A health and demographic surveillance system of cattle on communal rangelands in Bushbuckridge, South Africa: baseline census and population dynamics over 12 months

By

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Working in rural communities is a humbling experience, and applying veterinary knowledge to improve their livelihoods ever so slightly brings out the humane aspect of the One Health concept.

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List of Abbreviations

AHT	Animal Health Technician
BCS	Body Condition Score
CAHW	Community-based Animal Health Worker
CIRAD	French Agricultural Research Center for International Development
DSA	Demographic Surveillance Area
FAO	Food and Agriculture Organization
FMD	Foot and Mouth Disease
HAHC	Hluvukani Animal Health Clinic
HDSS	Health and Demographics Surveillance System
INDEPTH	International Network for the Demographic Evaluation of Populations and Their Health
MVS	Mpumalanga Veterinary Services
OIE	Office Internationale des Epizooties

Summary

A health and demographic surveillance system of cattle on communal rangelands in Bushbuckridge, South Africa: baseline census and population dynamics over 12 months

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The aim of this study was to establish a Health and Demographic Surveillance System (HDSS) in the cattle population of the Mnisi community in Bushbuckridge, Mpumalanga Province, South Africa. The study provided data on the cattle population dynamics over 12 months, from July 2012 through June 2013. It focused on over 4,500 cattle in Ward B2 of the foot and mouth disease (FMD) control zone, comprising five diptanks, allowing for data recording on individuals and collecting information from farmers when they came once a week to have their cattle dipped and inspected for FMD. A baseline census was established for all the herds via individual identification by ear-tagging, gathering data such as age, gender, type and body condition. This information was updated weekly over 12 months with demographic parameters - herd dynamics, entries and exits. With an average herd size of 25.8 cattle, ranging from 1 - 138 animals per herd, farmers in the study area own more livestock than many other communal farmers in other regions of southern Africa. Herd structure differs from that reported in other studies, with breeding cows aged three years and older representing 55.8% of the herd and heifers 2%, resulting in one bull per 2.1 cows. As for the herd composition, Sanga types and their crosses make up most of the herds in Ward B2, and their average body condition score was 2.7 on a 1 - 4 scale. The calving rate of 40.1% is a good sign of herd fertility, and represents 86.3% of all entries into the study population. The mortality rate of 7.3% is low compared to other studies, and represents 76.8% of all exits. Due to the restriction on movements of FMD-vaccinated cattle, intake and offtake rates are low. Cattle herds in Ward B2 show signs of good health such as good body condition, low mortality rate and good reproductive performance. Over a year, the study population increased by 13.3%. Such a project can hopefully be the starting point for further HDSS work in the Mnisi community, which will refine population parameter estimates over the years by continuing weekly information recording.

Introduction

The world's human population is expected to grow from 7 billion today to 7.7 billion by 2020 and 9.2 billion by 2050 (Delgado *et al*., 1999; Thornton *et al*., 2009). Tremendous stress will be placed on livestock farming systems globally to provide sufficient animal proteins in response. Since most developed countries have witnessed their agricultural land surface shrink under the pressure of urbanization, people are looking towards developing countries to meet the demand, and the African continent is in the spotlight. Indeed, 27% of the world's poor livestock farmers, amounting to 162 million people, live in Africa (Kruska *et al*., 2003). Of the world's domesticated ruminants, 65% are found in developing countries, yet they contribute to only 30% of the world's meat and 20% of the world's milk production (Bembridge & Tapson, 1993).

The increasing demand for livestock products combined with the already high density of livestock on communal lands mean that traditional farming systems should be optimised to provide sustainable and profitable livestock production on communal rangelands (Bembridge & Tapson, 1993). In this view, investments to enhance livestock productivity and control livestock diseases in traditional settings will contribute to poverty alleviation as well as to the conservation of rangelands (Bengis *et al*., 2004; Nin *et al*., 2007; Rich & Perry, 2011; Scoones, 1993). Understanding the potential role of communal cattle farming in the ever-increasing global market for livestock products, and how it relates to other livestock production systems, brings valuable information in terms of its economic potential at the individual, regional and national scale (Kruska *et al*., 2003). If not guided by government policies, current traditional farming systems will tend to become more commercially orientated under the market pressures; they should therefore be guided in the process (Casey & Maree, 1993; FAO, 2011; Kruska *et al*., 2003; Penrith & Thomson, 2004; Thomson *et al*., 2004).

1. Literature review

There are many studies worldwide concerning commercial cattle farming, looking at reproduction performance, husbandry, genetics, and various other aspects; however, relatively little comparable research has been done in the communal cattle farming sector. This literature review reveals relevant information gathered about cattle farming in rural communities, particularly its importance in southern Africa; how communal farmers can contribute to agricultural policy making through participatory research, and finally the definition of Heath and Demographic Surveillance Systems (HDSS) and their application to cattle populations in Africa.

1.1 Importance of the communal livestock farming sector in southern Africa

A community can be defined as a unit of social and economic activities (FAO, 1983). In the context of livestock production in Africa, it consists mostly of a rural village whose inhabitants own and manage multipurpose enterprises in which livestock are an integral part (De Leeuw *et al*., 1995). Currently, 41% of all cattle in South Africa are found on communal land; this amounts to 5.5 million heads (Department of Agriculture, 2006; RMRDT, 2008), of which 70% are situated at wildlife interfaces, which introduce additional disease-related complexities. This results in tremendous challenges for crop and livestock farming (Bengis *et al*., 2004; Mapiye *et al*., 2009b).

In South Africa, livestock production accounts for more than 40% of the total value of agricultural output. This reflects the fact that a large proportion - almost 80% - of agricultural land in South Africa is deemed marginal, allowing only for livestock husbandry (Department of Agriculture, 2006). Livestock production in South Africa can be broadly divided into commercial and communal sectors. Although the communal livestock farming sector suffers from many prejudices, such as being “unproductive”, or “backward” (Shackelton *et al*., 2001), it remains a complex issue to measure communal cattle productivity, as it depends on which criteria are used. Production efficiency differs dramatically between the commercial and communal sectors if one takes “beef output” as the productivity parameter of reference, amounting to 23% in commercial versus 3% - 5% in communal systems (Department of Agriculture, 2006; Scoones, 1992). Because the value of communal cattle lie in various aspects other than slaughter price, for instance capital savings, draught power, milk and manure production, using “beef output” as a reference may be inappropriate in traditional systems (Bembridge & Tapson, 1993; Dovie *et al*., 2006; Rocha *et al*., 1991; Scoones, 1992; Shakelton *et al*., 2001). Some studies even suggest that if one takes into account all multipurpose incomes from communal cattle, then traditional farming isn't necessarily less productive than commercial ranching (Dovie *et al*., 2006; Rocha *et al*., 1991; Scoones, 1992; Shakelton *et al*., 2001). According to Dovie *et al*. (2006), the average annual net value for the goods and services rendered by cattle and goats to communal households (including both stock-owning and non-owning households) was estimated at USD 656, which represents 23% of total annual household income. As a result of the various roles played by communal cattle, even people not owning livestock benefit indirectly from traditional farming through provision of jobs (cattle herding, milking, enclosure building, etc.), making the valuation of traditional farming even more intricate. Supporting this importance of livestock production in rural settings, Adams *et al.* (2000) reported that 2.4 million South African rural households benefit from ZAR 2.9 billion derived from livestock only, amounting to ZAR 1,200 per household.

A consistent attribute of southern African communal systems is the distribution of cattle breeds that are well adapted to such systems, and that represent a balance between robustness and productivity. These breeds are Sanga or Africander types (*Bos taurus africanus*), Brahmans (*Bos indicus*), a certain degree of imported breeds from the Northern hemisphere, and their crosses. Farmers opt for breeds able to cope with sometimes harsh climatic and environmental factors, such as droughts in winters and tick-borne diseases in summer (Mapiye *et al*., 2009b). Sanga cattle are renowned for their good disease resistance combined with low-maintenance feed requirements, while still providing an acceptable beef output (Mapiye *et al*., 2009b; Scholtz *et al*., 2008). However, their reproductive performances are suboptimal (Nqeno *et al.*, 2010) and both age at first calving and calving intervals exceed two years (Ainslie *et al.,* 2002).

The importation of European breeds into southern Africa in the past centuries to increase the beef output resulted in weakening of disease resistance traits in indigenous breeds, unmasking many endemic diseases that were silently cycling in the neighbouring wildlife (Bengis *et al*., 2004). The distribution of cattle breeds in communities greatly influences the farming inputs necessary to maintain them, with exotic breeds demanding more management and disease treatments than local breeds (Bengis *et al*., 2004; Mapiye *et al*., 2009b). Because of endemic high-impact transboundary animal diseases, such as foot-and-mouth disease (FMD) whose reservoir species are African buffalos (*Syncerus caffer*), communal livestock seldom have access to mainstream markets. This may partly explain the lack of farmers' input in managing their herds to make them more productive (Bengis *et al*., 2004; FAO, 2011).

The pressure placed on meat production systems in Africa, combined with poverty alleviating policies in the years to come could change this *status quo* and allow communal cattle access to more lucrative markets. Indeed, at present importing European countries are ignoring recommendations from the OIE (Office Internationale des Epizooties) to reduce the risk of FMD transmission by deboning and processing meat, but should emerging markets like Asian countries decide to import deboned matured meat products from FMD-infected countries, communal farmers might feel encouraged to increase the productivity of their herds (Mapitse, 2008). In doing so, their input would prove valuable when establishing regional or national policies, while their participation in research studies of their herds' performances would be important.

