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A 13-Year Retrospective Study of the Beef and Dairy Cattle Losses at Neudamm Farm in the Khomas Region of Namibia

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ABSTRACT

This study was carried out to get an appraisal of the losses occasioned by apparently high levels of stock mortality at Neudamm farm, University of Namibia. Losses of beef cattle (Afrikaner, Simmental and Sanga/Nguni) and dairy cattle (Friesian) were studied from July 2003 to December 2015. A total of 106 animals worth US$55 263.12 and representing 3.5% (SD=0.8%) of the animals at risk were lost during this period. In the years 2004, 2006, 2007, 2010, 2012, 2013 and 2014 the cattle losses were more than 1.5% whereas in 2005, 2008, 2011 and 2015 the losses were 1.0-1.5%. The lowest losses (<1.0%) occurred in 2003 and 2009. Since 2005, overall cattle losses rapidly increased until 2010 followed by a gradual decrease till 2015. Though there was no significant difference in the overall losses between male {3.4% (SD=0.7%)} and female animals {3.8% (SD=0.9%)} during the study period (P>0.05), the female losses were significantly higher than the male losses (P<0.05) in all the years except 2011 during which there was no significant difference between male and female losses (P>0.05). There were significantly more mature animals lost from 2003 to 2009 and from 2013 to 2014 (P<0.05). There was no significant difference in the mature and immature losses in 2012 (P>0.05). The losses in immature cattle were higher than those of mature cattle in 2010, 2011 and 2015 (P<0.05). The proportions of animals lost due to predation, unknown causes, dystocia, infections, trauma, old age, plant intoxication and traumatic reticulo-peritonitis were 29.2%, 29.2%, 14.2%, 11.3%, 9.4%, 4.7%, 0.9% and 0.9%, respectively. For the duration under study, the proportional losses in January, February, April, November and December were significantly higher than those of the rest of the months (P<0.05). Neudamm farm lost 3.5% of their beef and dairy stock, worth US$55 263.12, over a 13 year period as a result of infectious and non-infectious causes. The dynamics of the losses were such that the losses were higher in some years than others, more young than older animals were lost and, though not statistically significant, more females were lost than males.

1.INTRODUCTION

The loss of beef or dairy cattle from any cause is a major concern for farmers due to loss of farm income. It may also be an indication of animal welfare lapses. Economic losses result from reduced animal productivity, reproductive wastage and labour before the animal dies; and the actual death of the animal and costs associated with purchasing and rearing replacement animals. Culling of animals from a production group may be forced or voluntary. Involuntary or forced removal of animals may be necessitated by conditions such as low reproduction and infectious diseases (Ahlman *et al.*, 2011 and Karrar *et al.*, 2017). A high number of involuntarily culled animals in a herd especially due to mortality, is an indicator of suboptimal health, welfare or management of animals in a herd. Mortality can be broadly categorized into assisted and unassisted mortalities (Fiore *et al.*, 2010 and Mõtus et al., 2017). Voluntary culling is made by choice on animals such as old dairy cows and cows with low milk yield (Duncan, 2001 and Karrar *et al.*, 2017). In well managed livestock enterprises, culling should be based on economic reasons (Karrar *et al.*, 2017).

The focus on dairy farms is towards ensuring healthy cows at their maximum level of production. Dairy cow mortalities have been reported to be on the increase in many countries and mortality rates of 1-8% have been reported (Thomsen and Houe, 2006; Mee, 2013 and Reimus *et al.*, 2017). Most mortalities in dairy cows have been reported to occur during early lactation (Alvåsen *et al.*, 2014), in particular, during the first 30 days of lactation (Thomsen and Houe, 2006). Many authors have reported higher mortalities in older than young cows, while other studies have found no clear association between age or parity and cow mortalities (Thomsen and Houe, 2006). The high mortality associated with older cows has been attributed to the higher risk of calving and metabolic problems in these animals (Reimus *et al.*, 2017). The lowest mortality rates on dairy farms have been reported in heifers between 12 and 17 months of age (Reimus *et al.*, 2017). Herd level factors such as breed, a large herd size, low herd annual milk production and a high proportion of purchased cows are associated with increased cow mortality (Alvåsen *et al.*, 2014 and Shahid *et al.*, 2015). At cow level, age at first calving, season of calving, lactation stage and milk yield influence cow mortality (Thomsen and Houe, 2006). Calving problems, digestive disorders, metabolic disease, musculoskeletal problems, mastitis, unknown causes (Thomsen and Houe, 2006), fertility problems (Ahlman *et al.* and 2011; Reimus *et al.*, 2017), feet/claw disorders and trauma (Svensson *et al.*, 2006) have been documented as potential causes of assisted and unassisted cow mortality in dairy herds. Seasonal variations in older cow mortalities have also been reported in Estonia (Reimus *et al.*, 2017).

