

Lubungu, M., Sitko, N.J. and Hichaambwa, M., 2015. Analysis of beef value chain in Zambia: challenges and opportunities of linking smallholders to markets., Lusaka. http://fsg.afre.msu.edu/zambia/wp103.pdf

Makungu, C. and Mwacalimba, K.K., 2014. A quantitative risk assessment of bovine theileriosis entering Luapula Province from Central Province in Zambia via live cattle imports from traditional and commercial production sectors. Preventive Veterinary Medicine, 116, 63–74

McNerney, R., 2015. Diagnostics for developing countries. Diagnostics, 5, 200–209

Moll, H.A.J., 2005. Costs and benefits of livestock systems and the role of market and nonmarket relationships. Agricultural Economics, 32, 181–193

Moll, H.A.J., Staal, S.J. and Ibrahim, M.N.M., 2007. Smallholder dairy production and markets: a comparison of production systems in Zambia, Kenya and Sri Lanka. Agricultural Systems, 94, 593–603

Mubamba, C., Sitali, J. and Gummow, B., 2011. Trends of selected cattle diseases in eastern Zambia between 1988 and 2008. Preventive Veterinary Medicine, 101, 163–172

Muma, J.B., Munyeme, M., Samui, K.L., Siamudaala, V., Oloya, J., Mwacalimba, K. and Skjerve, E., 2009. Mortality and commercial off-take rates in adult traditional cattle of Zambia. Tropical Animal Health and Production, 41, 783–789

Muma, J.B., Pandey, G.S., Munyeme, M., Mumba, C., Mkandawire, E. and Chimana, H.M., 2011. Brucellosis among smallholder cattle farmers in Zambia. Tropical Animal Health and Production, 44, 915–920

Muuka, G., Songolo, N., Kabilika, S., Hang'ombe, B.M., Nalubamba, K.S. and Muma, J.B., 2012. Challenges of controlling contagious bovine pleuropneumonia in sub-Saharan Africa: a Zambian perspective. Tropical animal health and production, 45, 9–15

Muuka, G.M., Chikampa, W., Mundia, C., Bounavoglia, D., Pini, A. and Scacchia, M., 2014. Recent observations on site reactions in cattle to vaccination against contagious bovine pleuropneumonia (CBPP) using T1/44 vaccine in Zambia. Tropical Animal Health and Production, 46, 481–483

Naziri, D., Rich, K.M. and Bennett, B., 2015. Would a commodity-based trade approach improve market access for Africa? A case study of the potential of beef exports from communal areas of Namibia. Development Policy Review, 33, 195–219

Perry, B. and Grace, D., 2009. The impacts of livestock diseases and their control on growth and development processes that are pro-poor. Philosophical Transactions of the Royal Society B: Biological Sciences, 364, 2643–2655

Perry, B.D. and Rich, K.M., 2007. Poverty impacts of foot-and-mouth disease and the poverty reduction implications of its control. The Veterinary record, 160, 238–241

Randolph, T.F., Schelling, E., Grace, D., Nicholson, C.F., Leroy, J.L., Cole, D.C., Demment, M.W., Omore, A., Zinsstag, J. and Ruel, M., 2007. Invited review: role of livestock in human nutrition and health for poverty reduction in developing countries. Journal of animal science, 85, 2788–800

Salganik, M.J., 2006. Variance estimation, design effects, and sample size calculations for respondent-driven sampling. Journal of Urban Health, 83, 98–112

Sinkala, Y., Simuunza, M., Pfeiffer, D.U., Munang, H.M., Mulumba, M., Kasanga, C.J., Muma, J.B. and Mweene, A.S., 2014. Challenges and economic implications in the control of foot and mouth disease in sub-Saharan Africa: lessons from the Zambian experience. Veterinary Medicine International, 2014, 12

Sitali, D.C., Mumba, C., Skjerve, E., Mweemba, O., Kabonesa, C., Mwinyi, M.O., Nyakarahuka, L. and Muma, J.B., 2017. Awareness and attitudes towards anthrax and meat consumption practices among affected communities in Zambia: a mixed methods approach. PLOS Neglected Tropical Diseases, 11, e0005580

SNV, 2012. Assessment of opportunities for improving dairy production, marketing, and adoption of good animal husbandry practices within traditional cattle keeping areas of Zambia., Lusaka. http://saipar.org:8080/eprc/bitstream/handle/123456789/307/SNV_Assessment of Opportunities for Improving Dairy Production%2C Marketing and Adoption of Good Animal Husbandry_Dec. 2012.pdf?sequence=1

Steinfeld, H., Wassenaar, T. and Jutzi, S., 2006. Livestock production systems in developing countries: status, drivers, trends. Scientific and Technical Review of the Office International des Epizooties, 25, 505–516

Syfert, M.M., Smith, M.J., Coomes, D.A., Meagher, T. and Roberts, D., 2013. The effects of sampling bias and model complexity on the predictive performance of MaxEnt species distribution models. PLoS ONE, 8, e55158

World Bank, 2011. What would it take for Zambia's beef and dairy industries to achieve their potential? Finance and private sector development Unit, Africa Region. https://openknowledge.worldbank.org/bitstream/handle/10986/2771/623770ESW0Gray000public00BOX361530B.pdf?sequence=1