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Cattle Productivity under Traditional Village Husbandry System in Sellale, Central Ethiopia: A Four and a Half Year Herd Follow-Up

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***Abstract* – We conducted a longitudinal cattle productivity survey over 4.5 years amongst 20 traditional small-holder farms which included 794 cattle, in Sellale, Central Ethiopia. Upgraded high yield cattle (Holstein Friesian and their crosses) were kept the same way as traditional zebu breeds. The aims of this study were to assess herd dynamics, productivity profile, and investigate production constraints in these traditional small-holder farms. The results showed that overall herd size had increased during the study period, in particular the cross-breed animals but that all animals had low productivity (fertility and milk production). Cross-breeds showed highest adult mortality and highest weight loss at the end of the dry season. The main constraint to productivity was lack of proper feed. Constraints and recommendations are discussed.**

***Keywords* – Cattle, Ethiopia, Herd-Book, Small-Holders, Productivity.**

I. Introduction

Livestock are an integral part of the predominant small-holders crop-and livestock mixed farming system in the Ethiopian Highlands. Ethiopia has with 50 million heads, the largest cattle herd in Africa and its economy is based mainly on its agriculture sector (CIA 2009; Demeke 2006). Traditional zebu breeds (*B. indicus*) as multipurpose animals make the majority of the national herd whereas overall only 1% are upgraded milk producing exotic breeds (e.g. Holstein Frisian and their crosses). The latter are predominantly found in urban and peri-urban areas. Cattle in the rural Highlands are mainly kept for draft power, milk, meat, manure and social security; Oxen as draft animals are intimately linked with agriculture (Tschopp *et al.*, 2010). The livestock sector faces major challenges that contribute to the maintenance of poor productive performances e.g. genetically poor productive breeds; lack of fodder due to land degradation/erosion; change in land and water use; pasture overstocking; poor veterinary services, and animal diseases (Hurni 1993; Gete and Hurni 2001; Tadesse 2001; Gebremedhin *et al.*, 2004; Tschopp *et al.*, 2010).

Sellale, a commonly named region in North-West Shoa (Oromia region) is one of the major milk producing area in Ethiopia. Fertile land that includes pasture land, as well as favorable climatic conditions, freedom of major chronic infection diseases known to be severe constraints to animal productivity and economies such as Trypanosomiasis or Contagious Bovine Pleuropneumonia (CBPP) (Agyemang *et al.*, 1997; Swallow 2000; Lesnoff *et al.*, 2004; Mugunieri and Matete 2005), decades of upgraded cattle distribution, strengthening of artificial insemination and extension workers services and closeness to the capital Addis Ababa where there is a rapid increase demand for animal products are all assets and potentials that are conducive for dairy development. However to this date, commercial livestock industry is still in its infancy and most production systems remain traditional small scale subsistence systems characterized by low productivity.

Longitudinal productivity studies are essential to capture constraints and production potentials for farms. There is a shortage of published data in Sub-Saharan Africa on such long term studies. Examples of production constraints have been described by many authors but these studies were either non Sub-Saharan African ones (Houtabarat *et al.*, 1997; Susuki *et al.*, 2006), short term ones (Susuki *et al.*, 2006; Gashaw *et al.*,2011) or focusing on particular diseases such as Trypanosomiasis (Swallow 2000; Mugunieri and Matele 2005) or gastro-intestinal nematods (Zinsstag *et al.*, 1997) and only rarely addressed productivity per se (Itty *et al.*, 1997; Agyemang *et al.*, 1997).

This current study performed a four and a half year longitudinal productivity survey in cattle from small-holders in Sellale. The aims were to assess herd structure and dynamics, and collect baseline productivity data (reproduction, lactation, mortality and off-takes rates) to investigate production constraints, gaps and opportunities for better productivity under local conditions among these traditional small holders.

II. Material and Methods

A. Study sites

The study area was located in North-West Showa, Oromia Region (Central Ethiopia), commonly called Sellale, in two Woredas (districts), Mukatori and Degam situated around 80 and 120 km from Addis respectively on the main Addis Ababa-Debre Markos-Bahar Dar tarred road (Fig. 1). The elevation was between 2730 and 3000 masl.

