Improved Cattle Production Parameter Drivers Among Farmers in Mpumalanga Province of South Africa

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ABSTRACT

This study was conducted to identify weaning percentage drivers among cattle farmers in Mpumalanga province of South Africa. Two hundred (200) household cattle farmers were randomly selected from four major rural farming communities of Mpumalanga province of South Africa and questionnaires administered on management and production of cattle. Data generated was analyzed descriptively before ordered logit regression analysis model was used to identify determinants of weaning percentage among cattle farmers. Results indicate that majority of farmers mated their heifers at young age (below 2yrs) while medium calving percentage was maintained by majority of respondents. Among the production parameters influencing weaning percentage among cattle farmers in the Province, only calving percentage and weaning age significantly ($P<0.05$) determined the weaning percentage based on ordered logit analysis. Hence calving percentage and weaning age are very critical factors for productivity and profitability of cattle farming enterprise in Mpumalanga Province of South Africa.

Key words: Calving percentage, Heifers, Ordered logit, Questionnaires, Regression.

INTRODUCTION

Beef and dairy production is a major source of protein in human diets, particularly in industrialized countries of the world. The protein content in an average diet of about 58% of individuals in Organization for Economic Cooperation and Development countries (OECD, 2001) is made up of livestock products; comprising 12% beef and 20% dairy (FAOSTAT, 2013). The demand for protein from beef and dairy due to growth in population, urbanization and rising income, particularly in developing countries is expected to further increase (Alexandratos and Bruinsma, 2012). Meanwhile, weaning percentage record of beef and dairy production enterprise which is a major determinant of productivity in cow-calf outfit is farm specific and unique to a given environment. Numerous studies have reported that weaning percentage is one of the primary factors in the profitability of cow-calf outfits and several factors including experience in cattle farming, population of herd, age at mating, calving percentage, weaning age, supplementary feeding, internal and external disease management etc. which if not properly handled, will likely lead to reduced body condition and poor reproductive performance of breeder cows (Molefi *et al.*, 2017), resulting in low productivity (Blanco *et al.*, 2008; Myers *et al.*, 1999; Waterman *et al.*, 2012). Weaning percentage, as defined by (NCBA, 1992) and used by the Standardized Performance Analysis tool, is simply a ratio of live calves weaned to adjusted number of females exposed to mating during the breeding season (Mousel, 2013). Weaning percentage is calculated as:

Weaning percentage =

$$\frac{\text{Total number of calves weaning}}{\text{Number of females exposed in breeding season}} \times 100$$

Average weaning percentage in most cattle farms

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depends on the nature of the environment (genetics and management) which can either be favourable or not to the cows (Reiling, 2011). However, weaning age which depends on the farm's management practices could be between 30 to 231 days in beef calves production (Myers *et al.*, 1999; Richardson, 1979). Different researchers had reported different percentage of losses incurred at different stages of growth in beef cattle production enterprises. (Patterson *et al.*, 1987) reported over 67% deaths incurred within the first forty eight hours, while (Prayaga, 2004) reported 80% and 50% deaths incurred within the first week of birth due to natural causes and abortions respectively. Meanwhile among the breeding cows, mortality is twice as high in heifers as in adult cows (Goyache *et al.*, 2003; Harbers *et al.*, 2000; Meyer *et al.*, 2001).

(Bergh, 2013; Molefi *et al.*, 2017) highlighted many factors that could influences weaning percentage in beef and dairy farm operations. But factors influencing weaning percentage are specific to the environment and unique to

every outfit (Beffa *et al.*, 2009; Blanco *et al.*, 2008). However, this study assumes that there is lack of information on the management practices, its effects on productivity of cattle as well as major drivers of improved weaning percentage (a major determinant of productivity in cattle production) among the cattle farmers in Mpumalanga province of South Africa.

Objectives

(1) Understand the management practices of cattle farmers in the area.
(2) Determine the effects of management practices on the productivity of cattle.
(3) Determine the drivers of weaning percentage among cattle farmers in the area.