High dairy calf mortality is a welfare issue and has become an international concern (Mee, 2013). The survival of bull calves is often not prioritized because they contribute little to the overall income of the enterprise. It is estimated that half of the calf mortalities that occur on dairy farms can be prevented by implementing good calf management and welfare practices (McConnel *et al.*, 2008 and Santman-Berends *et al.*, 2014). Risk factors for calf mortality are well documented and include dam parity, dystocia, twin/triplet birth, congenital defects, sex, calf birth weight, respiratory disease, diarrhoea, arthritis (Svensson *et al.*, 2006 and Raboisson *et al.*, 2013), calving related disease, trauma (Svensson *et al.*, 2006), herd size, characteristics of calving area and type of housing system from two weeks of age (Gulliksen *et al.*, 2009 and Raboisson *et al.*, 2013).

A high proportion of calves die during the perinatal period. Studies have shown that about 75% of perinatal mortalities occur within one hour of calving (Mee, 2013). One study on dairy replacement heifers reported an overall mortality rate of 3.5% with a peak incidence at 11 days of age and an association between failure of passive transfer of antibodies and calf mortality (Windeyer *et al.*, 2014). Dairy calf survival rates can be improved by reprioritization and creation of awareness of calf welfare on the farms (Mee, 2013).

Most beef enterprises comprise of cow-calf operations that are managed extensively, but beef cattle losses have been extensively studied in intensive production systems particularly in calves and cattle in feedlots (Mõtus *et al.*, 2017). Beef cattle on-farm losses vary with age and the production system (Mõtus *et al.*, 2017). In a study by Waldner *et al.* (2009), traumatic reticulo-peritonitis, bloat and myopathies were the most common causes of beef cow mortality. Other causes included ocular squamous cell carcinoma, pyelonephritis and paratuberculosis. Annual culling and mortality rates of 14.3% and incidence of 1.1 deaths per 100-cow years at risk respectively have been reported in beef cows greater than 10 years of age (Waldner *et al.*, 2009). Season, age, sex, floor type, incidence of bovine respiratory disease, nutrition management have all been described as risk factors for mortality in older beef cattle (Waldner *et al.*, 2009; Rumor *et al*, 2015 and Struchen *et al*, 2015). Comparisons between male and female cattle up to the age of 18 months revealed that males are at a higher risk of mortality than females (Mõtus *et al.*, 2017).

Risk factors for beef calf losses have been described and they include the method of castration, management of colostrum, sex of calf, calf birth weight, season of calving, weather conditions at calving, intervention during calving, herd size and the rate of occurrence of respiratory diseases (Bunter *et al.*, 2013 and Elghafghuf *et al.*, 2014). Calf losses in extensively managed cow-calf operations (including Brahman calves) have been reported to vary between 1.4–9.5% (Bunter *et al.*, 2013 and Elghafghuf *et al.*, 2014). A greater proportion of beef calf mortalities occur within the first week of birth (Bunter *et al.*, 2013 and Murray et al., 2016). Some authors have reported the highest mortalities in calves less than 3 months of age (Mõtus *et al.*, 2017). Predation has been identified as a cause of significant calf losses in Australia. Predation by wild dogs (*Canis lupus dingo*) is estimated to have cost the beef industry over US$29 million in a period of two years (Allen, 2014).

On-farm cattle mortality varies with geographical location and management system, among other factors. There are limited reports on the causes of large stock losses on commercial farms in southern Africa. To the best of our knowledge, no systematic studies have been carried out in Namibia on the causes of cattle losses. Understanding the causes and risk factors for animal losses is an important step towards improving herd health through the implementation of preventive measures. In this study, the authors carried out a retrospective investigation of the beef and dairy mortalities at Neudamm farm, a farm which is in the Khomas region of Namibia.

2. MATERIALS AND METHODS

2.1. Study area

Neudamm farm is situated in the Khomas region, 40km east of Windhoek at the coordinates 22°31'0" S and 17°15'0" E. The farm covers over 10 187 hectares of land and is about 1 963m above sea level. The vegetation is predominantly savanna (dominated by shrubveld) and the area receives annual rainfall of between 300 and 400mm mostly from November to April (Mendelsohn *et al.*, 2002). The farm is located in a predominantly large stock farming area interspaced with wildlife farms.