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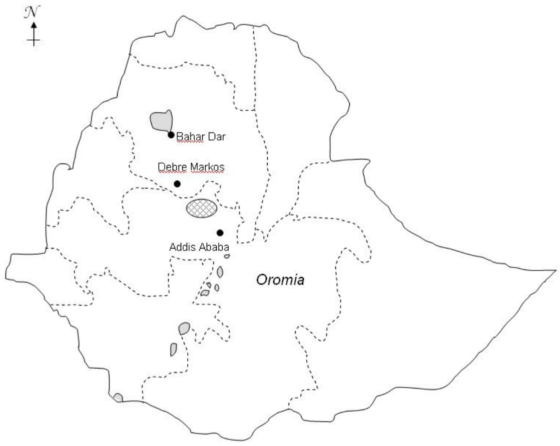

Fig.1. Map of Ethiopia showing the Oromia region and in grey checked circle the study area.

Sellale enjoys a temperate climate with biphasic season: a heavy rain season between June and September (*kiremt*) and a dry season (*bega*) from October to May-sometimes interrupted by a short rainy season in spring (*belg*).

Most of the land is used for agriculture (66 %), 20% is pasture and the rest is fallow land. The districts have around 180 000 cattle of whom 91.5% are local zebu breeds (*B. indicus*) and 8.5% are Holstein-zebu crosses to various degree (Mukatori Agricultural Bureau). Main cattle fodder is pasture grass and crop residues from primarily barley followed by teff (*Eragrostis tef*) and wheat. Supplementation with *frushka* (wheat bran) and *fagulo* (nough) is sporadic and in recent years *sinar* (forage closely related to oats) is sometimes supplemented but only in June.

B. Study farms and animals

Twenty farms were selected in the two Woredas, 8 around Mukatori town (from 2 Kebeles) and 12 around Degam town (from 2 Kebeles). All farmers were small-holders, involved in mixed livestock-cropping agriculture. They were all members of primary dairy cooperatives that are regrouped under the Sellale Dairy Cooperative Union (SDCU). Selection criteria of farms included easy accessibility with a motorbike throughout the year (including during heavy rainy season), willingness of owners to participate in a long term study and similarities amongst the farms in husbandry/management practices. All cattle in the farms were included in the study.

Each animal was recorded during an initial farm visit between September and October 2005 (age, sex, breed, function/purpose, parity, date of entry in the farm, type of entry in the farm e.g. purchase-gift-birth) so as to start the herd follow up with an initial stock. Breeds were categorized into local zebus, crossbreeds and Holstein Friesian. Exact exotic blood levels was not known, we therefore considered "Holstein" as animals having more than 75% Holstein blood. Each animal was given a unique ID number. From then on, each farm was visited by a veterinary technician every 14 days by means of motorbike for the following 4.5 years and the herd book updated at each visit. Every new animal entering the herd was given a unique numerical ID.

Parameters recorded during each visit were, in addition to baseline identification (sex, breed, age, function): new animals entering the herd (purchase, birth, gift), animals that have left the herd since the last visit (death, selling, theft), price of sold or purchased animal, weight of newborn calf, fertility parameters, and morbidity/mortality parameters.

In addition life weight were recorded twice a year, once in October after the end of the big rainy season and the second time in may at the end of the dry season with a measuring heart girth band. Calves weight was recorded after birth using a hanging scale, if possible the day they were born. As this was often not possible and the technician would see the animal only during his next visit, 3 consecutive weight measurements were taken at 14 days interval and birth weight plotted using a regression analysis. Calves weight was further monitored by heart girth measurement once a month until they were 12 months old. An attempt was made to record milk productivity where once a month, farmers milked their animals in a measuring jar and recorded the amount.

Structured forms were prepared for each farm hence constituting the farm herd book. The study was terminated in May 2010.

All animals were dewormed with Mebendazol boli (Ashialben 2500, Ashish Life Science PVT, 124 Mumbai, India) twice a year (after the big rainy season in October and around April in the middle of the dry season) alternated with Tetraclozan boli (2400mg, Oxyclozanide & Levamisole Hydrochloride, Choong Ang Biotech CO., Korea).