MATERIALS AND METHODS

Study area

A survey was conducted using total of 200 household cattle farmers selected through stratified random sampling method in Mpumalanga Province, South Africa. These comprise of 50 farming households from Elukwatini, 50 from Tjakastaad, 50 from Mooiplaas and 50 from Dundonald and they were interviewed using structured questionnaires through face to face interview. In addition, selected participants were based on the beef cattle availability and the willingness to participate in the study. This study was conducted as part of requirement for obtaining a Masters in Science at the Department of Agriculture and Animal Health, University of South Africa in 2016.

The study area has a sub-tropical climate with hot summers and mild to cold winters while average daily temperature in summer is 24°C and 14.8°C in winter (Mpumalanga DACE, 2003). Furthermore, their average rainfall is 767 mm per annum, with approximately 10 times more rainfall in summer than in winter. However, the rainfall volume increases from 600 mm to 1600 mm annually (Mpumalanga, 2006). The main economic activities in the district are crop farming, mining and livestock production.

Data collection

Data were collected on production practices of cattle farmers in communal areas of Mpumalanga province, South Africa. Production information on experiences in cattle farming, number of cattle owned, age at first mating in heifers, calving percentage, weaning age, mortality, supplementary feeding, weaning percentage and causes of mortality (disease treatment) were collected from the various household cattle farmers to understand their production practices and their improvement plan.

Data analyses

Data obtained from the questionnaire were coded and summarized prior to analysis. It was later imported into SPSS software (Patent No. 978-1-56827-401-0, 2017) and was analyzed descriptively and results presented in figures.

Determinants/drivers of weaning percentage were analyzed using the Ordered Logit Regression (OLR) according to (Patent No. 978-1-56827-401-0, 2017) among cattle farmers in the study area. The OLR model was suitable model for the analyses, since the weaning percentages of the herds are categorized into definable ordinal categories as: <40% (0), 41-50% (1), 51-60% (2) and >60% (3). The OLR is applied to explain or predict a polychotonous, ranked dependent variables as a function of explanatory variables that describe the characteristics of a unit, individual or economic agent (Gujarati and Porter, 2003). In order to run an OLR, the ">60%" category was selected as the base category, as it is of most interest while the model is designed on the cumulative probabilities of the dependent variables. The logit of each cumulative probability is assumed to be a linear function of the covariates, with regression coefficients constant across all categories. The OLR retains inherent ordinality in the data and the parameter that is estimated is a type of odds ratio that is recognizable and readily interpreted (Scott *et al.*, 1997). Cut-off points are used in the OLR model, with an underlying assumption that the homogeneity of effect exists across cut-off points. Another assumption underlying the model is the proportional odds assumption that the explanatory variables' effect on the cumulative odds does not change from one cumulative odds to the next. The only term that varies is the constant term (Williams, 2006).

To estimate the determinants of weaning percentage among the cattle farmers being <40%, 41-50%, 51-60% and >60%", the OLR model is defined by the regression equation.

$$Y^* = \beta X' + \varepsilon \qquad (1)$$

Where

Y^*, the latent variable in equation (1), is not observable. What is observable is the polychotomous Y defined by the following:

$Y=0$(weaning percentage of <40%) if $Y^* \leq 0$,
　$=1$(weaning percentage of 41-50%) if $0 < Y^* \leq \mu_1$,
　$=2$(weaning percentage of 51-60%) if $\mu_1 < Y^* \leq \mu_2$,
　$=3$(weaning percentage of >60%) if $\mu_2 < Y^* < \mu_3$

The μ's are unknown parameters to be estimated with β. The ε in equation (1) is normally distributed across observations with a constant mean and zero variance. The probabilities derived from equation (1) are:

$Prob(y=0|x) = \phi(-x\beta)$,
$Prob(y=1|x) = \phi(\mu_1 - x\beta) - x(-x\beta)$,
$Prob(y=2|x) = \phi(\mu_2 - x\beta) - x(\mu_1 - x\beta)$,
$Prob(y=3|x) = \phi(\mu_3 - x\beta) - x(\mu_2 - x\beta)$,