2.2. Study animals

The average annual population of large stock (dairy and beef cattle) at Neudamm farm from July 2003 to December 2015 was 366±86 animals. The largest annual population was 515 animals (in 2005) and the lowest annual population was 265 animals (in 2007). The average annual male and female populations from July 2003 to December 2015 were 65 (SD=37) and 167 (SD=47) animals, respectively. The average annual mature and immature populations from July 2003 to 2015 were 232 (SD=78) and 134 (SD=75) animals, respectively. The Neudamm farm management together with the Namibian Stud Breeders Association assessed all potential breeding stock at 18 months of age, a point at which these animals are considered to be mature. The cattle were reared in paddocks arranged into camps and only brought to the sheds for deworming, dipping, vaccinations, treatment and supplementary feeding with lucerne and grass hay when the paddocks ran out of grass during the dry seasons.

Beef cows from the various breeds were mixed during grazing except during times of breeding whereby they were carefully separated into breeding groups to the satisfaction of the management's breeding program. The management kept weekly records of large stock numbers and losses. Weekly records were captured on Microsoft Excel 2013 version and statistical analysis was carried out using the Z test for comparison of two or more proportions. P values <0.05 were considered statistically significant.

Table 1 Breed distribution of cattle at Neudamm farm from 2003 to 2015

Breed	Period reared	Annual average number of animals	Standard Deviation
Afrikaner	2003-2015	292	73
Sanga	2010-2015	105	20
Simmental	2012-2015	28	9
Friesian	2003-2015	41	2

2.3. Rainfall

The rainfall records kept by the farm management since 2002 till 2015 were captured on Excel 2013 and graphically presented in Figure 1. The average annual rainfall at Neudamm farm was 409±196mm. The highest precipitation (1009mm) was recorded in 2011 and the lowest (159.5mm) in 2007.

Figure 1 Total annual rainfall at Neudamm farm from 2002 to 2015

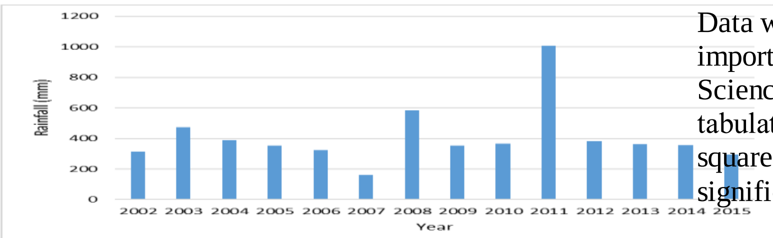
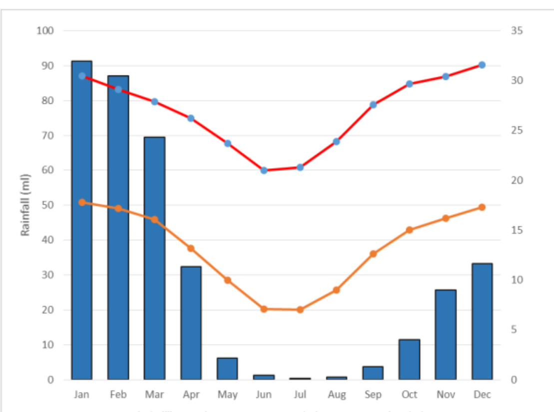


Figure 2 25-year climate data for Windhoek presented per month.



As shown in Figure 2, January, February and March are the wettest months characterized by relatively high diurnal temperatures. June, July and August are the driest and coldest months of the year. The diurnal variation of temperature is typically characterized with high daytime and low night time temperatures thus designating the Khomas region as a hot semi-arid region.

2.4. Statistical analysis

Data was captured in Microsoft Excel 2013 and then imported into the Statistical Package for Social Sciences (SPSS) version 16 for analysis. Cross tabulations were performed using Pearson's Chi square test and p values ≤ 0.05 were considered significant.

3. RESULTS

Figure 3 shows that large numbers of dairy and beef cattle ($\geq$1.5%) were lost in 2004, 2005, 2006, 2007, 2008, 2010, 2012, 2013 and 2014. Relatively lower losses (1.0-1.5%) were recorded in 2003, 2009, 2011 and 2015.

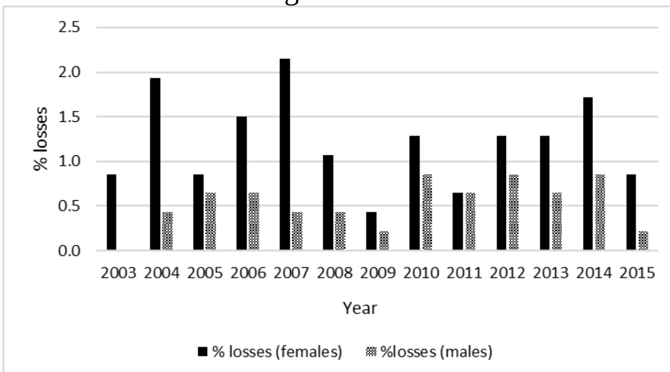
Figure 3 Overall large stock losses

Table 2 Overall losses of large stock according to sex from 2003 to 2015

Sex of animals	Number of losses	Total number of animals at risk	Average losses (%)	Revenue losses (US$)	Proportion of total revenue lost (%)
Female	74	2175	3.4 (SD=0.7)	33 664	60.9
Male	32	841	3.8 (SD=0.9)	21 599	30.1
Overall	**106**	**3016**	**3.5 (0.8)**	**55 263**	**100**

Table 2 shows that overall, the same proportions of male and female large stock were lost from July 2003 to December 2015. The corresponding cost of the losses in females was, however, significantly higher than those in males (P<0.05).

