Effect of Dry Season Supplement Feeding of Malawi Zebu Cows on Reproductive Performance, Lactation and Weight Gain in Calves

M. A. Bhatti, W. Chanza, L. A. Kamwanja, S. Chikomola, M. Chipandula, A. Chikaonda, D. C. Jansen, S. Klevar, T. B. Klem, M. Stokstad, and O. Reksen

Abstract Climate change affects food security and livelihood in Malawi, and the Food and Agricultural Organization emphasises the intensification of milk and meat production to reduce greenhouse gas emissions. Measures to increase the robustness of smallholder dairy production to better cope with the new challenges are urgently needed. A field experiment was therefore conducted to investigate the effect of supplementing lactating Zebu cows on performance of the cows and their offspring in Malawi.

A total of 98 cows were included and allocated to experimental and control groups matched by parity, age of calves and geographical location of farm. The intervention was additional feeding during the dry season with 2 kg extra maize bran per cow per day and leguminous leaves (*Gliricidia sepium*). The experimental group in year one of the study ($n = 28$) received in total 114 kg additional leaves, and the experimental group ($n = 21$) received 240 kg extra leaves during the second year of study. The cows were followed for 15 consecutive months (experimental period). The outcome was reproductive performance, length of the lactation period and weight gain in calves.

The Kaplan-Meier survival estimator was used to compare calving interval and lactation period between experiment and control groups. Additional feeding did not stimulate reproduction efficiency in this trial. However, it promoted the length of the lactation period. Multivariable linear models predicted increased growth in calves of cows fed the higher quantity of leguminous leaves. Body girth was numerically lower in male compared to female calves. This study reveals a potential for intensified and more sustainable meat and milk production through changes in feeding regimes.

M. A. Bhatti (✉) · D. C. Jansen · T. B. Klem · M. Stokstad · O. Reksen
Norwegian University of Life Sciences (NMBU), Faculty of Veterinary Medicine, Department of Production Animal Clinical Sciences, Oslo, Norway
e-mail: muhammad.azher.bhatti@nmbu.no

W. Chanza · L. A. Kamwanja · S. Chikomola · M. Chipandula · A. Chikaonda
Trustees of Agricultural Promotion Programme, LPMU Headquarters, Lilongwe, Malawi

S. Klevar
Norwegian Veterinary Institute, Oslo, Norway

B. R. Singh et al. (eds.), *Climate Impacts on Agricultural and Natural Resource Sustainability in Africa*, https://doi.org/10.1007/978-3-030-37537-9_14

1 Introduction

Intensification of livestock production is necessary to decrease greenhouse gas emissions and improve farmers' economic situation and food security in Africa. The livestock sector contributes 14.5% of greenhouse gas emissions worldwide. Reducing the unproductive part of the herd by improving health, weight gain and reproductive performance is the most important contribution for reducing the carbon footprint from this sector (Gerber et al. 2013b).

Malawi has a cattle population of 1.5 million, dominated by the indigenous Zebu cattle (Nandolo et al. 2015). The Malawi Zebu cattle depend mainly on natural grass and crop residues, which most often have low nutritive value. Usually, there is no supplemental feeding with concentrates or legume crop. During the rainy season, cattle grazing is restricted to the hill and roadsides as the arable land is used for growing crops while the dambo (wetland) is unsuitable because of high prevalence of worms and liver flukes.

Malawi has a tropical climate with two distinct seasons, which are rainy (November to April) and dry (May to October) seasons, with annual rainfall ranging from 700 to 2400 mm (Banda et al. 2012). Climate change effects have become visible in Malawian livestock farming. Erratic rainfalls and prolonged dry season may further decrease fodder availability (Morton 2007), which severely affects production and reproduction of the livestock (Thornton et al. 2009). Since grazing lands are shrinking due to increased incidences of drought, farmers migrate into traditional grazing areas for cattle (Akinnagbe and Irohibe 2014). During the dry season, both the quality and quantity of pasture diminish, and the livestock struggle to maintain body condition; hence, reproduction may be compromised (Klinedinst et al. 1993). Particularly, the onset of ovarian activity after calving may be delayed, leading into longer calving intervals, fewer calves per cow and reduced herd growth and health (Chauhan and Ghosh 2014). Previous studies from Malawi have shown significant potential for increased reproductive efficiency by improved availability of bulls and better care of primiparous Zebu cows (Bhatti 2016). Also, improved calf survival and enhanced milk production will decrease the carbon footprint of milk and meat production (Gerber et al. 2013b).