When the explanatory variable increases by one unit, the marginal effects reflect a change in probability of a given category. They appear as approximations of the extent the dependent variable is to increase or decrease for a unit change in an explanatory variable. For continuous variables this represents the instantaneous change given for a unit increase and for dichotonous variables, the change is from

zero to one (Williams, 2006). The marginal effects of the regressors (Xs) on the probabilities are not equal to the coefficients. For the four probabilities, the marginal effects of changes in the explanatory variables are:

$$\frac{\delta \ Prob(y=0|x) = - \ \phi \ (x\beta) \ \beta}{\delta x},$$

$$\frac{\delta \ Prob(y=1|x) = [\phi \ (-x\beta) \ -\phi \ (\mu \ -x\beta)] \ \beta}{\delta X},$$

$$\frac{\delta \ Prob(y=2|x) = \phi \ (\mu \ -x\beta) \ \beta}{\delta X},$$

$$\frac{\delta \ Prob(y=3|x) = \phi \ (\mu \ -x\beta) \ \beta}{\delta X}.$$

The reference group is the "weaning percentage of >60%" category (the highest category). Table 1 below presents the *apriori* expectations for the explanatory variables in the model.

RESULTS AND DISCUSSION

Productivity parameters of the respondent cattle farmers
Age of mating in cows

The results show that majority of farmers (90%) mated their heifers at less than two years of age while 6.5% of farmers bred their heifers after 2 years of age. Fewer farmers (3.5%) reported other breeding age on their cows (Fig 1).

Calving percentage

Farmers (17.5%) declared that they have less than 40% calving percentage while 43.5% of farmers maintained 50 - 70% of calving percentage. On the other hand, 34% of farmers reached more than 80% of calving percentage and 5% of farmers do not record their calving percentage (Fig 1).

Weaning age

Weaning at 5 and 7 months was practised by 77.5% of farmers while 18% of farmers weaned their calves at 7-9 months after birth and 4.5% of farmers do not consider weaning calves (Fig 1).

Weaning percentage

Weaning percentage shows that 25% of farmers had less than 40% while 54.5% of farmers have a range between 50-60% weaning percentages. Though 16% of farmers reached more than 60% weaning percentage and 4.5% of farmers do not record the weaning percentage (Fig 1).

Mortality

Most farmers (36%) experienced mortality at weaning while 20% of farmer reported during breeding and 16.5% of farmers reported mortality at birth. 15% and 12.5% of farmers, respectively declared birth, weaning and breeding as critical stages of mortality (Fig 1).

Causes of mortality

Diseases were a major cause of mortality (42%) while 29% reported malnutrition as a cause of mortality in their herd. However, other farmers (19%) mentioned snakes, predators, still births and lighting as causes of mortality (Fig 1).

Experience in cattle farming

22.5% of respondents have 1-10 years of beef cattle farming experience while 14% have 11-12 years of experience. However, 21% of respondents have more than 20 years of experience and 39.5% have more than 20 years of experience in beef cattle farming (Fig 2).

Number of cattle owned

Majority of the farming household had 4-10 cattle making 40% of the respondents, while those owning above 10 cattle

Table 1: Variables included in the Ordered Logit Model.