Figure 4 Annual cattle losses at Neudamm according to sex from 2003 to 2015



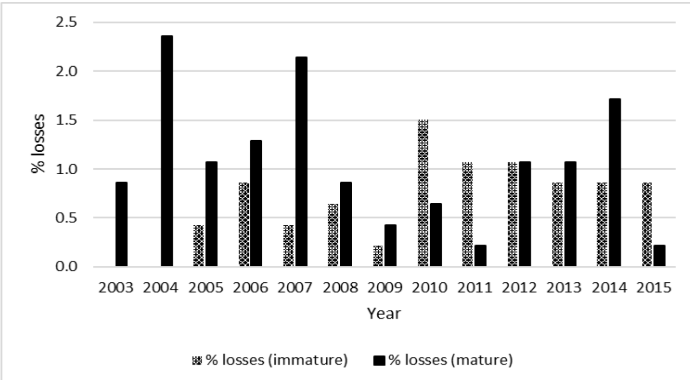
Overall, significantly more female cattle (15.9%) than male cattle (6.9%) were lost from 2003 to 2015 ($P<0.05$). Statistical analysis of annual losses showed that significantly more female cattle than male cattle were lost from 2003 to 2015, except for the year 2011 ($P<0.05$). There were no significant differences in the proportions of male and female cattle lost in 2011 ($P>0.05$).

Table 3 Proportional losses of cattle according to breed and age from 2003 to 2015

Age category and breed	Female animals	Female Proportion (%)	Male animals	Male Proportion (%)	Grand Total (Number of Animals)
Immature	**23**	**56.1**	**18**	**43.9**	**41**
Afrikaner	19	57.6	14	42.4	**33**
Sanga	3	50.0	3	50.0	**6**
Simmental	1	50.0	1	50.0	**2**
Mature	**51**	**78.5**	**14**	**21.5**	**65**
Afrikaner	37	75.5	12	24.5	**49**
Friesian	7	100.0	0	0.0	**7**
Sanga	3	60.0	2	40.0	**5**
Simmental	4	100.0	0	0.0	**4**
Overall	**74**	**69.8**	**32**	**30.2**	**106**

Table 3 shows that overall, a significantly higher proportion of mature females (78.5%) than immature females (56.1%) was lost between 2003 and 2015 ($P<0.05$). A significantly higher proportion of immature males (43.9%) than mature males (21.5%) was lost during the period under study ($P<0.05$). Proportional losses of both mature and immature Afrikaner female animals were significantly higher than losses in mature and immature Afrikaner male animals ($P<0.05$). There were no significant differences in the proportional losses of male and female immature animals of both the Sanga and Simmental breeds ($P>0.05$). The proportional losses in the mature females of the Afrikaner, Friesian, Sanga and Simmental were all significantly higher than the proportional losses of the males in these breeds ($P<0.05$). There were no loses of immature Friesian cattle.

Figure 5 Annual large stock losses according to age of animal



Overall, a significantly greater proportion of mature cattle (13.9%) was lost in comparison to the proportion of immature cattle (8.8%) lost at Neudamm farm from 2003 to 2015 (P<0.05). A significantly greater proportion of mature cattle was lost from 2003 to 2009 and from 2013 to 2014 (P<0.05). A significantly greater proportion of immature cattle was lost from 2010 to 2011 and in 2015 (P<0.05). There was no significant difference in the proportion of mature and immature cattle lost in 2012 (P>0.05).

Table 4 Losses of cattle at Neudamm from 2003 to 2015 according to breed

Breed	Total number of losses	Average annual losses	Average annual number of animals at risk	Average annual losses (%)	Corresponding revenue losses (US$)
Afrikaner	82	6.3	292	2.2	43 198
Sanga	11	0.8	105	0.8	4 916
Simmental	6	0.5	28	1.7	2 979
Friesian	7	0.5	41	1.2	4 171

Overall, the greatest proportion of cattle lost from 2003 to 2015 were Afrikaner beef cattle (77.4%) with corresponding revenue losses totalling US$43 198.00 (78.2% of the total revenue lost), followed by Sanga beef cattle losses with corresponding revenue losses of (US$4 916.00), Friesian losses (US$4 171.00) and Simmental losses (US$2 979.00).