1.2 Participatory research and policy making in communal areas

While many livestock development projects designed and implemented by international organizations have failed to demonstrate clear impacts on poor farmers in Africa, most nationally-founded local projects involving the participation of rural farmers are still proving effective (Catley & Leyland, 2001; Nin *et al*., 2007). This notion of "participatory epidemiology" was started in the late 1980s in eastern Africa, and it consists of combining the academic knowledge and communication skills of professionals (veterinarians, epidemiologists, animal health technicians) with the field experience of farmers to design animal health surveillance projects (Catley *et al*., 2012). In some cases, it goes even further by training a few community members with an interest in animal health to become community-based animal-health workers (CAHWs), in other terms "locally adapted field research assistants". Participatory epidemiology has contributed a great deal to the understanding and control of both rare and common animal diseases in Asia and Africa (Jost *et al*., 2007).

Two striking success stories of participatory epidemiology are the eradication of rinderpest in eastern Africa and tsetse fly control in Kenya, Uganda and Zambia. The challenge in rinderpest control was to vaccinate all cattle, including in remote villages hard to access by common means of transportation, so as to eliminate all possible foci of virus persistence. CAHWs proved particularly useful to that end, given their network of acquaintances among the most remote villages, hence they could be aware of remaining unvaccinated animals, or even report sick livestock. As for tsetse fly control, cheap and user-friendly traps were set up by community farmers, who kept on using them for as long as the research projects were providing them (Catley & Leyland, 2001; Jost *et al*., 2007). Community-based approaches are proving successful thanks to the farmers' detailed knowledge about their animals and environment, together with increased responsibility for projects outcomes (Catley & Leyland, 2001). In practice, farmers' participation is sought through questionnaire surveys, which generate a huge and valuable amount of data for analysis and modelling, and bring new perspectives to research topics (Chatikobo *et al*., 2013; Oliver *et al*., 2012).

Communities' inputs do not just contribute to animal health projects; they eventually constitute the rationale behind efficient decision-making processes regarding local or even national livestock production development schemes (De Leeuw *et al*., 1995). Both livestock owners and non-livestock owners should be consulted on such matters, since they all share the same interest for increased economic returns on cattle farming (Campbell *et al*., 2000; Scoones, 1992). In the end, having a thorough grasp on the socio-economic and political context of communal farming is the best way forward to operate agrarian reforms relevant to rural communities (Bembridge & Tapson, 1993).

Nonetheless, despite the invaluable information provided by farmers, one needs to address animal health issues with a broader approach, including all stakeholders' inputs and objective data before concluding on projects' outcomes. Indeed, according to Perry and Grace (2009), in the disease control prioritization process, the greatest divergence of opinions is between experts and farmers. Communal farmers' and government's interests aren't always in line; for example FMD control is a priority for sub-Saharan African governments to access lucrative beef markets, while communal farmers feel much more affected by haemorrhagic septicaemia in terms of economic loss (Perry & Grace, 2009). Objective data provided by research projects are proving relevant to fill the gap between this divergence of opinions.

To gain more information about communal cattle productivity and population dynamics, projects should ideally include large numbers of animals and be run over many years to provide objective, repeatable and reliable data. In the public health sector, similar projects are known as Health and Demographic Surveillance Systems (HDSSs).

1.3 Heath and demographic surveillance systems

The INDEPTH Network (International Network for the Demographic Evaluation of Populations and Their Health), founded in 1998, is a group of international independent public health research centers operating human populations HDSSs in developing countries of Asia, Africa and Oceania (Sankoh & Byass, 2012). According to the INDEPTH Network (http://www.indepth-network.org), an HDSS site is a "geographically-defined population under continuous demographic monitoring with timely production of data on all births, deaths, migration events and associated health indicators". It provides longitudinal measurements of demographic and health variables of the entire population of the designated area (the demographic surveillance area, or DSA), through regular updates of all primary subjects.

In developed countries, public health institutions can rely on adequate vital statistics and good access to health facilities on which to base their policies; this is seldom the case in developing countries. To fill this gap, HDSS sites were created to obtain sufficient unbiased data to inform adequate health-services planning and resources allocation in developing countries. Indeed, without an HDSS, the only information that policymakers can rely on is collected from health facilities, yet poor rural areas seldom benefit from health facilities, and not everyone in the population has access to such facilities, resulting in many individuals (often the most vulnerable - children, women, elders, and the poorest) being left out of health improvement schemes. By collecting data from an entire population over years, one gets an accurate reflection of disease burden and distribution, and enables demographers, epidemiologists and health planners to act upon it at the regional and/or national scale. Currently, the INDEPTH network gathers data from 44 HDSS sites in 20 countries, following up on a population of 3.2 million people (Sankoh & Byass, 2012; Ye *et al*., 2012). Of these 44 sites, 32 are situated in sub-Saharan Africa, to compensate for a severe lack of health and demographic event records in communities in this region (Ye *et al*., 2012).

To establish an HDSS, one needs to define the population to be followed, and create a baseline census as a start-up point. This baseline census is then updated at regular visits of all the individuals of the population. All HDSS data consist of core demographic parameters (Figure 1) in addition to other site-specific data (e.g. epidemiological data on certain diseases).

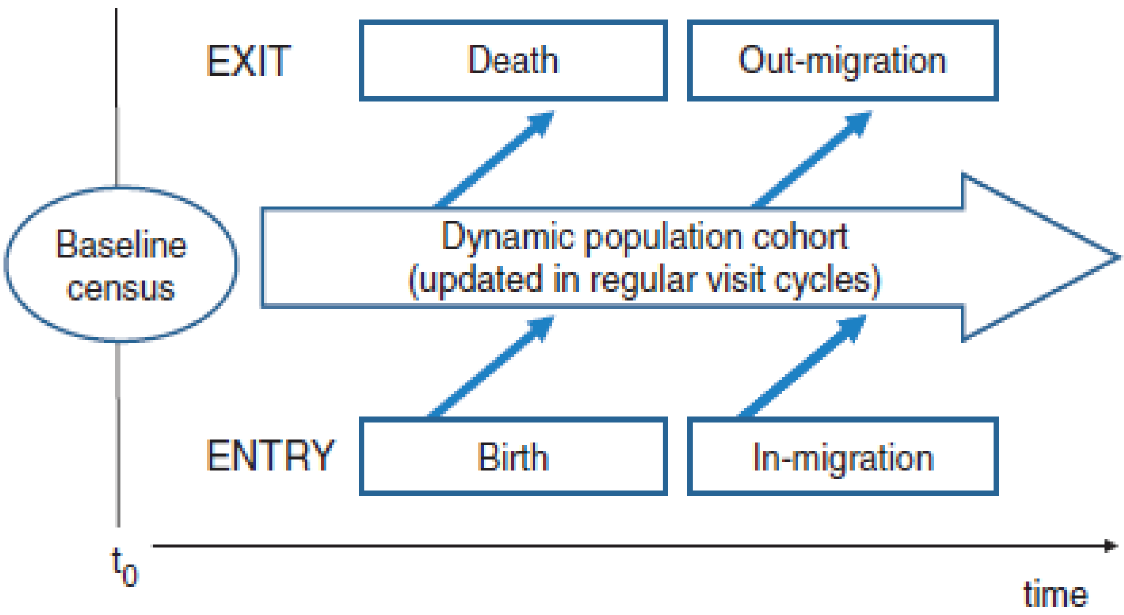

Figure 1 Conceptual structure of the dynamic cohort model used by INDEPTH Health and Demographic Surveillance System (HDSS) sites. From Sankoh and Byass (2012)

Core demographic parameters consist in updating all entries (births, in-migrations) and exits (deaths, out-migrations) from the HDSS population. Birth is a critical parameter to evaluate fertility, while death documented by age and sex provide valuable data to formulate life tables, detect early neonatal deaths and calculate other demographic parameters. Establishing causes of mortality remains a challenging task, since most deaths do not occur in health facilities and only a "verbal autopsy" can be performed to establish the cause of death from relatives' recall. As for in- and out-migrations, one needs to monitor the number of people migrating within, in or out of the HDSS site and possibly the reasons behind this (Kahn *et al*., 2007; Sankoh & Byass, 2012).

HDSS sites worldwide have already demonstrated valuable insights into health-related issues, such as how climate change adversely affects communities' health in developing countries, and how combining climate and health research could be beneficial in the One Health context (Hondula *et al*., 2012). Contrary to longitudinal cohort studies concerning a sampled population over a relatively short period of time, HDSS sites have provided data gathered over decades on all participants, as illustrated by a study of long-term effects of infant vaccination with diphtheria-tetanus-pertussis on mortality over 15 years of age in Matlab, Bangladesh (Breiman *et al*., 2004). In the Bushbuckridge community, South Africa, the Agincourt HDSS covering 70,000 people in 21 villages investigates causes and consequences of complex health, population and social transitions, such as human immunodeficiency virus transmission, urbanization and psycho-social well-being (Kahn *et al*., 2007; Kahn *et al*., 2012). Once a baseline census has been created and core population dynamic trends established, sideline projects can focus on health issues affecting only a subpopulation, for instance chronic conditions in elderly people (Gomez-Olive *et al*., 2013) or infant mortality (Adazu *et al*., 2005).