C. Data management and statistical analysis

All data were entered into Microsoft Access Tables. Data analysis was done with Stata Version 10.1 (StataCorp, Texas, USA), SAS^{TM} (SAS Inc. Cary, USA) and with Microsoft Excel. The majority of data were analyzed descriptively. Calving rates, off-take rates, sales rate and mortality rates were derived from the collected data. Net off-take rates were calculated as number of animal removals (sold or slaughter) minus animal additions (purchases or gifts) divided by the start herd size (opening number) multiplied by 100. No thefts were recorded hence this category does not appear in the calculations. Sales rate were calculated as number of sold animals divided by the start herd size multiplied by 100. General linear mixed models were used for the analysis of lactations and birth weight of calves. Results are shown as SE, 95%CI and p-value. All prices of purchased and sold animals were recorded in Ethiopian birr. Since the currency was subjected to inflation, all prices were converted into US dollar according to the exchange rate on the day of the animal's transaction (www.oanda.com).

III. Results

A. Herd structure and herd dynamics

Overall during the whole study period and considering all animals that entered the study (N=794), 36.8% were zebus, 44.6% crossbreeds and 18.6% Holstein. Female numbers (51.5%) approximately equaled the numbers of

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total males (male uncastrated: 28.1%, ox: 20.4%). Milk production involved 40.3%, reproduction 42.6% and draft 46.3% of the animals respectively and included all 3 breeds. Zebus however, made the bulk of the draft animals (55.8%) whereas crossbreeds were the majority of milk producing animals (40%). The great majority of draft animals were oxen (82.2%). Zebus were multi-purpose animals, also exclusively used in fattening, whereas Holsteins were mainly used for milk production (64.3%). Cross-breeds were equally used for milk production (44.9%) as for draft purpose (43. 3%).

In total 331 animals were recorded in the 20 farms in October 2005. In May 2010, there were 437 animals, showing a total herd increase of 32% over the entire study time. Table 1 shows the herd composition by breed, sex and age categories throughout the years. Cross-breeds have increased by 82%, whereas zebu and Holstein numbers have remained stable.

B. Herd turn-over and off-takes

The great majority of animals were born on the farm (N=554; 69.8%) whereas 235 (29.6%) were purchased and 5 animals (0.6%) came in as gifts. Among the purchased animals, 160 came from local village markets and 55 from neighboring farms.

The great majority of the animals that left the farms were sold (N=244, 68.5%), whereas 94 animals (26.4%) died of natural causes and 18 (5%) were slaughtered privately in farm backyards. Main reasons for selling and-or slaughtering an animal were mainly for immediate cash flow (88% of the cases) or because the animal was either sick (5.6%) or old (3.2%). Table 2 shows the average annual net off-take rates per category

Table 1: Herd composition between the registration of the initial stock (Sept-Oct 2005) and May 2010, by breed, sex, age class and year. Calculation takes in account the initial registered animals, the added animals (born or purchased) and the animals that left the farms (death, sold, slaughtered)

		Initial stock	by end 2005	by end 2006	by end 2007	by end 2008	by end 2009	by May 2010
Variables	Categories	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)
Breed	Zebu	120 (36.2)	132 (35.4)	132 (33.9)	131 (32.1)	123 (30.5)	125 (28.8)	122 (27.9)
	Cross	126 (38.1)	145 (38.9)	167 (42.9)	190 (46.6)	194 (48)	221 (50.9)	229 (52.4)
	Holstein	85 (25.7)	96 (25.7)	90 (23.2)	87 (21.3)	87 (21.5)	88 (20.3)	86 (19.7)
Sex	Female	195 (58.9)	221 (59.2)	228 (58.6)	237 (58.1)	234 (57.9)	252 (58.1)	257 (58.8)
	Male	68 (20.5)	80 (21.5)	97 (24.9)	105 (25.7)	99 (24.5)	116 (26.7)	118 (27)
	Ox	68 (20.6)	72 (19.3)	64 (16.5)	66 (16.2)	71 (17.6)	66 (15.2)	62 (14.2)
Age class	< 1 year	60 (18.1)	85 (22.8)	122 (31.4)	150 (36.8)	156 (38.6)	197 (45.4)	204 (46.7)
	1-3 year	61 (18.4)	65 (17.4)	63 (16.2)	69 (16.9)	70 (17.3)	70 (16.1)	71 (16.3)
	> 3 year	175 (52.9)	181 (48.5)	178 (45.7)	168 (41.2)	160 (39.6)	156 (36)	151 (34.5)
	> 10 year	35 (10.6)	42 (11.3)	26 (6.7)	21 (5.1)	18 (4.5)	11 (2.5)	11 (2.5)
Total Herd Size		331	373	389	408	404	434	437