Table 5 Cross tabulation of proportional losses in cattle breeds using Z-scores and P values

	Z-scores			
	Afrikaner	Sanga	Simmental	Friesian
Afrikaner	-	3.65*	0.75#	1.49#
Sanga	-	-	1.54#	-1.09#
Simmental	-	-	-	0.45#

*P<0.05; significant difference between cross-tabulated breeds
#P>0.05; no significant difference between cross-tabulated breeds

The losses in Afrikaner cattle were significantly higher than those of the Sanga breed (P<0.05) but not significantly higher than the losses of the Simmental and the Friesian breeds (P>0.05). There was no significant difference in the losses between the Simmental and the Friesian, the Sanga and the Simmental and the Sanga and the Friesian (P>0.05).

Table 6 Proportional causes of cattle losses according to age at Neudamm farm from 2003 to 2015.

Cause of loss	Mature animals lost	Immature animals lost	Total Number of losses	Proportion of losses (%)
Dystocia	15*	0*	15	14.15
Hardware-disease	1	0	1	0.94
Infection	2*	10*	12	11.32
Old-age	5	0	5	4.72
Predation	1*	30*	31	29.25
Toxic-plant	0	1	1	0.94
Trauma	10*	0*	10	9.43
Unknown	31*	0*	31	29.25
Grand Total	**65**	**41**	**106**	**100.0**

*There was a significant difference between these proportions (P<0.05).

As shown in Table 6, the highest proportion of losses of cattle at Neudamm farm from 2003 to 2015 resulted from unknown causes, dystocia and predations which collectively accounted for 72.6% of the total losses. Losses due to infections, trauma, old age plant intoxication and traumatic reticulo-peritonitis were collectively responsible for 27.4% of the cattle losses during the period under study. Most of the immature animals were lost to predation (96.8%, n=31) and infection (83.3%, n=12)) whilst most of the mature animals were lost to dystocia (100%, n=15), old age (100%, n=5), trauma (100%, n=10) and unknown causes (100%, n=31). Statistical analysis showed that there was a significantly higher proportion of mature animals lost to dystocia, trauma and unknown causes (P<0.05). There was a significantly higher proportion of immature animals lost to infection and predation (P<0.05). There was no significant difference in the proportion of mature and immature animals lost to retculo-peritonitis, old age and toxic plants (P>0.05).

Table 7 Proportional causes of cattle losses according to sex at Neudamm farm from 2003 to 2015.

Cause of loss	Number of females	Number of males	P value
Dystocia	15	0	0.02
Hardware-disease	1	0	0.11*
Infection	8	4	0.67*
Old-age	4	1	0.70*
Predation	16	15	0.01
Toxic-plant	0	1	0.11*
Trauma	3	7	0.00
Unknown	27	3	0.03
Overall	**74**	**32**	**0.59***

*There was no significant difference between these proportions (P>0.05).

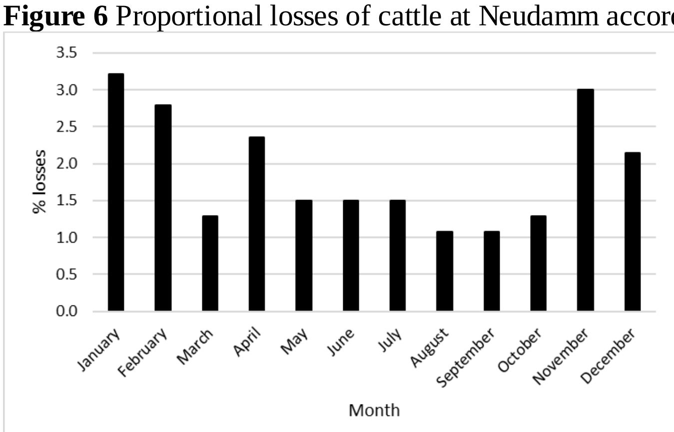
As shown in Table 7 above, there was no significant difference in the losses between male and female animals (P>0.05). Significantly more female animals in comparison to male animals were lost to dystocia and unknown causes (P<0.05). Significantly more male animals in comparison to females were lost to predation and trauma 0P<0.05). There was no significant difference in the proportion of male and females animals lost to infection, hardware disease, toxic plants and old age (P>0.05).

Table 8 Proportional cause of cattle losses according to breed from 2003 to 2015.