HDSS sites are considered a medium-term attempt to break the link between material and data poverty (Sankoh & Byass, 2012), while providing an estimated picture of the nation-wide health situation in the absence of adequate national civil registration centers if HDSS are strategically located throughout the country's main regions (Ye *et al*., 2012). All the information provided by HDSS sites worldwide is available to the general public, and represents a compass for health-related policy making. Nonetheless, because HDSS sites are very resource-intensive and need to be sustainable in the long-term, efforts are being implemented to combine them with national policies so as to be less dependent on external funding (Sankoh & Byass, 2012; Ye *et al*., 2012).

If human HDSS are so successful in providing long-term exhaustive data of a rural human population, there is no reason to think that such systems wouldn't prove as successful when applied in other sectors, such as to communal cattle populations.

1.4 HDSS applied to cattle populations

Hypothetically, HDSS data on animal populations in rural communities could generate valuable information for animal health and demographic monitoring in communities. Although various longitudinal cohort studies have been conducted on communal cattle populations throughout Africa (Ainslie *et al.*, 2002; Angassa & Oba, 2007; Ba *et al.*, 2011; Chatikobo *et al.*, 2001), few of them last much longer than a few years, hence the need for cattle HDSS sites running over a substantial number of years (ideally more than a decade), so as to visualize an accurate picture over the years of population trends and dynamics.

Since early 1960s, scientists from Western countries have run agropastoral projects in African countries, from broad system descriptions to focused evaluations of diseases impact and livestock productivity (De Leeuw *et al*. 1995). Because information is the starting point to decision making, collecting data on livestock health and production in rural areas is the foundation of future reforms and policies, such as subsidized vaccination campaigns, ectoparasite controls, animal movement regulations, etc. A questionnaire survey conducted by the Food and Agriculture Organization of the United Nations (FAO) concluded that 80% of livestock-orientated project stakeholders (researchers, non-governmental organizations, national institutions, livestock ministries, etc.) feel that there is a significant lack of livestock data in four core sectors: livestock inventory, animal health and disease, livestock nutrition, and meat and milk production (Pica-Ciamarra *et al*., 2012). These data are needed mostly for research purposes (70% of the respondents), and to a lesser extent at government level for project design and policy planning.

Livestock health and productivity monitoring can yield four practical applications: collection of baseline data, descriptive and analytic research, support for government regulatory functions, and improvement of service delivery to farmers (Dohoo, 1993). By setting up HDSS sites for cattle in rural communities of sub-Saharan Africa, scientists would have longitudinal data over long periods of time and for an entire cattle population, enabling them to assess population dynamic and impacts of diseases or environmental changes on livestock production (Rich & Perry, 2011; Thornton *et al*., 2009). As a result, one could potentially improve communal livestock productivity which has until now been restricted by insufficient knowledge on communal herd dynamics (Ainslie *et al.,* 2002; Bembridge & Tapson, 1993).

Demographic surveillance of livestock herds consists of collecting standard parameters regarding animals' biological characteristics (calving and mortality) as well as management practice indicators (slaughter, sales, purchases, etc.). This allows accurate evaluation of the impact of interventions (agricultural reforms, changes in livestock husbandry) or environmental hazards (droughts, floods, disease outbreaks) on herd dynamics (Moulin *et al*., 2004; Lesnoff, 2011; Lesnoff *et al*., 2011). There are various approaches to tackle cattle population census and monitoring in communal areas, among which three stand out as the most frequently implemented: retrospective studies based on farmers' recall of events, cattle population follow-up without individual identification, and cattle population follow-up of all individually-identified animals with regular updates at least every two months (Lesnoff, 2011). The first two approaches, although less resource-intensive and easier to implement, suffer a certain degree of bias and may not be accurately representative of herd dynamics over long periods of time (Faugère & Faugère, 1986; Lesnoff, 2008; Van Klink *et al*., 1996). A complete enumeration of individually-identified animals with regular updates over long periods of time remains the gold standard, despite being time-consuming and resource-intensive (FAO, 2005; Faugère *et al*., 1991; Lesnoff, 2009; Lesnoff, 2011; Tillard *et al*., 1997). As with HDSS sites in public health, it consists of an initial baseline census during which all animals of the studied population are uniquely identified (e.g. ear-tagged) and descriptive data recorded, including age, sex, breed/type and body condition score (BCS). Thereafter, all individual events are updated on a regular basis (e.g. weekly or monthly) through interviews with farmers, including calving, mortality, sale, donation, etc. (Lesnoff, 2011). A complete enumeration census of the cattle population in a given community allows for more strategic sampling methods for potential research projects and bypasses time-consuming and unpractical field sampling (Herve-Claude *et al*., 2011).

Several demographic surveillance projects of communal livestock have been run in Africa, contributing to a better understanding of the current productivity levels and assessment of potential for increased production. The French Agricultural Research Center for International Development (CIRAD) has conducted various projects in northern and western African countries over several years, demonstrating the variety of research topics associated with livestock demographics. Valuable data on traditional livestock herd dynamics and productivity were obtained from Senegal, in collaboration with local research institutes (Faugère *et al*., 1991; Ickowicz & Mbaye, 2001; Lancelot *et al*., 1998). In southern Ethiopia where contagious bovine pleuropneumonia (CBPP) is enzootic, combining demographic surveillance of cattle herds with CBPP epidemiology contributed to national policies on CBPP control (Ezanno & Lesnoff, 2009; Lesnoff *et al*. 2002; Lesnoff *et al*., 2004). CIRAD also focused on the impact of climate changes and natural disasters on cattle populations, for instance by studying the ability of cattle herds in the Sahel region to recover from severe droughts (Lesnoff *et al*., 2012). Other demographic projects were run on communal cattle in sub-Saharan Africa by various independent research centers or by national institutions, to either study core demographic parameters as final variables of interest (Mapiye *et al*., 2009a; Perry *et al*., 1984; Rocha *et al*., 1991; Scoones, 1992) or to study demographic trends relating to disease surveillance (Makgatho *et al*., 2005), reproductive performance (Mokantla *et al*., 2004; Nqeno *et al*., 2010; Nqeno *et al*., 2011), or husbandry practices (Lesnoff *et al*., 2011; Siegmund-Schultze, 2012). As with public health HDSS sites, establishing an HDSS site in a cattle population requires the collection of core demographic parameters of individuals in herds, namely entries (calving, in-migration by purchase or donation) and exits (death, slaughter, and out-migration by sale or donation).

1.5 Cattle population dynamics studies results

Various HDSS-type cattle population studies have been run in rural communities of southern Africa, with baseline census and data collection at regular intervals over one to several years.

Herd structure and composition

Herd structure

Herd structure consists of the average herd size, the gender-age distribution of animals and related calculated parameters such as cow-to-bull ratio.

Average herd size

According to Casey and Maree (1993b), it is estimated that owning 10 cattle is the minimum amount to address primary needs for subsistence in a traditional farming system. Yet in southern Africa, 68% of communal farmers own fewer than ten cattle, with an average of six cattle per household. Table 1 shows herd size recorded in various African communal areas.

Distribution of gender and age within herds

Commonly, herd composition is assessed according to gender and age, distinguishing calves less than a year old, heifers (nulliparous females), breeding cows, and bulls/oxen. In the commercial sectors, the targeted percentage of breeding cows is 50% (Scholtz & Bester, 2010). Table 2 shows distribution of gender and age recorded in various African communal cattle herds.

Cow-to-bull ratio

In the commercial beef sector, it is recommended to have about one bull for 30 cows, but because communal cattle tend to roam freely, most breeding cows can be mated by almost any bull, so the following ratios are just an indication. Almost all (98%) of communal farmers allow natural mating throughout the year, with no restricted breeding period (Scholtz *et al*., 2008). Table 3 shows cow-to-bull ratios in various African communal areas.

Table 1 Average herd size in communal areas of southern Africa

References	Location	Average herd size and range
Rocha *et al.*, 1991	southern Mozambique	19.5 (0 - 100+)
Bembridge, 1987a	Transkei, South Africa	6 (0 - 25+)
Mtetwa, 1982	Botswana	16
Dovie *et al.*, 2006	Bushbuckridge, South Africa	19.8 (0 - 67)
Bembridge & Tapson, 1993	southern Africa	6
Perry *et al.*, 1984	Western, eastern and central provinces, Zambia	11 - 50 (0 - 114)
Chatikobo *et al.*, 2001	Sanyati Communal Area, Zimbabwe	1 - 4
Reed *et al.*, 1974	Moshupa district, eastern Botswana	21.3
Nthakheni, 1993	Venda, South Africa	9.7 (0 - 39)
Scholtz *et al.*, 2008	Communal sector in South Africa Particularly in Mpumalanga	19 24
Scholtz *et al.*, 2008	Commercial sector in South Africa	413

Table 2 Distribution of gender and age within herds in communal areas of southern Africa

References	Location	Calves < 1y	Heifers (nulliparous)	Cows	Bulls > 1y	Oxen
Rocha *et al.*, 1991	southern Mozambique	10.3%	17.2%	36.4%	15.4%	20.7%
Bembridge, 1986; Tapson, 1985	South Africa	10.7%	18.9%	35.6%	25.6%	9.2%
Perry *et al.*, 1984	Zambia	19%	16%	35%	5%	25%
Chatikobo *et al.*, 2001	Sanyati Communal Area, Zimbabwe	20%	32%		3%	45%
Nthakheni, 1993	Venda, South Africa	7.7%	19.5%	51%	17.9%	3.4%
Reed *et al.*, 1974	Moshupa district, eastern Botswana	6.6%	18.9%	33%	10.8%	30.6%

Table 3 Cow to bull ratio in communal areas of southern Africa

References	Location	Cows per bull
Mapiye *et al*., 2009a	Eastern Cape, South Africa	28 - 32
Siegmund-Schultze *et al*., 2012	Okamboro, central Namibia	36
Perry *et al*., 1984	Zambia	35 - 39
Nthakheni, 1993	Venda, South Africa	3
Tschopp *et al*., 2014	Sellale, central Ethiopia	9.5

Herd composition

Herd composition parameters include - among others - types and individual descriptive parameters of the animals, such as the body condition score.