Table 2: Average annual selling rate (SR), net off-take rate (NOR) and mortality rate (MR) by categories for the entire study period

			Entry			Exit			SR (%)		NOR (%)		MR (%)	
Vari-able	Category	Total registered animals	Born	Gift	Purchased	Death	Sold	Slaugh-tered	Average per month	SE	Average per month	SE	Average per month	SE
Sex	Female	409	332 (81.2)	2 (0.5)	75 (18.3)	48 (11.7)	89 (21.8)	13 (3.2)	1.2	1.6	0.4	1.1	5.1	1.3
	Male	223	180 (80.7)	3 (1.3)	40 (18)	41 (18.4)	64 (28.7)	1 (0.5)	1.7	2.2	0.6	1.3	10.2	2.2
	Oxen	162	42 (26)	0	120 (74)	5 (3)	91 (56.2)	4 (2.5)	4.5	5.8	0.1	3.3	1.9	0.7
Breed	Zebu	292	166 (56.8)	0	126 (43.2)	30 (10.3)	132 (45.2)	7 (2.4)	44.0	4.0	42.9	1.4	5.7	1.4
	Cross	354	271 (76.5)	1 (0.3)	82 (23.2)	40 (11.3)	78 (22)	7 (2)	21.7	1.5	21.2	0.7	5.6	1.4
	Holstein	148	117 (79)	4 (2.7)	27 (18.3)	24 (16.2)	34 (23)	4 (2.7)	16.3	1.4	15.8	0.5	6.3	1.3
Age class	Calf	330	325 (98.5)	0	5 (1.5)	40 (12.1)	56 (17)	1 (0.3)	0.9	2.3	-0.1	2.4	12.0	4.6
	Juvenile	105	63 (60)	1 (0.9)	41 (39)	17 (16.2)	25 (23.8)	4 (3.8)	1.6	1.1	-0.3	2.0	5.7	2.5
	Adult	308	144 (46.7)	4 (1.3)	160 (52)	25 (8.1)	133 (43.2)	7 (2.3)	2.7	2.4	0.9	0.5	3.7	1.1
	Old	51	22 (43.1)	0	29 (56.9)	5 (9.8)	30 (58.8)	6 (11.8)	43.3	5.9	42.4	7.3	5.5	2.4

C. Mortality due to natural death

Among the 94 animal that died of natural causes, 40 (42.5%) were calves less than 12 months of age. Cross breeds accounted for the majority of natural deaths (N = 40; 42.5%). Table 2 shows average annual mortality rate age- sex and breed.

Overall the majority of natural deaths (40.4%; N=38) occurred during *kiremt,* the big rainy season (June-September), and the minimum (22.3%) during the dry *bega* season (Oct-Jan). Overall adult mortality showed 2 peaks, one in April-May (end of the dry season) and one in August-Sept (end of the big rainy season). Trends however varied by sex and breed:

Cross-breed mortality peaked in April-May (10/22 animals) whereas 53.3% of the Holstein (8/15 animals) died between August and September. Mortality curve of zebus was more or less constant throughout the year. Females mortality peaked at the end of the big rainy season (August-September) (10/27 animals, 37%), in the opposite of bulls which peaked during the end of the dry season between April and June (1 out of 22 animals, 45%). Forty animals died in their first year of life; among them 20 (50%) died within the first 6 months. Five calves (12.5%) died during the first 3 months of life. Mortality peaked in calves aged 5 to 7 months (N=18, 45%). Main mortality peak was during the dry season (April-June) 45% (N=6) followed by a second peak in September at the end of the dry season (15%) and a third in December (15%).

D. Fertility

During the study time 156 cows gave birth to 249 calves (averaging grossly 1.6 calves per cow for 4.5 study years). Nearly half of these cows were cross breeds (N=76, 48.7%), followed by 45 Holstein (28.9%) and 35 zebus (22.4%). Thirty cows (19.2%) were older than 10 years, of which 9 were older than 15 years at the time of calving. Over half had only 1 calf during the entire study period (N=83; 53.2%). Mean annual calving rate during the study period was 40.6% (SE ± 2.26). No abortions were recorded. A significant overall calving minimum frequency was observed during the big rainy season between June and August (Fig. 2).