	Proportion of cattle losses (%)			
Cause of loss	**Afrikaner**	**Friesian**	**Sanga**	**Simmental**
Dystocia	14.6	14.3	0	33.2
Traumatic reticulo-peritonitis	1.2	0	0	0
Infection	11	14.3	18.2	0
Old-age	3.7	0	18.2	0
Predation	31.7	0	36.4	16.7
Toxic-plant	0	0	0	16.7
Trauma	9.8	0	9	16.7
Unknown	28	71.4	18.2	16.7
Grand Total	100.0	100.0	100.0	100.0

As shown in table 8, the highest cause of deaths in large stock was unknown (71.4%) in the Friesian. The highest known cause of death, however, was predation (36.4%) in the Sanga. The absence of losses due to old age, predation, trauma and plant intoxication in the Friesian were noteworthy. There were no losses attributable to dystocia, traumatic reticulo-peritonitis and plant intoxication in the Sanga. There were no losses due to traumatic reticulo-peritonitis, infection and old age in the Simmental.

Figure 6 Proportional losses of cattle at Neudamm according to month from 2003 to 2015.



As shown in Figure 6, the proportional losses of cattle in January, February, April, November and December were significantly higher than those in the rest of the months (P<0.05).

4.DISCUSSION

Over the 13-year study period, relatively few cattle were raised at Neudamm farm. Beef cattle were raised extensively on natural pastures, but received regular animal health care and supplementary feeding. The Afrikaner breed was the most common beef breed on the farm followed by the Simmental and Sanga breeds, while the Friesian was the only dairy breed on the farm. The Brahman, Simmental, and Nguni breeds are the most common breeds of beef cattle in Namibia (Sebsibe and Munyua, 2015). The data that was analysed for the Afrikaner and Friesian breeds of cattle was for 13 years, while the data for the Sanga and Simmental cattle was for four years.

A total of 106 cattle worth US$55 264 were lost from various causes during the study period. This figure is much smaller than the US$161 280.00 lost through small ruminant mortalities at the same farm (Dr Erick

Kandiwa, personal communication). About 60.9% (US$33 664) of the revenue lost was due to the loss of female cattle and this loss was significantly higher ($p < 0.05$) than that of male animals. From 2003 to 2015, significantly more female cattle than male cattle were lost ($p<0.05$) confirming that females animals were at considerably greater risk. In 2011, there were no significant differences ($p>0.05$) in the proportions of male and female cattle that were lost from the herd.

The largest losses of beef and dairy cattle occurred in 2004, 2005, 2006, 2007, 2008, 2010, 2012, 2013 and 2014 with mortality rates of 1.5% and above in the cattle population. In these years, relatively low annual rainfall of less than 400mm was received. Animal losses could therefore have been due to feed and water shortages during the drought years. The number of cattle lost in the year (2011) with the highest annual rainfall received was lower than the number of cattle lost in the drought year (2007). An assessment of cattle losses by month showed that significantly higher numbers of cattle ($p < 0.05$) were lost in January, February, April, November and December than in any other month. These five months fall within the hot, humid rainy season though typically characterized by cold nights. These findings suggest a possible association between cattle losses and annual rainfall, probably related to higher parasite burden during these months.

In Namibia, the recommended breeding season for beef cattle starts in January or February extending for about 66 days, with a second breeding season in August/September (Stehn, 2008). Routine culling of heifers and adult cows that are not pregnant and losses of animals due to dystocia during the calving season may explain the losses recorded in January, February, April, November and December. It is well documented that the rainy season is associated with a rise in the tick population and incidence of tick-borne diseases (Lima *et al*, 2000) which may explain the apparent association of cattle mortality and season in this study. The extensive beef cattle rearing system may mean that animals contracting these tick-borne diseases die on the veld before diagnosis and treatment can be done.

Average annual dairy cow losses of 0.5% determined by this study were lower than the rates of 1-8% reported under intensive conditions in other studies (Thomsen and Houe, 2006; McConnel *et al.*, 2008; and Mee, 2013). However, the dairy herd size in this study was small, with an annual average of 41 dairy animals. Only seven dairy cows were lost over the 13 year study period as a result of dystocia, infections and from unknown causes. These findings are in agreement with other studies which have reported calving problems (Thomsen and Houe, 2006; Fusi *et al.*, 2017) and unknown causes (Thomsen and Houe, 2006; Ahlman *et al.*, 2011) as common causes of dairy cow losses. Higher mortality in dairy cows than heifers has also been reported (Thomsen and Houe, 2006), and this has been explained by the higher susceptibility of older cows to calving and metabolic complications (Shahid *et al.*, 2015). Due to the absence of records, we could not determine the role of milk production and stage of lactation on dairy cows' mortality. The replacement rate for dairy cows was very low, perhaps reflecting their primary use as teaching animals.