Cattle types

In South Africa, the breed contribution to the beef cattle seed stock industry can be divided into three main categories: 47% Sanga type, 30% Brahman type and 23% European breeds (Scholtz *et al*., 2008). The conservation of indigenous breeds such as the Sanga type in communal areas of southern Africa is crucial to face future challenges of communal farming, thanks to their resistance to endemic diseases, particularly in the context of global warming (Makgatho *et al*., 2005; Scholtz *et al*., 2008).

In the emerging livestock farming sector of South Africa, a study by the National Emerging Red Meat Producers Organisation (NERPO 2000) reported a breed distribution as follows: 35% Sanga type, 32% Brahman type, 17% Bonsmara and 8% Afrikaner. In a questionnaire-based survey of South African communal areas, Scholtz *et al*. (2008) reported similar observations according to the breed of bull used, if crossbreds are ignored (35% of bulls used): 23% Sanga type, 18% Brahman type, 10% Afrikaner and 5% Bonsmara. In the Okamboro, central Namibia, 42% of the cattle population was Sanga type, 22% Brahman, 17% Brahman crossbreeds, and 19% others (Siegmund-Schultze *et al*., 2012).

Further north, in Sellale, central Ethiopia, 37% of the cattle in traditional small-holder farms are zebus, 19% Holstein cows, and 52% their crossbreds (Tschopp *et al*., 2014).

Body condition score (BCS)

Body condition score can change dramatically between seasons, especially in breeding cows, and can significantly influence reproductive parameters. On a 1 - 4 scale (1 being cachexia and 4 obesity, with 3 being the ideal target), it has been estimated that above a body condition score of 2.5, ovarian activity and pregnancy rate in breeding cows are 49%, while at a BCS of less than 2.5 the pregnancy rate drops down to 16% (Honhold *et al*., 1992).

Population dynamics: entries

As mentioned earlier, entries reflect the incoming animals into the studied herd, either by birth or by purchase/donation/exchange. In communal areas of the Eastern Cape province of South Africa, 88% of all entries are contributed by births and 12% by purchases (Mapiye *et al*., 2009a). In a survey of small-holdings of central Ethiopia, 70% of all entries are births, 30% purchases and 0.6% gifts (Tschopp *et al.*, 2014).

Calving rate

Reproductive performances of cows are best reflected by the calving rate, which is the total number of calves born (dead or alive) out of the total number of breeding cows (Mokantla *et al*., 2004). A breeding cow is defined as a cow susceptible to be pregnant, but studies differ on the age of puberty from which a cow can first bear a calf: 1.5 to 2 years (Nqeno *et al*., 2011), 2 to 2.5 years (Mokantla *et al*., 2004; Siegmund-Schultze *et al*., 2012), three years (Scoones, 1992), 3.5 to 4.3 years (Reed *et al*., 1974), to 5+ years (De Leeuw *et al*., 1995; Lesnoff *et al*., 2002; Siegmund-Schultze *et al.*, 2012). Table 4 shows calving rates in various African communal areas.

When calculating the number of calves in one year, one needs to take into account the seasonality of calving, and therefore averages over several years are more accurate (Lesnoff & Lancelot, 2009). Major perceived causes of low reproductive performances in communal cattle are delayed age at puberty and at first calving, long intercalving interval and insufficient bull numbers (Nqeno *et al.* 2011).

Depending on the studies, target calving rates in the commercial sector vary from 55% (Scholtz & Bester, 2010) to 95% - 99% (Mokantla *et al*., 2004), while in the communal sector, the accepted norm is 40% (Scholtz & Bester, 2010). One needs to be cautious when evaluating calving rates, as actual rates may be higher due to unrecorded neonatal mortality (Rocha *et al*., 1991). Calving rates in communal areas are usually much lower than in the commercial sector, and it appears that the main reason is malnutrition resulting in poor body condition of the dam and failure to conceive, as opposed to embryonic death or abortion (Mokantla *et al*., 2004; Nqeno *et al*., 2010).

Intake rate

During their study in the Eastern Cape province of South Africa, Mapiye *et al.* (2009a) found that 4% of all cattle farmers bought some cattle, which amounted to 12% of all cattle entries, but that no cattle were ever exchanged nor donated.

Table 4 Calving rates in communal areas of Africa

References	Location	Type of study	Calving rate and range
Rocha *et al*., 1991	Southern Mozambique	Monthly questionnaire over 12 months (February 1987 - 1988)	49% (46% - 53%)
Scoones, 1992	Mazvihwa, southern Zimbabwe	Regular questionnaire with farmers over 12 years (1986 - 1998)	68% - 82%
Bembridge and Tapson, 1993	Ciskei and Transkei, South Africa	Unspecified	41% (39% - 43%)
Angassa & Oba, 2007	Southern Ethiopia	Retrospective analysis of data collected over 21 years (1938 - 2003)	55% (12% - 81%)
Perry *et al*., 1984	Zambia	Questionnaires based on farmers' recalls of preceding year	44% - 80%
Nthakheni, 1993	Venda, South Africa	Questionnaires based on farmers' recall	15%
Scholtz & Bester, 2010	Communal sector in South Africa	Questionnaires	27%
Scholtz & Bester, 2010	Commercial sector in South Africa	Questionnaires	61%
Tschopp *et al*., 2014	Sellale, central Ethiopia	Follow-up of identified animals on 20 farms every two weeks for 4.5 years	41%

Population dynamics: exits

According to different cattle population dynamics studies, exits are mostly represented by either mortalities (Casey & Maree, 1993b; Oba, 2001; Scholtz & Bester, 2010; Upton, 1989) or sales (Mapiye *et al*., 2009a; Tschopp *et al*., 2014). In the study by Mapiye *et al.* (2009a), sales accounted for 45% of all exits, mortalities 30%, slaughter 15% and thefts 10%. In a survey of small-hording farms in central Ethiopia, exits comprised 69% of sales, 26% death by natural cause and 5% home slaughter (Tschopp *et al*., 2014). On the other hand, certain studies show that the mortality rate can be more than double the offtake rate (Casey & Maree, 1993b).

Most authors agree that the larger the herd size, the higher the exit rate due to a higher offtake rate (Ba *et al*., 2011; Mapiye *et al*., 2009a; Scoones, 1992), but that herd size does not affect the mortality rate (Mapiye *et al*., 2009a).

Mortality rate

Most communal cattle population studies report that calves have the highest mortality rate, due mainly to drought, malnutrition and/or tick-borne diseases, although many causes of death remain unknown because of limited access to animal health services (Chatikobo *et al*., 2001; French *et al*., 2001; Makgatho *et al*., 2005; Mapiye *et al*., 2009a). Compared to the commercial sector where average annual mortality is around 3%, the communal sector suffers on average 13% annual mortality rate (Casey & Maree, 1993b). Table 5 shows mortality rates in various communal cattle populations in Africa.

Offtake rate

As opposed to mortalities, offtake can be defined as all the voluntary exits - including sale, slaughter, donation and exchange (Scholtz & Bester, 2010). In South Africa, annual offtake in the communal sector is significantly lower than in the commercial sector, amounting to an average of 7.5% - 10% and 25% respectively (RMRDT, 2008), although not all studies concur with these figures (Scholtz & Bester, 2010). Table 6 shows offtake rates in various communal cattle populations in Africa.