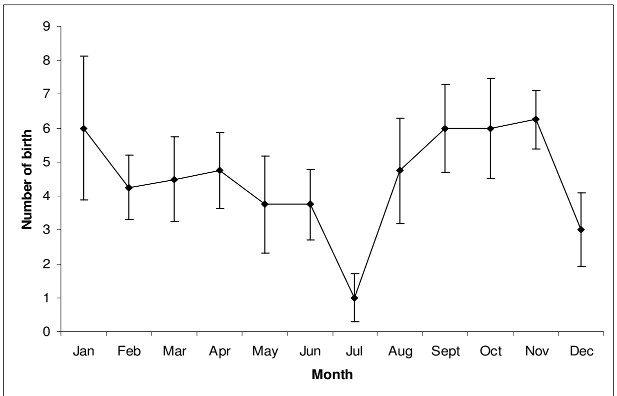

Fig.2. Overall number of calving by months (N=156)

Data from 102 cows (Table 3) that have calved at least twice during the time of the study showed that mean calving interval was shortest in Holstein (568.91 days; 95%CI: 502.16 – 635.67) and longest in zebus (692.77 days; 95%CI: 574.69 – 810.85). Mean calving interval did not differ statistically between breeds (p: 0.09).

E. Lactation length

Milk production was monitored in 164 cows, of which 128 finished their lactation by the end of the study (Table 4). Mean lactation length did not differ statistically between the breeds (p: 0.71). Twenty cows were monitored through two lactation cycles. There was no statistical difference (p = 0.21) in lactation length between the first lactation and the second lactation

Data from 140 lactating cows were used in a 10 month follow-up after birth. Accurate milk production could not be assessed since calves were also suckling the dams, hence only trend of lactation curves are presented. All 3 breeds showed a similar trend with a maximum production during the first month after birth and steady decline until 3rd-4th month 4. From the 4th month on, milk production plateau-ed. Overall daily mean production by breed resulted in 3.6 liters for zebus, 4.5 liters for cross-breeds and 5.6 liters for Holsteins. The estimated total lactation production for 365 days was 1084 liters for zebus, 1667 liters for crossbreeds and 2314 liters for Holsteins.

F. Animal weight

Two hundred and five adult animals were weighed in October (after the big rainy season) and in May towards the end of the dry season. All animals lost weight between both seasons. Overall average weight loss was 8.9 Kg/animal (p:0.01). Biggest and statistically most significant loss was observed in crossbreeds (7.5% weight loss; p= 0.0001) and un-castrated males (weight loss 12.6%; p= 0.01). Oxen lost only 2.5% of their body mass which wasn't statistically significant (Table 5).

In total, 196 newborn calves were weighed; among them 58.2% were females. The majority of the calves were crossbreeds (60.2%). Birth weight varied significantly depending on the breed (p=0.003) with Holstein having the highest (34.2 Kg; 95%CI: 31.7; 36.7) and zebus the lowest (28 Kg; 95%CI: 26.1; 29.9) mean birth weight. Sex did not influence birth weight (p=0.17).

Breed was the only significant variable (p= 0.0075) that affected significantly body weight increase of calves during their first 12 months of life. Holstein calves gained almost 19 kilos more than zebu calves but only 3 kilos more than cross-breed calves.

G. Selling and purchasing, prices, benefits

The great majority of farmers (96.3%) sold animals because they needed immediate cash. Number of sold animals dropped significantly in March, July and November. These months coincided with the months when prices fetched for animals were lowest. Animal price and number of animal sold peaked before major Ethiopian holidays. Overall more animals have been sold than purchased.