| Variable	Description	Expected effect of Xi on Yi
Experience (X_1)	Years of cattle rearing by farmer	Positive
Cattle number (X_2)	Total number of cattle kept by farmer	Negative
Age at mating	Average age at which calves on the farm are mated	
	1=age>2years	
	2=age 2 years	
	3=age ≤ 2years	Positive
Calving % (X_3)	Calving % of the herd	Negative
Weaning age (X_4)	Average age at which calves on the farm are weaned	
	1=wean calves 5-7 months	
	2=wean calves 7-9 months	
	3=wean calves >9 months	Positive
Supplementary feeding (X_5)	Provide supplementary feeding: Yes=1, No=0	Positive
Internal and external disease treatment (X_6)	Provide treatment regularly: Yes = 1, No = 0	Positive
Weaning percentage (Y)	Number of calves successfully weaned classified as ordered:	
	O=weaning percentage of ≤40%	
	1=weaning percentage of 41-50%	
	2=weaning percentage of 51-60%	
	3=weaning percentage of >60%	
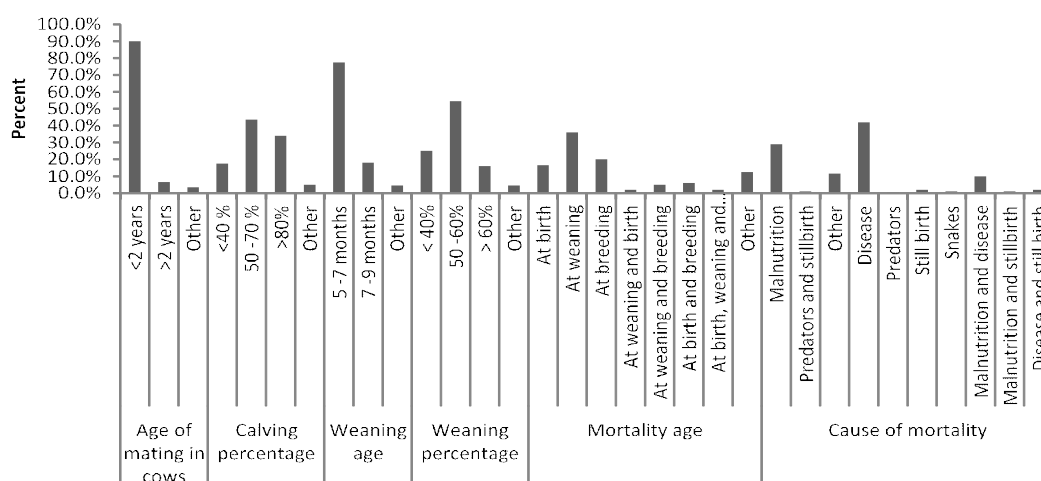
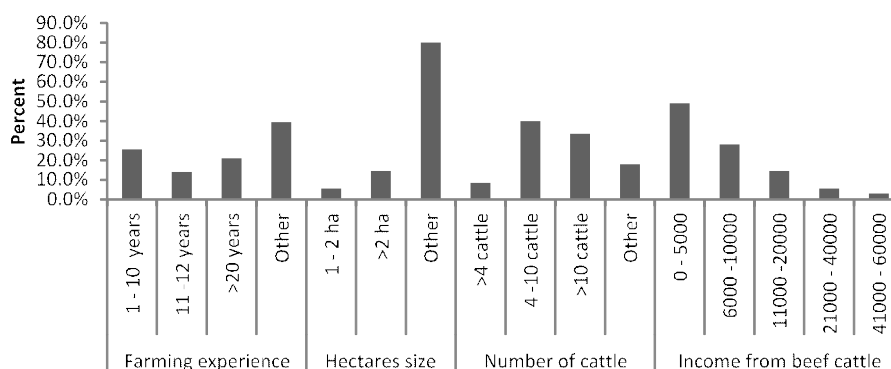**Fig 1:** Productivity records of the farmers in the study (n = 200).

Fig 2: Farming experience and size of cattle reared by respondents in the study (n = 200).

were 30%. Meanwhile, 10% of the respondents have less than 4 cattle, while those who couldn't specify how many cattle they have were 20% of the respondents (Fig 2).

Feeding practices

93.5% of respondents feed their cattle on the veld, 2.5% prefer on pastures while 4.0% feed theirs on bought in feed. This indicates that the majority of the respondents allow their cattle to graze freely on the veld, while others allow them on bough in feed. Of the farmers that graze their cattle, 82.5% of respondents were supplementing their grazing with supplements due to the harshness of the season, especially during winter, while 17.5% of the respondents do not supplement their grazing irrespective of the season of the year.

Determinants/drivers of weaning percentage among cattle farmers based on ordered logit regression model

The parameter estimates of the ordered logistic regression analysis shows the estimates labelled 'location' as the coefficients for the independent variables (Table 2), while the logistic coefficient is the estimates labelled 'threshold. The logit is what is being predicted (dependent variables); and it is the odds of membership in the category of the outcome variable which has been specified. Also the

standard error, Wald statistic, *df*, Sig. (*p*-value), as well as the confidence interval were displayed as the test statistics (Table 2). The Wald test (and associated *p*-value) is used to evaluate whether or not the logistic coefficient is different than zero. Predictors that increase the logit will display estimates greater than 1.0; those that neither increase nor decrease the logit will display an estimate of 1.0, while those that decrease the logit will display values less than 1.0. The model fits since the chi-square value is highly significant (0.000). The difference between the -2log-likelihoods and the chi-square has an observed significance level of less than 0.0005; which implies that if the null hypothesis is rejected, the one the model exhibits without predictors will be as good as the model with the predictors. This also means that if one rejects the null hypothesis that the model exhibits without predictors, it is as good as the model with the predictors.