Table 5 Annual mortality rates of cattle in communal areas of Africa

References	Location	Mortality rate (total cattle)	Cows mortality rate	Calves mortality rate
Rocha *et al.*, 1991	Southern Mozambique	8.4%	3.8%	23.8%
Makgatho *et al.*, 2005	North West, South Africa	4.5%	4.8%	7.3%
Lesnoff *et al.*, 2002	Ethiopian Highlands		3%	17%
Perry *et al.*, 1984	Zambia		4% - 16%	4% - 32%
Nthakheni, 1993	Venda, South Africa	45.1%		75.6%
Bembridge, 1987	Transkei, South Africa	16.7%		26.8%
Scholtz & Bester, 2010	Communal sector in South Africa	4.7%		
Chatikobo *et al.*, 2001	Sanyati Communal Area, Zimbabwe	26%		

Table 6 Annual offtake rates in communal areas of Africa

Reference	Location	Sale rate	Slaughter rate	Offtake
Scholtz & Bester, 2010	Commercial sector in South Africa			32.3%
Scholtz & Bester, 2010	Communal sector in South Africa	4.11%	1.84%	6.07%
Scoones, 1992	Mazvihwa, southern Zimbabwe	0% - 7.8%	1% - 4.2%	5.7%
Nthakheni, 1993	Venda, South Africa	1.1%	0.8%	6%
Ainslie *et al.*, 2002	Eastern Cape, South Africa			2%
Rocha *et al.*, 1991	southern Mozambique			8%
Bembridge, 1987	Transkei, South Africa			6.9%
Perry *et al.*, 1984	Zambia			10%
Tschopp *et al.*, 2014	Sellale, central Ethiopia			31.4%

Although most of these projects brought valuable information on communal cattle population and productivity parameters in southern Africa, there is a need for long-term longitudinal data of an entire subpopulation of communal cattle to gain repeatable and reliable average parameters. For this reason, a cattle HDSS site has been set up in the Bushbuckridge community of Mpumalanga, South Africa, to follow up on several thousand cattle over a number of years to provide these data for a communal cattle farming area at a wildlife interface in South Africa.

2. Materials and methods

The Mnisi community in Bushbuckridge, Mpumalanga Province was identified as a suitable study area. This study aimed at creating an HDSS site that would be large enough to gather data over numerous herds while benefitting from an existing disease surveillance and tick control system, supervised by the Mpumalanga Veterinary Services.

2.1 Study site description

The Mnisi community is located about 130 km north of Mbombela in the Bushbuckridge Local Municipality of the Mpumalanga Province of South Africa. It is bordered by the Manyeleti Provincial Reserve to the east, the Sabi Sands Game Reserve to the south, and the Timbavati Private Nature Reserve to the north. The study area is centered on Hluvukani village, located at latitude 24°38'S and longitude 31°20'E, about 450 meters above sea level. The University of Pretoria runs the Hluvukani Animal Health Clinic (HAHC) and oversees numerous research projects at this wildlife-domestic animal interface.

The rainfall pattern in this semi-arid area is unimodal with a rainy season from November to March. The mean annual rainfall is about 600 mm. Vegetation is typical of savannah ecosystems: scattered trees, short bushes and grass. Agricultural activity is based on a crop-livestock production system. Cattle ownership is common, with about 15,000 cattle owned by 1,300 farmers. Other common livestock species are goats, sheep, chickens and donkeys. Cattle graze in the communal rangelands during the day and are penned at night.

2.2 Demographic surveillance area (DSA)

The DSA falls within the control zone for foot and mouth disease (FMD). FMD virus is maintained in the African buffalo population in the adjacent wildlife reserves. Because the cattle in the DSA are regularly vaccinated against FMD and subject to movement restrictions, farmers cannot access mainstream markets and the meat mostly gets sold to local butcheries.

For the purposes of FMD control, the Mnisi community is divided into three wards (B1, B2 and B3) each consisting of five diptanks where cattle are dipped against ticks on a weekly basis under the supervision of the Mpumalanga Veterinary Services. The DSA covers the entire cattle population of Ward B2, amounting to 4,683 heads of cattle in July 2013. This study focused on the cattle population in Ward B2 from July 2012 through June 2013. Ward B2's five diptanks, and the days of the week on which cattle are dipped, are Eglington (Monday), Share (Tuesday), Utah Scheme (Wednesday), Shorty (Thursday) and Athol (Friday). Animal Health Technicians (AHT) working for the Mpumalanga Veterinary Services prepare the diptanks with adequate acaricide concentration, oversee cattle dipping, vaccinate against FMD and other diseases, record and report signs of FMD, and write down the total number of cattle per owner at each dipping session in a stock card. This stock card has a unique number allocated to each cattle owner within a diptank, facilitating data capture and follow-up. AHTs also record the number of exits from and new entries into herds. When an animal needs to move out of its designated ward (sale, donation, seasonal grazing), it requires a movement permit issued by AHTs enabling movement control and traceability.

2.3 Data collection and management

Baseline census

At the time of this study, records on cattle demographics in the Mnisi community consisted of herd sizes, entries and exits entered in stock cards by AHTs on a weekly basis at the diptanks and aggregated into monthly reports of herd-level data for each diptank. During the months of February and March 2012 (end of the wet season), all cattle in Ward B2 were eartagged and tattooed with a unique identification number combining the diptank number with the stock card number and an individual animal number. Baseline data on each individual were collected at the time of enrolment into the study, including type, sex and age (estimated by the observation of size of horns and teeth and based on farmers' recall). The project received approval from the University of Pretoria's Animal Ethics Committee (protocol v032-11). A consent form prepared and translated into the local language (XiTsonga) was read to all farmers enrolled in the study and signed by them. It described all the procedures that were to be performed on their animals, namely:

- Restraint in a mobile crush by a neck-clamp system.
- Identification by application of an ear-tag in the left ear and a tattoo in the right ear with the number of the diptank, the stock card number of each farmer and the individual animal number. A profile and face picture was taken for each animal.
- Parameters recorded: Breed type, sex and estimated age.
- Questions: total number of animals in the herd, which cows had a calf in the herd, and (whenever possible) the calf's ID number linked to the dam's.

The team collecting the data comprised six members, including a supervising veterinarian, two research assistants recording data and allocating identification numbers, a liaison between the farmers and the team, and two field workers to physically handle the neck-clamp system and apply ear tags and tattoos.

First year follow up on demographics events

Demographic events were recorded at weekly intervals for each animal over 12 months (from July 2012 to June 2013) when cattle were taken to the diptanks. Entries recorded were births, purchases and donations whereas exits comprised mortalities, slaughters, sales, and donations. Data were captured electronically using an open access application running on mobile phones (Open Data Kit). Collected data were aggregated online at a Google Appspot account using the ODK Aggregate tool. They were downloaded at regular intervals and automatically transferred to a MySQL relational database. Statistical analyses (analysis of variance and chi-square test) were carried out with R software (R Foundation for Statistical Computing, Vienna, Austria, www.R-project.org).

2.4 Calculation of demographic parameters

The following parameters have been calculated, with their definitions taken from the discrete time approach with LASER animal-based monitoring data of Lesnoff *et al*. (2011). To calculate demographic parameters, the mid-interval population denominator was used, i.e. population figures in January 2013.

Tables 7 and 8 summarize the parameters of interest to this study, in terms of herd structure and composition, entries and exits, and study population annual growth rate.

Herd structure and composition

Herd structure consists of herd size, gender-age distribution of animals and related calculated parameters such as the cow-to-bull ratio. On the other hand, herd composition parameters include - among others - the types, as well as the individual descriptive parameters, such as the body condition score (BCS).

Table 7 Herd structure and composition parameters

	Parameters	Definition	Numerator	Denominator
Herd structure	**Herd size**	Average herd size in the Ward B2 and per diptank	Total number of cattle in January 2013	Total number of herds in January 2013
	Distribution of gender and age	Distribution of male and female cattle according to their age: Calves 0 - 11 months Heifers 1 - 2 years Breeding cows ≥ 3 years Bulls ≥ 1 year	Number of females or number of males in each age category	Total number of cattle in January 2013
	Cow-to-bull ratio	Number of females per male	Total number of males	Total number of females
Herd Composition	**Cattle types**	Based on observation of body and head shape, the cows were broadly classified into Sanga types (relatively short and slender cows with short ears), Brahman types (tall frame with the characteristic fatty bump at the withers and long ears), and Sanga crosses with mixed characteristics.	Number of cattle of each type	Total number of cattle in January 2013
	BCS	Based on observations of the short ribs, back bone and skeletal structures, a BCS between 1 and 4 was attributed to each animal at the beginning of the census, with 1 referring to cachectic animals and 4 to overweight ones, 3 being the optimal body condition and 2 suboptimal.	NA	NA

Population dynamics: entries and exits

Table 8 Population dynamics: entries, exits and growth rate

	Parameters	Numerator	Denominator
Entries	**Calving rate**	Number of calves born over 12 months	Number of breeding cows aged 3 years and older in January 2013
	Intake rate	Number of animals entering the herd excluding through calving (i.e. purchases, donations, exchanges)	Total number of animals in January 2013
Exits	**Mortality rate**	Number of animals dead due to diseases, accidents, predation or natural causes over 12 months	Total number of animals in January 2013
	Offtake rate	Number of animals exiting the herd based on the farmer's decision - slaughtering, sales, donations, exchanges	Total number of animals in January 2013
Global demographic indicator	**Study population growth rate**	Total number of animals in June 2013 minus the total number of animals in July 2012	Total number of animals in July 2012

The farmers enrolled enthusiastically in the project, as ear-tagging seemed to be a good incentive in itself, and after some laborious field organization and fastidious data cleaning, a valuable set of results was obtained.

3. Results

The 363 farmers in possession of a stock card and interviewed in the five diptanks of Ward B2 owned a total of 4,586 cattle in January 2013, the mid-interval of the study period. In decreasing order, the entire cattle study population is divided between Eglington (27.8%), Athol (24.8%), Share (18%), Utah Scheme (16.7%) and Shorty (12.7%).