Table 3: Calving interval information from 102 animals

	Zebu	Crossbreed	Holstein
Number of animals	18 (17.7%)	47 (46%)	37 (36.3%)
Mean days	692.77	651.14	568.91
SD	237.44	214.44	200.20
SE	55.96	31.27	32.91
95%CI	574.69 – 810.85	588.18 – 714.11	502.16 – 635.67
Minimum days	361	320	226
Maximum days	1268	1425	1197

Table 4: Lactation length information from 128 cows

	Zebu	Crossbreed	Holstein
Number of animals	27 (21%)	66 (51.6%)	35 (27.4%)
Mean days	420.22	424.53	409.97
SD	277.76	196.08	178.89
SE	53.45	24.13	30.23
95%CI	310.34 – 530.10	376.32 – 472.73	348.52 – 471.42
Minimum days	110	105	191
Maximum days	1230	991	907

Table 5: Weight loss amongst 205 adult animals between the end of the rainy season (October) and the end of the dry season (May), by breed and sex

	Categories	Number of animals	Mean weight October (95%CI)	Mean weight May (95%CI)	Mean weight difference	Mean % weight loss	p-value
Breed	Zebu	60	289.7 (268.9-310.6)	276 (248.4-303.6)	13	4.5	0.2
	Crossbreed	94	326.5 (306.6-346.3)	301.8 (283.8-319.8)	24.7	7.6	0.0001
	Holstein	51	380.9 (348.3-413.6)	356.5 (324.2-388.7)	24.5	6.4	0.03
Sex	Female	132	294.8 (279.8-309.9)	273.9 (259-288.8)	21	7	0.0001
	Male	25	363.8 (317.9-409.8)	317.9 (279.2-356.6)	46	12.6	0.01
	Oxen	48	405.9 (379.3-432.6)	395.9 (365.5-426.3)	10	2.5	0.35

After having been purchased, half of the animals (52.3%) were kept between 1 and 3 years before being sold again; this was particularly the case for oxen (49.2%) and males (75%); 13% of all animals were kept longer than 10 years. The great majority involved in these transactions were zebus (86%).

We followed 97 animals that were purchased and sold during the time of the study. Without taking in account cost of feeding, cost of veterinary treatment, various benefits (e.g. milk yield and draft) but only looking at crude trading prices to gain information on cash benefit/loss, a third (30 %) of the farmers sold their animals with a net cash deficit, whereas 50% sold their animals with no- to marginal profit.

IV. Discussion

Scarcity of grazing land, overstocking and subsequent land degradation leading to further fodder scarcity is a current dramatic problem in the Ethiopian Highlands described in length by many authors (Teketay 2001; Tadesse 2001; Tschopp *et al.*, 2010). Despite the high potential of the area for dairy development, the feed shortage problem was, like in most parts of the country (Dejene *et al.*, 2009) never properly addressed. In our study area, grazing land was a third of the land allocated for crops, and is rapidly decreasing due also to the expansion of peri-urban settlements. But on the other hand herd size has increased by 32% over the last 5 years. Cross-breeds have increased by 71%, highlighting the importance for farmers to have productive cattle. Selling of liquid milk and milk products is an important source of income. However, despite having a growing number of upgraded higher yielding animals, farmers did not reduce their herd size putting further strain on fodder availability and used same husbandry practice for high yield animals as for their traditional low productive zebus.

Poor productivity

Cross-breeds and Holstein cows produced only 0.9 liter and 2 liters more milk per day respectively in average than zebus. These figures are not entirely accurate since production was measured after the calf had suckled the cow. However, these results show that Holsteins and their crosses can definitively not produce to their genetic potential. In comparison, upgraded animals produced in intensive urban dairy farms in average 11.7 liter per day per cow if adequately fed as opposed to 4.5 - 5.6 liters per day in our study) (Tschopp, data unpublished).

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Considering the price of 1 liter milk, these 6 liters difference would mean around 3.50 USD production loss per cow per day for the owner.

Similarly, mean calving interval was much longer than the one described by previous authors in Ethiopia (Bekele *et al*., 1991; Shiferaw *et al*.; 2003, Lobago *et al*., 2007). There was no statistical difference in mean calving interval between breeds when kept under this traditional management system. Calving interval up to 47 months and lactation length of over 900 days were also recorded which highlights poor breeding management.

Fertility and milk data collected in this study highlight the very poor productivity of cows, in particular cross breeds and Holsteins, for which the full production potential is not used. We postulate that the main reason is mainly poor nutritional status. Other factors are probably poor heat detection, poor AI technique, and calf suckling.