Leguminous plants have been used to improve protein content in cattle feeding in several African countries. *Gliricidia sepium* leaves comprise of 21% crude protein, 23.8% crude fibre and 21–34% dry matter (Ministry of Agriculture and Fishries 2013). The high content of protein makes *Gliricidia* an excellent protein supplement to grass and other basal feeds. Numerous reports conclude that supplementing feeding with these leaves gives the cows increased weight gain and milk production (Aye and Adegun 2013). Therefore, the overall objective of this investigation was to study the effect of supplementing lactating Malawi Zebu cows during the dry season on reproductive performance and lactation in cows and weight gain in the offspring. Specifically, our first aim was to study the impact of supplemental feeding of leguminous leaves and maize bran on the calving interval. Our second aim was to study the association between supplemental feeding and the length of the lactation period and lastly to study the association between supplemental feeding and body girth circumference as a proxy for body weight attainment in the offspring.

2 Materials and Methods

In order to assess the association between the outcome variables and the intervention, a field experimental study was conducted in Bolero EPA, Rumphi district, Malawi. The outcomes were calving interval (days), length of the lactation period (days) and body weight attainment in calves (cm changes in body girth); and the intervention was supplemental feeding of the dam. Herds from seven agricultural sections were represented: Bolero, Bata, Chozoli, Chikwawa, Chirambo, Mjumba and Jalir.

A total of 98 cows were included in the study. They were enrolled at calving and followed for 15 months. The study was conducted for two consecutive years. The first trial ($n = 56$) commenced at calving between August 15th and September 12th in 2015 and ended on December 22nd in 2016, and the second trial ($n = 42$) started at calving between August 1st and September 19th in 2016 and ended on December 22nd in 2017. Half of the cows ($n = 49$) were assigned to a control group with no additional feeding, and the other half (28 in 2015 and 21 in 2016) were assigned to an experimental group receiving supplementary feeding. The extra feeding consisted of *Gliricidia sepium* leaves and maize bran and was given only during the driest months of the year: October, November and December. For both experimental groups, 2 kg maize bran was given per cow per day. In the first year of the study, each of the experimental cows was fed 114 kg leguminous leaves during the dry period (experimental group 1). The quantity of leaves was increased to 240 kg per cow for experimental cows in the second year of the study (experimental group 2). This gave us a total of four experimental groups: experimental group 1 (low-level additional feeding), experimental group 2 (high-level additional feeding), and two control groups for years 1 and 2, respectively (Table 1). Each pair of control and experimental cows was matched according to calving date (±15 days), parity of the dam (first, second and third parity and older) and within one out of the seven agricultural sections.

The feed was analysed for dry matter, ash (oven drying) and crude protein by Kjeldahl using the AOAC (2000) procedures at the Animal Science Department, Lilongwe University of Agriculture and Natural Resources, Malawi. Gross energy was calculated using 6100 Oxygen Bomb Calorimeter (Yan and Kim 2011). The acid detergent fibre was analysed by using an Ankom fibre analyser and Ankom (xt10) extractor as described by (Cao et al. 2009).