3.1 Herd structure and composition

Herd structure

Herd sizes ranged from 1 - 138 animals per herd, with larger herds found in Utah Scheme (mean 77.3 animals per herd). Herd sizes were more homogenous in the four other areas, averaging 11.7 - 14.3 animals per herd. The overall average herd size was 25.8 (Table 9). Mean herd sizes were significantly different between the five diptanks (analysis of variance, p <0.001), but not when Utah Scheme was excluded from the analysis (p = 0.3).

Table 9 Herd size in the five diptanks of Ward B2

	Number of stock cards	Number of animals per herd				
		Mean	**Median**	**SD**	**Minimum**	**Maximum**
Eglington	130	11.7	7	13.7	1	79
Share	66	14.3	9	16.9	1	100
Shorty	52	12.8	8	12.5	1	59
Athol	103	12.9	10	9.8	1	57
Utah Scheme	12	77.3	86.5	47.9	3	138
Total	**363**	**25.8**	**9**	**19**	**1**	**138**

Distribution of gender and age within the study population

In January 2013, the study population comprised 20.8% calves, 2% heifers (< 3 years), 55.8% breeding cows (≥ 3 years) and 20.7% bulls (≥ 1 year), as depicted in Figure 2. If one excludes the calves from the total herd, then breeding cows represent 70% of the adult cattle.

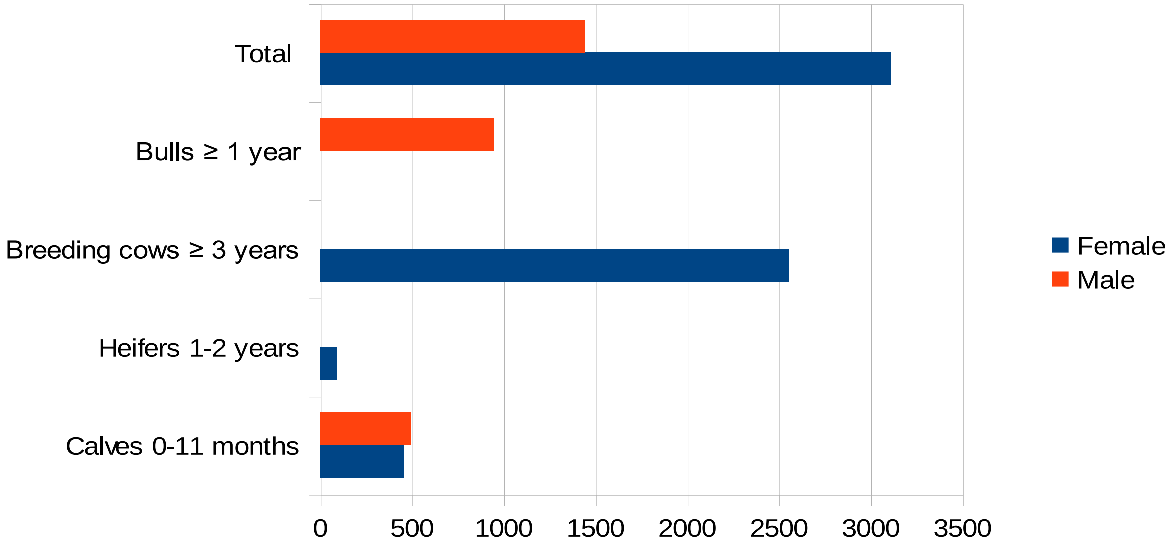

Figure 2 Distribution of gender and age in January 2013

Cow-to-bull ratio

On average, farmers own one bull for 2.1 cows. As illustrated in Figure 3, this ratio is fairly homogenous across four of the diptanks: 1:2.3 in Eglington, 1:2.2 in Share, 1:2.3 in Shorty and 1:2.7 in Athol, but was significantly lower (1:3.5) in Utah Scheme (chi-square test, $p = 0.01$).

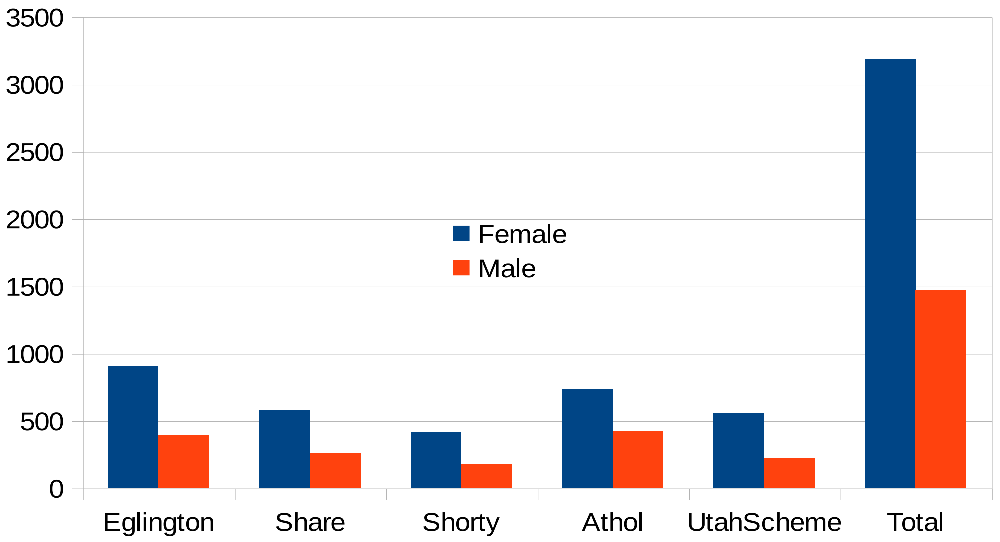

Figure 3 Distribution of gender by diptank

Cattle types

The cattle population in Ward B2 is represented by 56% Sanga types (mostly Nguni and Afrikander), 6% Brahman types, 37% Sanga crosses and 1.2% others (Figure 4).

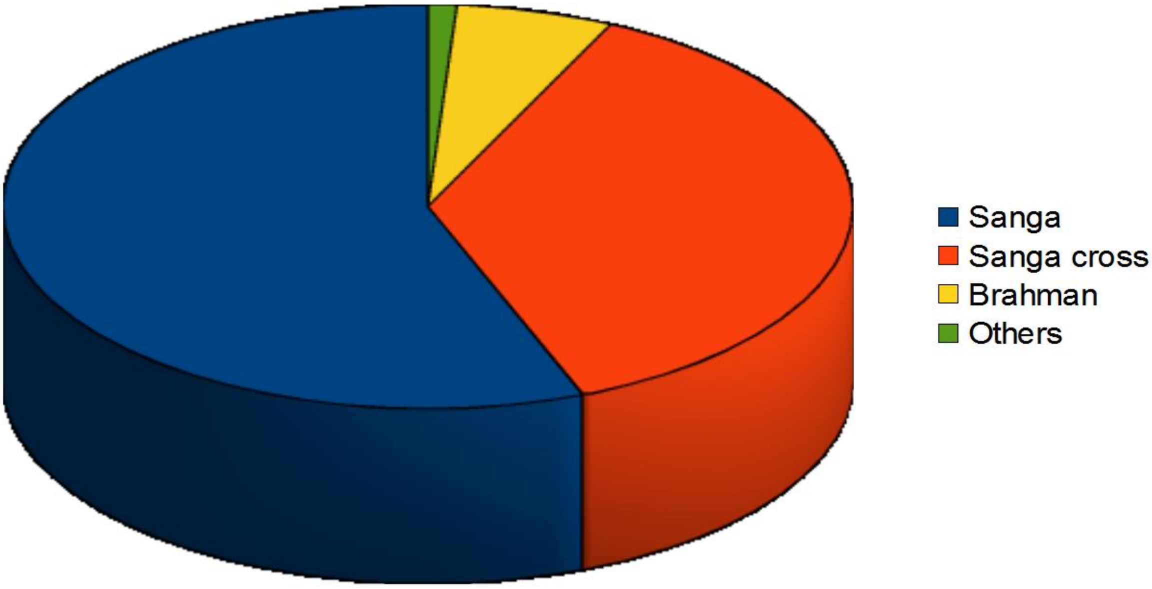

Figure 4 Distribution of cattle types in the Ward B2 cattle population

Body condition score (BCS)

In Ward B2, the majority of cattle had a BCS of three out of four, and the average BCS is 2.7 (Figure 5).

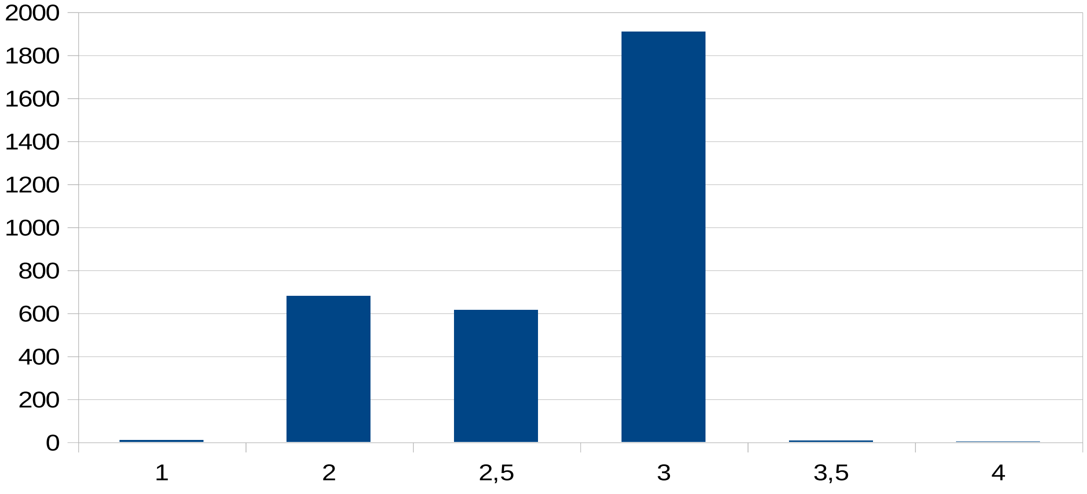

Figure 5 Distribution of BCS of the cattle population in July 2012

3.2 Population dynamics: entries

From July 2012 through June 2013, 86.3% of all 1,191 entries into Ward B2 were through calving and 13.7% through intakes.