The results show that only two variables under location were statistically significant at the 99.99% significance level. These variables were calving % of the herd and weaning age category 1 (coded1=5-7 months). It can be seen from the results that a unit change in calving % of the herd significantly changed the odds of being classified in the higher category of the outcome variable while controlling the influence of the other variables. Thus a unit increase in

Table 2: Parameter Estimates of the Ordered Logit Model.

Estimates		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Weaning = 1]	-32.267	.722	1995.48	1	.000	-33.682	-30.851
	[Weaning = 2]	-28.459	.887	1028.89	1	.000	-30.197	-26.720
	[Weaning = 3]	-10.663	969.277	.000	1	.991	-1910.411	1889.085
Location	Experience	-.028	.128	.049	1	.826	-.278	.222
	Cattleno	.019	.010	3.674	1	.055	.000	.038
	Age=1	-13.301	0.546	3.21	1	.761	-.034	.689
	Age=2	0.231	0.980	1.21	1	.087	.006	.076
	Ag3=3	0.04	.012	3.1	1	.450	.000	.367
	Calving % of herd	2.095	.282	55.371	1	.000	1.543	2.647
	[Weaningage=1]	-35.757	.397	8094.25	1	.000	-36.536	-34.978
	[Weaningage=2]	-34.825	.000	.	1	.	-34.825	-34.825
	[Weaningage=3]	0	.	.	0	.	.	.
	[Supplement=0]	.015	.415	.001	1	.971	-.797	.828
	[Supplement=1]	0	.	.	0	.	.	.
	[Treatment=0]	0	.	.	0	.	.	.
	[Treatment=1]	0	.	.	0	.	.	.
Model fit information		-2 Log Likelihood		Chi-Square		df.		Sig.
Intercept Only		420.380						
Final		260.419		159.961		7		.000
Goodness-of-Fit				Chi-Square		df		Sig.
Pearson				507.595		501		.410
Deviance				240.952		501		1.000

the calving % of herds of the farmers will increase weaning percentage of the herd, with other factors held constant (2.095, sig. 0.000). The results on the other hand show that farmers who wean calves 5-7 months (weaning age category 1) are more likely to have higher weaning percentage (-35.757, sig. 0.000).

Majority of farmers (90%) mated their heifers at less than two years of age while 6.5% of farmers bred their heifers after 2 years of age showing that age of mating was a major factor considered by cattle farmers in communal areas of Mpumalanga region of South Africa. Fewer farmers (3.5%) reported other breeding age on their cows. This could be attributed to uncontrolled breeding management and long calving interval as practiced by the farmers. Respondents observed that heifers/cows would conceive but die due to dystocia as a result of poor nutritional quality of the grazing field or improper development of their reproductive organs due to early mating. This is supported by the report from the farmers who observed that the causes of long delays in calving intervals within their flock include poor nutrition after parturition, low bull/cow mating ratios and absence of systematic weaning. (Nqeno, *et al.*, 2011; Patel and Boghra, 2018) reported that late bulling resulted in the birth of calves during winter months when the nutritional status of the rangeland is at its poorest condition. Tavirimirwa *et al.*, 2013 also observed similar results where the age of mating was 36 months in communal management while (Gusha *et al.*, 2014) reported 18 - 27 months age of mating in heifers in

Zimbabwe. However, results of (Tada *et al.*, 2012) were in contrast to the present finding, where he reported that most heifers would have a calf before attaining four years of age in Eastern Cape, South Africa. The results show that calving percentage was between 50-70% as reported by most farmers in the province. The result was unexpected due to low bull/cow ratio and poor feeding before breeding season and some farmers reported unplanned calves during winter. These factors above could lead to low calving percentage and high mortality in calves due to poor nutritional status of veld in winter season in the country. (Siegmund-Schultze *et al.*, 2012) observed similar results where 60% calving rate was recorded in Okamboro in Namibia. (Sibanda, 2014) reported 56% calving percentage as compared to national average of 46% calving rate in communal sectors in four district of Zimbabwe.