Reproductive outcome was measured as time from recruitment at calving in 2015 or 2016 and until next calving occurred within 15 months (calving interval). The follow-up period in each of the years ended on December 22nd the year after (2016 and 2017). Data from both years were collated ($n = 98$), and calving ($n = 58$)

Table 1 The study design for supplementary feeding in years 2015 and 2016

Year	Supplementary feed group (*n*)	Control group (*n*)	Supplementary feed offered (kg/cow)
2015	28	28	114
2016	21	21	240

was the event of interest (failure). Cows that had not delivered a calf before December 22nd 2016 or 2017 were right censored ($n = 28$). Cows that were excluded from the study (before the study period ended) were left censored ($n = 12$).

Milk samples were obtained two times weekly for progesterone assessment during the first year of the study (results reported in another publication included in this book), such that frequent visits by the field technician enabled an accurate determination of the lactation period in 56 cows, and cessation of milk production ($n = 42$) was the event of interest (failure). Cows that were still lactating at the end of the milk sampling period were right censored ($n = 14$). The last day of milk sampling was used as the day of censoring in these cows. None of the cows were left censored before cessation of milk yield.

The calves ($n = 98$) were subject to body girth measurements in October, November, December, January and March. The difference in body girth between October and January the following year, and between October and March the following year, was used to assess associations between body girth change (weight gain) and supplemental feeding of the dams. The age of the calf at the day of body girth measurement in October, January and March and sex of the calves were recorded for inclusion in statistical models.

3 Statistical Analyses

The statistical software package Stata 14 (StataCorp LLC, Texas, USA) was used in all statistical analyses. Statistical significance was considered with a *P*-value less than 0.05 in all models. Univariable Kaplan-Meier (K-M) estimators were used to assess relationships between calving interval and supplemental feeding (feeding, 1/0). Differences in survival functions between feeding groups were tested separately for each cohort and for the two cohorts joined. Similarly, the association between lactation period and feeding, 1/0, was assessed for the first year of the study. Difference between the groups was assessed by the log-rank test for equality of survivor functions.

Separate generalised multivariable linear regression models were run for the assessment of associations between body weight attainment and the explanatory variables: feeding, 1/0, gender (sex) and age of the calves in January and March. Initially, univariable associations between the two outcome variables, body girth attainment from October through January and October through March, and the explanatory variables were explored by analysis of variance (feeding, 1/0, and sex) or linear regression (age). Univariable associations with a *P*-value of less than 0.15 for the two-directional association with the outcome qualified for inclusion in a separate multivariable linear regression analysis. A backward selection procedure was employed, and explanatory variables with a *P*-value of less than 0.10 were kept in the final model. This resulted in two models explaining the body weight attainment for the two periods. The first model assessed body weight attainment for the period from October through January and included the explanatory variables: feeding, 1/0, and age of the calves in January. The second model estimated body weight attainment from October to March and included the explanatory variables: feeding, 1/0, and sex of the calves. Overall statistical significance of the models was assessed by the type III F-test in Stata. Homoscedasticity and normality of the residuals were assessed using plots of standardised residuals.

4 Results

The composition of feed shows that crude protein value of mixed supplement feed (*Gliricidia* and maize bran) is up to the recommended level (17–19%) for dairy cattle (Colmenero and Broderick 2006). The feed nutrient composition is presented in Table 2.

Altogether, 58 cows calved within the 15-month observation periods when the 2 years were collated. The reasons for left censoring were mortality ($n = 4$), sold for slaughter ($n = 5$), non-compliance ($n = 1$) and abortion ($n = 2$). Cows that had not delivered within the 15-month observation period were right censored ($n = 28$).

Feeding was not associated with calving interval in any of the three analyses conducted (separately for each experimental group and collated for both groups). For the assessment of both groups simultaneously (Fig. 1), the log-rank chi-square statistic was 0.21 ($P = 0.64$). The median number of days to the next calving (calving interval) was predicted to be 372 days with the upper and lower confidence interval (CI) of 322 and 415 days, respectively.

The length of the lactation period was associated with supplemental feeding for experimental group 1 of the study (log-rank statistic, 4.70, $P = 0.03$) (Fig. 2). The median number of days to cessation of milk yield was 133 days (CI: 125–158). This period was extended to a median value of 158 days in cows receiving supplemental feed versus 127 days in the control group that were subjected to pasture feeding only.