Calving rate

The percentage of breeding cows aged three years and more giving birth to a calf from July 2012 through June 2013 was 40.1%. Of the 1,028 calves, 48% were female and 52% male. On a month to month basis, the calving rate shows a clear seasonal peak in November 2012 (Figure 6).

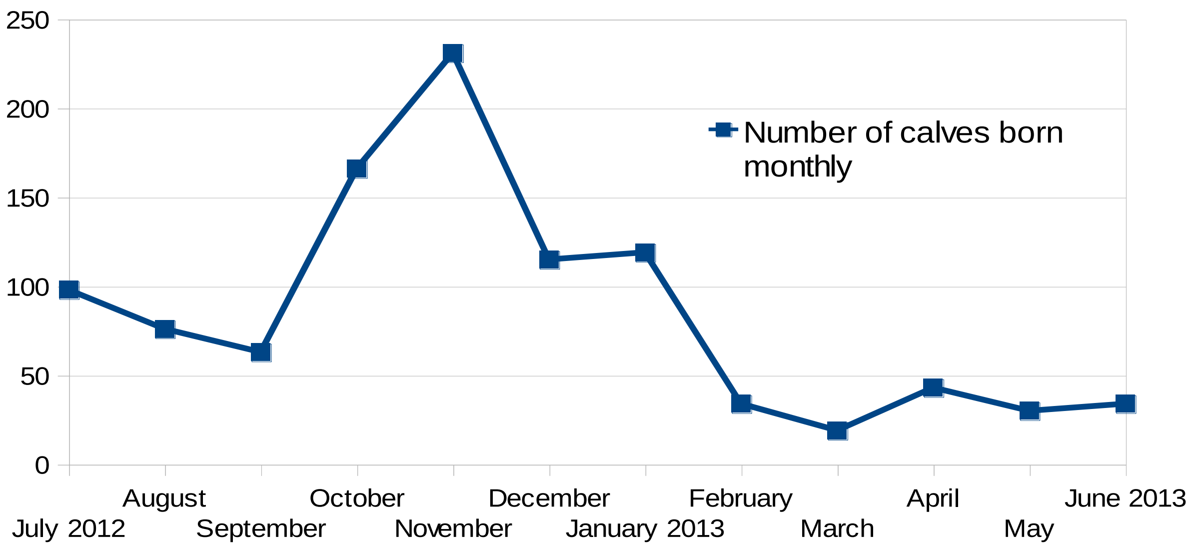

Figure 6 Seasonality of calvings from July 2012 through June 2013

Intake rate

From July 2012 through June 2013, the overall intake rate was 3.5%. These intakes were contributed by purchases (86.5%), donations/gifts (8.1%), exchanges (2.7%) and others (2.7%). Figure 7 shows the categories of all entries into the study population from July 2012 through June 2013.

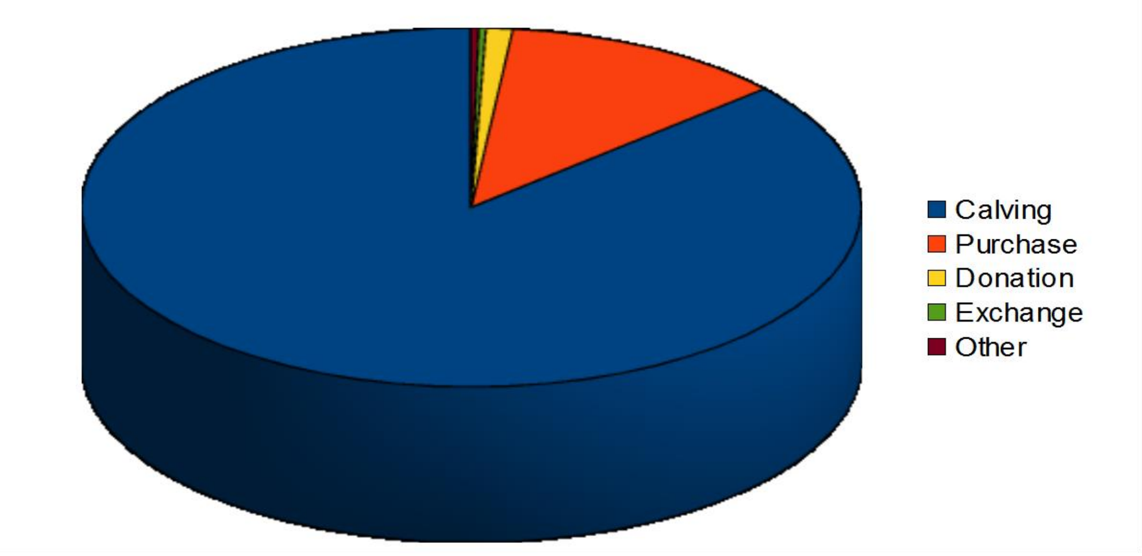

Figure 7 Entries into the study population from July 2012 through June 2013

3.3 Population dynamics: exits

The 440 exits from Ward B2 cattle population from July 2012 through June 2013 comprised 76.8% mortalities and 23.2% offtakes.

Mortality rate

With a total of 338 deaths over 12 months, the annual mortality rate recorded is 7.3%, with a peak in mortalities in April (Figure 8). Some information about the cause of death was established in 79 animals by questioning the farmers: acute death (60%), acute disease (27%), chronic disease (2.5%), accidents/injury (3.7%), natural cause (3.7%), others (3.7%).

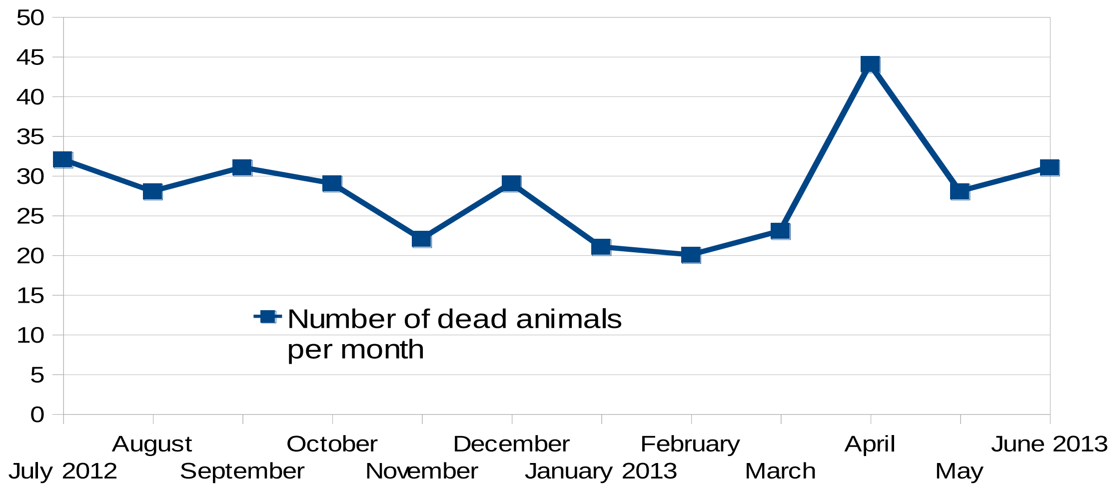

Figure 8 Number of dead animals per month from July 2012 through June 2013

Offtake rate

With a total of 102 offtakes, offtakes represent 2.2% of the total cattle population. They comprised sales to another farmer (75%), slaughters (14.5%), exchanges (3.6%), donations/gifts (1.2%) and others (6%). Figure 9 shows the categories of all exits from the study population from July 2012 through June 2013.