Analysis of proportional losses of cattle using the Z score revealed that significantly higher numbers of Afrikaner cattle were lost than Sanga cattle. About 77% of cattle lost from the farm were of the Afrikaner breed, the majority of which were female (68.3%). This observation may be explained by the higher proportion of Afrikaner cattle and females than males on the farm. With regards to overall losses, there were no significant differences in losses between male and female animals. The lowest losses (5.6%) were recorded for the Simmental breed of cattle, which had the least number of animals on the farm. Both the Sanga and Afrikaner cattle are indigenous cattle breeds that are highly adapted to the local conditions (Collins-Lusweti, 2000).

It was expected that proportionally low numbers of these two breeds would be lost than in the exotic breeds, but this was not the case. Previous studies found that Afrikaner cattle have a low calving rate (56-74%) (Moyo *et al.*, 1996; Collins-Lusweti, 2000) compared to the Sanga breed (92%), which may account for the differences in animals lost in this study. Assessment of losses by age revealed that significantly more adult animals (61.3%) were lost than young animals (38.7%) over the study period ($p<0.05$). About 79% of the adult animals lost were mature females though significantly more immature males than mature males were lost ($p < 0.05$). In all breeds, more mature females than males were lost from the herd. Contrary to our findings, other studies have reported higher losses in males than females (Mõtus *et al.*, 2017).

Unknown causes (29.2%) and predation (29.2%) were the main causes of cattle losses at Neudamm farm, affecting more female than male cattle. 'Unknown' causes have also been reported as the main reason for mortality in dairy cattle (Thomsen and Houe, 2006; McConnel *et al.*, 2008 and Alvåsen *et al.*, 2014;). The value of animals lost to 'unknown' causes (US$19736.83) was more than double the value of animals lost to predation (US$8937.43) although the same number of cattle were lost in each case. These findings suggest that high value animals were lost to 'unknown' causes, while lower value animals, presumably calves were lost to predation. Other studies have reported that predation occurs in seasons of low rainfall when normal wild prey for wild predators is scarce (Allen, 2014). A high proportion of losses designated as 'unknown' may be an indication of inadequate inspection of the herd for earlier detection of disease symptoms (Fusi *et al.*, 2017) and the absence of further investigation of causes of death due to discovery of animals in advanced stages of decomposition in the camps.

This might explain the high number of losses attributed to unknown causes. Such cases are not prevented or controlled and may thus continue to affect the herd leading to severe economic losses. However, it is expected of farmers or managers to not know the reason for death (Alvåsen *et al.*, 2014). This trend of high losses due to unknown causes may be explained by the absence of resident veterinarians at Neudamm farm prior to 2014. This trend is most likely going to come down with the establishment of the School of Veterinary Medicine at the farm. Availability of resident veterinarians are is bound to decrease total losses while necropsy services are expected to diminish deaths due to unknown causes.

Known causes of cattle losses were identified as dystocia, infection, predation, trauma, old age, toxic plants and traumatic reticulo-peritonitis. They were responsible for 70.8% (75/106) of animal losses on the farm. In this study, dystocia, trauma and unknown causes were the major causes of losses of adult cattle on the farm. Losses of cows due to dystocia were not reported in the indigenous Sanga breed. Infectious and toxic plant causes of mortalities were not investigated further and their control and prevention were not prioritized. Interestingly, plant poisoning was a cause of mortality in the exotic Simmental breed of beef cattle. Exotic breeds are not familiar with the local forages and are less selective and therefore prone to plant poisoning. The absence of losses due to old age, predation, trauma and plant intoxication in the Friesian were noteworthy and may be a reflection of the longevity of these animals in production, the daily observations of the animals during milking and the fact that they were raised on pastures free of toxic plants and causes of injury.

Traumatic losses were attributed to beef animals only. Beef animals tend to be less tame and easily excitable due to less handling, which predisposes them to injuries as reported in this study. However, the environment on the farm needs to be investigated to identify and remove possible causes of traumatic injuries. There were no losses attributed to dystocia, traumatic reticulo-peritonitis and plant intoxication in the Sanga. This may be a reflection of indigenous breed adaptation to local conditions (Collins-Lusweti, 2000). The Sanga breed of cattle produce small calves (33kg) that are unlikely to be delivered with complications, while the exotic Simmental breed produces calves of up to 39 kg which are prone to dystocia (Schoeman, 1996). No losses due to traumatic reticulo-peritonitis, infection and old age in the Simmental were reported. Traumatic reticulo-peritonitis (Waldner *et al.*, 2009) and infections (Waldner *et al.*, 2009; Rumor *et al.*, 2015 and Struchen *et al.*, 2015) have been reported as causes of beef cattle losses. As expected, there were no significant sex differences with regard to animals lost to infection, hardware disease, toxic plants and old age.