Supplemental feeding was significantly associated with body girth attainment in the calves in experimental group 2 (body weight) ($P < 0.01$) not only for the shorter period until January (Table 3), but also a prolonged effect of feeding was apparent until March in the second year of the study (Table 4).

These associations were not significant for experimental group 1 when cows were fed a markedly lower quantity of leguminous leaves (114 kg). *P*-values for the

Table 2 Nutritional composition of the supplemental feed

Sample	Crude protein (%)	Dry matter (%)	Ash (%)	Crude fibre (%)	Fat (%)	Energy (Cal/g)
Gliricidia sepium	19	87	8.5	16.7	11.2	6934
Maize bran	13	90	4.6	17.1	14.9	7258
Total supplemental feed	16	88.5	6.5	16.9	13.1	7096

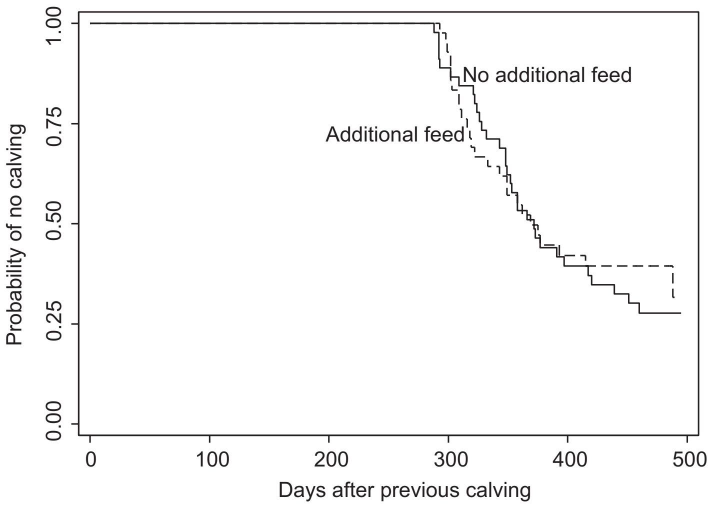

Fig. 1 Kaplan-Meier plot of proportion of calvings distributed by cows (n = 98) that received additional feed (n = 49) and a control group (n = 49) that were subjected to pasture feeding only. The time variable is days since the previous calving

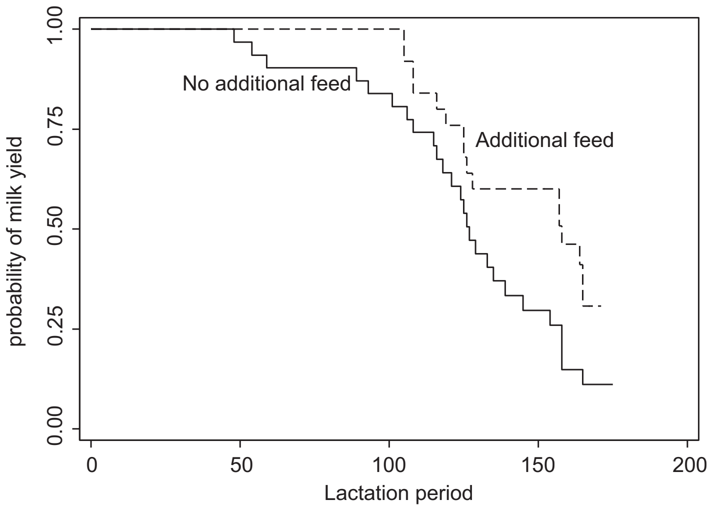

Fig. 2 Kaplan-Meier plot of the length of the lactation period distributed by cows (n = 56) that received additional feed (n = 28) and a control group (n = 28) that were subjected to pasture feeding only. The time variable is days since the previous calving

association between additional feeding and body weight gain in univariate tests during the October to January period were 0.37 and 0.49 for both years pooled and for the first year, respectively. Corresponding *P*-values for the October to March periods were 0.25 and 0.98.