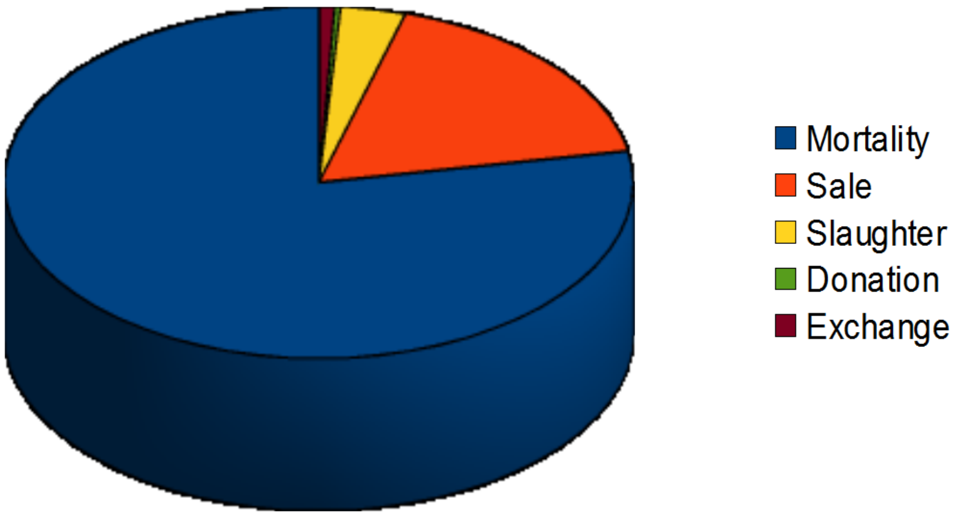

Figure 9 Exits from the study population from July 2012 through June 2013

3.4 Global demographic indicator

The overall growth rate of the cattle population in the DSA from July 2012 through June 2013 was 13.3%, from 4,061 to 4,683 animals.

4. Discussion

Through the individual identification of 4,683 cattle, this 12 month old HDSS is already benefitting from a wide number of subjects, and weekly updates of demographic parameters have enhanced the accuracy of the results revealed in this study. These results are all the more interesting since Mnisi is located at a wildlife interface, where FMD vaccination is compulsory and movements of cloven-hooved animals strictly regulated. In spite of these restrictions, the Ward B2 cattle herd is doing well.

When one considers that 10 cattle is the minimum herd size to achieve a level of minimum subsistence, and that 68% of communal farmers in southern Africa own fewer than 10 cattle (Casey & Maree, 1993b), the farmers in this study compare well, with an overall average herd size of 25.8 cattle. This finding is close to the average herd size of 24 cattle in Mpumalanga revealed by Scholtz *et al.* (2008), and is above most average herd sizes found in other southern African countries (6 - 21; Table 1). However, the analysis of variance shows that one diptank in particular - Utah Scheme - tends to push up this number as most of the farmers there own larger herds in comparison with the other diptanks.

The herd structure revealed by this study differs significantly from that of other cattle populations reported in the literature, except for the percentage of calves less than a year old (ranging from 13.9% in July 2012 to 20.3% in June 2013). In other studies, the percentage of calves ranges from 6.6% in eastern Botswana (Reed *et al*., 1974) to 20% in the Sanyati communal area of Zimbabwe (Chatikobo *et al*., 2001). On the other hand, the bulls and heifers percentages are particularly low compared to other studies, while breeding cows three years and older represent more than half of the herd composition. If one excludes the calves less than a year old from the total herd, breeding cows represent 70% of the adult cattle, which is much higher than the targets of 20% - 25% in the communal sector and 50% in the commercial sector (Scholtz & Bester, 2010). Such a high percentage of breeding cows could be explained by the fact that farmers are reluctant to slaughter them, even the older ones, therefore they probably live until they die of old age, unlike in the commercial sector where aging cows are continuously replaced by younger stock. Another point of importance is the age of reproductive maturity: in the commercial sector, where animals are fed industrial rations, reproductive maturity is estimated when heifers reach 60% of their adult weight, and are then penned together with the bull, but in the communal areas where cattle depend on available grazing, and heifers roam freely with bulls, there is no real control over the age of first breeding. Determining the age of breeding cows in communal areas, i.e. age when heifers are able to bear a calf for the first time, remains difficult, knowing that it differs greatly between various studies: 1.5 to 2 years (Nqeno *et al*., 2011), 2 to 2.5 years (Mokantla *et al*., 2004; Siegmund-Schultze *et al*., 2012), three years (Scoones, 1992), 3.5 to 4.3 years (Reed *et al*., 1974), to 5+ years (De Leeuw *et al*., 1995; Lesnoff *et al*., 2002; Siegmund-Schultze *et al.*, 2012). For this study we considered that age of reproductive maturity was three years old, since farmers reported first calvers to be aged two to four years old. Should we have considered breeding cows to be five years and older, then the herd structure would appear more similar to what was found in other studies. Percentages of breeding cows aged five years and older would be 39%, heifers less than five years old 18.8%, calves less than a year old 20.8% and bulls aged one year and older 20.7%.

Compared to the commercial sector where it is recommended to have 30 cows per bull, and to other studies done in communal areas revealing ratios similar to the commercial sector (Mapiye *et al*., 2009a; Perry *et al*., 1984; Scholtz *et al*., 2008; Siegmund-Schultze *et al*., 2012), the cattle population in Ward B2 is made up of roughly two thirds females and one third males. This finding almost coincides with what Nthakheni (1993) recorded in a communal area of Venda, South Africa, where the bull to cow ratio was 1:4.

In terms of herd composition, European breeds are not common in the study population, yet Scholtz *et al.* (2008) reported that European breeds make up to 23% of the South African beef cattle seed stock industry. The majority of indigenous Sangas and their crosses allow for an overall good disease resistance trait amongst the herds (Makgatho *et al*., 2005; Scholtz *et al*., 2008). The rather low contribution of the Brahman breed to the herds (only 6%, as opposed to approximately 30% reported by Scholtz *et al*., 2008 and a NERPO study of 2000) could be explained by the fact that this breed is particularly difficult to handle and therefore farmers prefer Sanga types which are more docile and easier to farm with.

Calvings contribute to almost eight times as many intakes as all other entries into the study population, which is consistent with the findings of Mapiye *et al.* (2009a) in the Eastern Cape where entries were represented by 88% calvings and 12% purchases. The calving rate in communal cattle population studies varies greatly, from 14.9% in Venda, South Africa (Nthakheni, 1993) to 68% - 82% in Mazvihwa, southern Zimbabwe (Scoones, 1992). The calving rate of 40.1% in the population during the study period is comparable to that found in previous studies done in the same region, i.e. calving rate of 41.1% in the former Ciskei and Transkei (Bembridge & Tapson, 1993), and corresponds to the "normal expected calving rate" in communal areas of 40% (Scholtz & Bester, 2010). The combination of a good calving rate and an average BCS of 2.7 are positive indicators of reproductive performance, since ovarian activity and pregnancy rate are optimized with a BCS superior to 2.5 (Honhold *et al*., 1992). Finally, the calving rate shows a clear seasonality with a peak in November, which corresponds to the beginning of the rainy season, allowing both suckling dams and their offspring to make the most of the available grass during lactation and growth.

From July 2012 through June 2013, the mortality rate was 7.3%, which is less than the average mortality rate in the communal sector of 13% established by Casey and Maree (1993b), but more than the 4.7% reported by Scholtz and Bester (2010). However one needs to be careful when evaluating and comparing the mortality rate, as mortalities can easily go unnoticed, especially in the case of neonates, or confused with other causes of disappearance, such as thefts or escapes. There seems to be a peak of mortalities in April, the end of summer, possibly related to the high prevalence of vector-borne diseases at this time of the year, such as tick-borne bovine anaplasmosis and babesiosis. This hypothesis is further supported by the fact that information about cause of death provided by the farmers points mostly towards sudden death or acute diseases.

The total offtake rate of 2.2% is lower than what is recorded in other studies (Table 6), but does concur with the 2% offtake rate recorded by Ainslie *et al.* (2002) in the communal areas of the Eastern Cape. Because the Mnisi community is located in the FMD control zone of South Africa, where vaccination against FMD is compulsory and all movements of livestock require a permit, sales and slaughter outside the community remain constrained. This may explain why the offtake rate is lower than the recorded average offtake rate of 6% in communal areas in South Africa (Scholtz & Bester, 2010).

With an annual growth rate of 13.3% between July 2012 and June 2013, the cattle population of Ward B2 increased at a significant rate, which is supported by the good calving rate of 40.1% and low mortality and offtake rates. Moreover, the average BCS of 2.7 and low mortality rate indicate overall good herd health.

These insights into the cattle population of Ward B2 have contributed to a better understanding of communal farming potential and constraints, and have revealed positive aspects about the health and reproductive state of its animals. The fact that herd structure differs so much from other studies could warrant a study on sexual maturity and reproduction parameters in general in the study population. Investigation of mortalities in late summer could also contribute to the better management of vector-borne diseases. Rates found in this study may suffer a degree of bias since some results rely on farmers' recall which isn't always exact, together with the fact that animals are left to roam around freely during the day and demographic events can easily go unnoticed, e.g. abortions or neonatal mortalities. However, following up on the study population over the years would give a more accurate reflection of the demographic events and could allow for year to year comparison. Data have been collected over a twelve month period only, therefore they will need to be refined over the years and will hopefully benefit from other studies run in parallel in the same DSA.

Conclusion

Compared to other studies on communal cattle in southern Africa, the cattle population of Ward B2 showed overall good herd health and steady growth during the study period, reflected by the combination of good calving rate, good body condition, majority of disease-resistant Sanga types, low mortality and positive annual growth. As for the low intake and offtake rates, which are based on the farmers' decisions, the movement restriction placed on cattle vaccinated against FMD at the livestock-wildlife interface hinders trading over far distances, and blocks access to lucrative markets. As a result, most of the Mnisi cattle are meant for local markets with currently no prospect of commercial farming. However, the results of this study suggest that there is significant potential for cattle production in this area, should alternative approaches to FMD control be adopted that might allow these farmers to access other markets.

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