Physiological differences in the hypothalamic, pituitary and ovarian relationships between *B. indicus* and *B. taurus* explain the delayed puberty, postpartum anoestrus and long inter-calving interval in zebus (Chenoweth 1994; Abeygunawardena and Dematawewa 2004). However, poor body condition was shown to be a major contributor to poor fertility regardless of breeds (Mukasa-Mugerwa 1989; Abeygunawardena and Dematawewa 2004). Postpartum anoestrus period is delayed by loss of bodyweight, and even when the animal regains the optimal weight, ovarian activity will not start again immediately which can lead to inter-calving period of 26 months (Mukasa Mugerwa *et al*., 1971; Hale 1975; Enwistle 1983); also the weight re-gain requires bigger quantity of food as body mass produced during re-alimentation is a less efficient process than maintenance (Zerbini *et al*., 1996a). Our study results are in line with these statements: Cross-breeds and Holstein showed the biggest weight loss during the dry season, which was likely to hamper ovarian activity. Maximum calving rate was found between September and December, meaning the animals conceived between December and March, a period of best body weight. The highest mortality of adult cross-breeds was also found at the end of the dry season, highlighting the negative effect of undernourishment not only on fertility but also on mortality in this particular breed.

A second contributor to poor fertility is calf suckling. Although necessary in *B. indicus* in particular, to let the milk down and shown to increase overall the milk yield over the whole lactation (Reinhardt and Reinhardt 1981; Little *et al*., 1991), calf suckling prolong the post partum anoestrus period (Little *et al*., 1991; Shiferaw *et al*., 2005). Early calf withdrawal (Abeygunawardena and Dematawewa 2004) or temporary removal of the calf for 96 hours (temporary interruption of suckling, TIS) have been suggested to induce a shortening of the interval to next oestrus without negative effects on the calf (Soto-Beloso *et al*., 2002; Mahecha *et al*., 2004). These techniques could be used in the Sellale context to improve fertility but warrant further research under local conditions.

Mortality

Highest mortality rate was found in young calves. Main causes were thought to be starvation (qualitative and quantitative lack of nutrients). Diarrhea was a problem mainly seen when calves fed on fresh grass during the big rainy season (e.g. Clostridia, internal parasites), whereas infectious diseases (e.g. pneumonia) played a minor role (*personal communication, veterinary clinic Mukatori*). This is reflected by the seasonality of death occurrence: 45% of all calves death occurred between Apr-June, the end of the dry season followed by a second peak in September towards the end of the big rainy season (15% of all deaths) and a third peak in December (15%), when there is food shortage again (the crops are harvested in January, thus no crop residue is available yet).

The majority (45%) of the calves died between 5-7 months of age. During the first months of life, calves are suckling their mother *ad libitum*. After 2-3 months, the calf is left to suckle just for a couple of minutes (restrictive suckling) in order to let the dam's milk down. The rest of the milk is then milked twice a day by hand for human consumption. Hence, even during the suckling phase, calves are likely to be underfed. Malnutrition and lack of micronutrients has shown to affect disease resistance and impair cell mediated and humoral immune response of the adaptive immune system (Griebel *et al.*, 1987; Spears 2000; Chase *et al*., 2008). In addition, around 4-6 months of age, depending on breed, the calf immunity reaches a natural low point: the protective maternal antibodies have weaned out while the acquired immunity is building up and weak leading to an increase of disease incidence and severity (Dwinger *et al*., 1991; Pollock *et al*., 1994; Lorenz *et al*., 2011).

High mortality in these young animals lead to a decrease numbers of replacement animals, which have then to be purchased.

Amongst adults, females mortality rate was nearly twice (8.1%) of those of bulls and oxen. Main reason was, as with calves, lack of fodder (*personal communication*). Since draft animals are essential for the agriculture, they are usually better looked after and fed with supplemental feed. Interestingly, the study showed that females predominantly died at the end of the rainy season when grass is plentiful. The reason could well be metabolic through a rapid change of diet (starvation at the end of the dry season followed by fresh grass shoots high on protein during the rainy season). In the opposite, bulls and oxen predominantly died at the end of the dry season between April and June (45%).

Most of the Holstein in our study died between August and October, when young fresh grass is at his highest, suggesting metabolic disorders. Cross-breeds in the contrary died mainly during the dry season between April and May. Amongst all breed types, cross breeds also lost most weight during the latter season.

Knowledge of these differences in mortality by age, breed and sex can further help adjust feeding strategy by for instance supplementing selected animals during restrictive period of times when most needed (selective supplemental feeding) so as to use supplemental feed in the most cost-effective way for a maximized animal survival rate and productivity in particular when nutritional value and fodder quantity is at its lowest.