Most farmers (36%) experienced mortality at weaning while 20% of farmer reported mortality at breeding and 16.5% of farmers reported mortality at birth. 15% and 12.5% of farmers, respectively declared birth, weaning and breeding as critical stages of mortality. This might imply that mortality was experienced throughout the year; however, weaning was the most critical stage as reported by the farmers. The main reason for mortality at weaning was calves born during dry season when the nutritional status of the rangeland is at its poorest condition and hence subjecting weaned calves to nutritional inadequacy. Therefore, cows would struggle to get sufficient feed to maintain their calves. At the same time

cows will lose weight and milk production will decline which would negatively affect the growth of the calves and hence resulting in the development of different disease. Sibanda (2014) also reported high mortality in calves aged between 6 months to two and half years in Matobo area of Zimbabwe. However, (Scholtz and Bester, 2010) reported 30.7% more mortality in communally managed cattle than in private groups. This therefore reflects a significant effect on the profitability of cattle farming due to the mortality rate in a herd which is a direct reflection of management efficiency (Tavirimirwa *et al.*, 2013). Disease and malnutrition was the most important cause of mortality reported by farmers in the Province. However, red water was the most dominant disease in summer month and lack of supplementary feed during winter since it is the most critical season in those communal areas. Other causes of death were unknown; although some farmers stated that high temperature and high rainfall in the province resulted to red water due to poor management and the drugs for the disease were costly. This situation accordingly leads to negligence by the farmers as they rarely observed the health status and condition of their cattle and in most cases; animals were treated late or died unnoticed. At the same time, some farmers stated that uncontrolled breeding result to unplanned calves during dry season which contributed to more calves dying at weaning stage. Similar results were reported by (Sibanda, 2014) where babesiosis was amongst common disease in communal areas of Zimbabwe.

Weaning percentage of cattle

The calving percentage and weaning age at 5-7months were the determinants of weaning percentage in the Province. This could be due to targeting of the right season for calving when enough pasture and veld is available for the cows to produce quality milk for the calves, as well as other variables being constant; resulting in high weaning percentage that could be within 60-100% in Mpumalanga province of South Africa. Calving percentage gives an estimate of the farrowed calves carried to term relative to the total number of females exposed to males during mating season (Aarif *et al.*, 2019; Reiling, 2011). This does not take cognizance of whether the calf was born alive or dead, so long as it was carried to term. Although aborted calves were not considered as full-term, hence were not included in the number of calves born, this measure of calving percentage is quite an important estimation, as it gives an idea of a cow herd's reproductive efficiency, performance and management during the cows' gestational period. (Reiling, 2011) reported that a good herd calving percentage should be 90 percent and above, hence when estimated values falls below 90%, investigation of potential causes must be conducted. This may be indicative of poor nutrition to the herd, presence of reproductive diseases, low fertility of the bull or mating of genetic relatives in the herd. Meanwhile the weaning age of 5-7 months (155-217 days) reported in this study is still within the range of 30 days and 231 days reported by (Aarif *et al.*, 2019) and

Myers *et al.*, (1999a) respectively. Bottle-fed calves could be weaned at one month of age, while nursed cows could be weaned between ages 3 to 8 months (Filley, 2011; Getahun *et al.*, 2020).

CONCLUSION

The productivity records of household farmers in Mpumalanga Province of South Africa have shown that they are highly experienced and their interest in increasing productivity of their beef cattle enterprise is high. The major parameter with which to increase productivity in beef cattle enterprise - weaning percentage, has shown that its improvement is determined by calving percentage and weaning age, based on ordinal logit regression model, at 99.99% probability levels. Hence the improvement of calving percentage and weaning age of cattle within the age of 155-217 days will greatly drive the productivity of beef enterprise in Mpumalanga Province of South Africa by improving the weaning percentage favourably.

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