About 38.7% (n=106) of animal losses on the farm were due to losses of young animals less than 18 months of age. The majority of young animal losses (80.5%) occurred in the Afrikaner breed of cattle. This study found that predation and unspecified infections caused significantly more losses in calves than in mature animals. These findings are in agreement with the fact that common predators in the study area such as leopards and jackals are too small to prey on adult animals. In other studies, infections of the digestive tract and pneumonia have been reported to be prevalent in calves (Hossain *et al.*, 2014 and Hulbert and Moisa, 2016). Due to their lower immunity and exposure to stressors such as castration and dehorning, calves tend to be susceptible to infectious disease (Hossain *et al.*, 2014) than older animals. High mortality rates (11%) in young animals of the Afrikaner breed that are less than two years of age have been reported (Trail *et al.*, 1977).

Other studies have reported the method of castration, management of colostrum, sex of calf, calf birth weight, calving season, weather conditions at calving, intervention during calving, herd size and the rate of occurrence of respiratory diseases as risk factors for beef calf mortality (Elghafghuf *et al.*, 2014 and Murray *et al.*, 2016). The average annual loss of immature animals of 2.98% is within the range of 1.4-9.5% reported in beef calves by elsewhere (Bunter *et al.*, 2013 and Murray *et al.*, 2016). It has been reported that a large proportion of beef calf mortalities occur within the first week of birth (Bunter *et al.*, 2013 and Murray *et al.*, 2016). It was not possible to confirm this in our study due to the absence of age specific records. Surprisingly, no young animal deaths or losses from other causes were reported in dairy animals which may be a reflection of good calf management practices, poor record keeping or a smaller dairy herd size. Dairy calf mortality has been reported to vary from 2.4-9.4% (Reimus *et al.*, 2017). Calf mortalities have been reported as a problem on small holder dairy farms in Tanzania (Swai *et al.*, 2010). Previous studies have associated small dairy herd sizes with reduced risk of calf mortality (Rogers *et al.*, 1985 and Pannwitz *et al.*, 2015).

Our results indicate that 85.8% (91/106) of cattle losses were due to involuntary culling or unassisted deaths as a result of difficult births, hardware disease, unspecified infections, predation, toxic plants and unknown causes. A high proportion of involuntarily culling in a herd is an indicator of poor animal health and welfare (Karrar *et al.*, 2017). In well managed beef and dairy enterprises, culling should primarily be voluntary and based on economic reasons (Van Arendonk, 1988). In this study, 14.2% (n=106) of the losses were due to voluntary removal of the animals from the herd due to old age and serious injury.

Results of this study revealed an annual variation in cattle losses and an apparent association between cattle losses and amount of rainfall received. In most years, the losses of female cattle were significantly higher than the losses of male animals. Significantly more mature animals were lost from various causes in most of the study years. Seven specific and one non-specific cause of mortality were identified. Modifying factors identified in this study and management practices may lead to reductions in cattle losses. The use of a suitable breed and breeding practices, frequent monitoring of herds, further investigation of animal deaths, implementing disease prevention measures such as regular vaccinations and quick interventions can reduce mortality in beef and dairy animals.

The total economic losses of US$55 263.12 are very low compared to small ruminant losses of US$161 280.00 over the same period (Dr Erick Kandiwa, personal communication) confirms that the area around Neudamm is more suitable for large animals and game than it is for small ruminants. Empirical evidence of the farming activities in the area suggest that large stock and game holds the future of the Neudamm farming community as these species are amenable with the large number of smaller predators that are abundant in the area.

5. CONCLUSIONS

This study revealed that 3.5% of the animals at risk were lost during a period of 13 years at Neudamm farm. Most of these losses occurred in the summer months of the each year and were mainly due to predations, unknown causes, dystocia and infections. The categories of animals at most risk were mature females and immature males of the Afrikaner breed. Mortalities in the relatively smaller Friesian dairy herds were lesser at 0.5% and due to dystocia, infections and unknown causes. The authors recommend that increased rearing of the Sanga and Simmental breeds at the expense of the Afrikaner breed may improve productivity in the establishment revenue through reduced losses.

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7.AUTHORS' CONTRIBUTIONS

EK did the designing of the study, the statistical analysis and the final manuscript write up and editing. BM and OM contributed to the designing of the study, supervision of the project, and writing of the final version of the manuscript. NFN did the data collection and writing of the draft manuscript. AB did the data analysis, the write up of the draft and editing of the final version of the manuscript. AS did the designing of the studies, write-up of the draft, editing the final version and coordinated the publication of this manuscript. All authors read and approved the final manuscript.

8. CONFLICT OF INTEREST DECLARATION

The authors declare that there was no conflict of interest in the preparation of this manuscript.

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