Fodder

Crop residues are widely used in Sellale as major basal roughages. They have high cell wall content and high concentrations of phenolic compounds, but are low on nitrogen, energy value, vitamins and minerals (Kabaiji and Little 1988; Reed and Goe 1989). The addition of by-pass proteins such as high protein leguminous plants, legume hay, urea treated straw have been used worldwide for decades to increase fiber digestibility and rumen fermentation and thus animal productivity (Mpairwe 1998; Hinderichsen *et al*., 2004, Misra *et al.,* 2006; Roy and Rangnekar 2006; Derso 2009). In Ethiopia, Dejene *et al* (2009) showed that teff straw treated with 4% urea, supplemental feeding of linseed cake and wheat bran during the dry season increased food intake, milk productivity, bodyweight and farmers net profit in addition to a maximized utilization of locally available feed resources. However, despite knowledge and data accumulated over the last decades globally and nationally, these easy techniques to increase animal productivity, remain largely inexistent in Ethiopian rural systems in large and Sellale in particular. In our study sites, there was hardly any on-farm fodder production that would provide a constant supply of by-pass protein and would cut costs of purchased supplemental feed. Due to land scarcity (land competition with crop land), lack of time and interest of farmers (personal observation) these options were considered with skepticism by the small-holders in Sellale, an attitude already mentioned by other authors (Kabiziri *et al*., 2006). Purchased feed supplementation was in form of *sinar* (new) in June-July only, *Frushka* and *Fagulo* ("noug" cake, *Guizotia abyssinica*), however due to their high cost they are often not affordable to small-holders and are rapidly deteriorated by sun and inadequate storage. Crop residues of properly collected and stored could allow in Sellale a more constant supply of a higher nutritive product throughout the year. However, the full potential of feeding crop residues was not used in our study farms, a scenario already described 25 years ago by Reed and Goe (1989): they were not collected by farmers, animals trampled fields thus wasting the residues, nutritive quality of the straw likely decreased with time spent in the field, and overall were only available seasonally after the fields had been harvested in January.

Gaps, constraints and opportunities

This study highlights an existing bottleneck caused by increasing number of animals, decreasing grazing land and fodder availability and thus poor animal productivity. As suggested previously by many authors, this could potentially be resolved by 1) de-stocking herds, 2) increasing fodder availability, and 3) intensifying farming (Dejene *et al*., 2006; Tschopp *et al.,* 2010; Derso 2009).

Use of cow traction in peri-urban areas is a concept already suggested in the 80s and 90s as being an attractive option to reduce herd size while at the same time demand for milk is growing (Zerbini *et al*., 1996c). However a working cow if to keep up milk productivity will have higher nutrient requirement as draft oxen (Zerbini *et al*., 1996b; Agyemang *et al*., 1991). In our study no cow was used as draft animal.

Fodder shortage was the main productivity constraint in our study. Site-specific research is warranted to define best options for on-farm by-pass protein production making use of local conditions and most efficient use of crop residues and land resources. A good extension worker program to inform farmers about best options is essential. A participatory method of learning, technology adaptation and dissemination has been part with success of agriculture extension in many countries in form of Farmer field schools (FFS) (Davis *et al*., 2012).

More research is also needed to quantify the energy requirement for the different functions that animal have in Sellale (e.g. draft, milk) and for the different breeds used in this traditional system in order to maximize land and resource utilization.

V. Conclusion

Our study showed a poor herd and breeding management and a lack of herd monitoring system. It also showed that the main constraint to productivity was lack of fodder (quantitative and qualitative) having a negative repercussion on fertility, milk productivity, immunity, and mortality, thus impacting negatively on the economy at household level. The baseline data collected can be a pre-requisite for further analysis of the economics at household and village level.

Despite decades of published reports and manuscripts on recommendations for better feed supply, this problem remains neglected and not addressed by most agricultural organizations whose main focuses often remain on market access, and genetic improvements of dairy animals. In Sellale, increased integration of cross breeds is essential in order to meet the growing urban demand for milk and milk products, however management of these animals has to be reevaluated and addressed properly by on-farm improved feeding strategies and husbandry. New opportunities are emerging for Sellale small-holders but compromises between herd size, herd productivity and maximizing land resource use for crop, fodder and grazing will have to be found.

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