Table 3 Associations between body girth attainment of offspring from October to January and additional feeding of maize bran and 240 kg leguminous leaves for the dams, adjusted for the difference in age (range 127–183 days)

Explanatory variable		Body girth attainment (cm)	S.E.	*P*-value
Feeding	No	-----	1.83	<0.01
	Yes	5.35		
Age in January		0.13/day	0.06	0.04
Intercept		−7.47	9.63	0.44

Table 4 Model assessing associations between body girth attainment from October to March and additional feeding of maize bran and 240 kg leguminous leaves for the dams adjusted for sex of the calves

Explanatory variable		Body girth attainment (cm)	S.E.	*P*-value
Feeding	No		1.94	<0.01
	Yes	5.42		
Sex	Female	------	2.10	0.08
	Male	−3.8		
Intercept		21.3	10.87	<0.01

The October–January model for experimental group 2 showed a positive linear relationship between body girth attainment and age of the calves, showing a more substantial body weight attainment for calves born early during the calving season. This model explained 24% of the variation ($R^2 = 0.24$) in body weight attainment (F-statistic: 6.04, $P < 0.01$) (Table 3). The mean age of the calves at the start of the study was 19.9 days in the group that received additional feeding (experimental group) and 19.2 days in the control group.

The effect of age was not apparent in the October to March model (Table 4). However, a numerical association between body weight attainment and sex becomes apparent when the calves were followed until March. The model assessing live weight from October through March explained 21% of the variation ($R^2 = 0.21$) in body weight attainment (F-statistic 5.27, $P < 0.01$) (Table 4).

5 Discussion

It has been stated that greenhouse gas emission from livestock production can be reduced by almost one-third if the practices currently applied by the producers with the lowest emission rate were widely adopted. This reduction can be achieved without changes in the production systems (e.g. from smallholder to industrial). The most significant decreases in the emission rate are associated with practices that improve efficiency at farm and animal level. They include better health and reproduction management and better feeding practices, such that the unproductive part of the herd decreases in number (Gerber et al. 2013a).

To our knowledge, it is the first Malawian study where nutritional regimes for cattle have been studied to meet the challenges that climate change represents for animal production in northern Malawi. The results in the present study show that supplementing lactating cows during the dry months when feed is scarce and of low quality is a manageable way of increasing body weight attainment in their calves. Calves from dams receiving supplemental feeding had 5 cm more body girth after adjustment for gender and time of birth in multivariable generalised linear models. These findings are in agreement with Maphane and Mutshewa (1999) who demonstrated that growth and body weight are profoundly affected by supplementation of feeding in dry season.

Body weight was greater in female calves in March. It is also reflected in previous investigations, revealing that female calves are better cared for than male calves. This is probably because they represent greater value for the farmer. These findings are in line with previous results (Chang'a et al. 2012; Young 1972) that found that predicting cattle live weights can be influenced by sex, environment, production system, animal husbandry practices and other factors. Increased food production and decreased environmental impact from livestock production require that the meat production potential in male calves is exploited in a more efficient matter than is currently the case.

Prolonged lactation periods may very well explain why the body weight attainment was greater in calves from experimental cows as compared to calves from cows in the control group in this study, although this was not measured during the same 2nd year. However, length of the lactation period was positively influenced by a relatively low quantity of leguminous leaves (114 kg) during experiment 1. Due to resource demanding work in the field, it was not possible to determine accurately when the lactation stopped during experiment 2. This was only possible during experiment 1 when the field assistant collected milk samples from all 56 cows twice weekly in 36 different farms. We were also not able to obtain accurate measures of milk yield, so lactation length was chosen as a measure for increased milk yield.

This study showed that feeding supplementation of lactating Malawi Zebu cows during the dry season did not influence reproductive outcome in this population of Zebu cattle. Another publication included in this book shows a relatively low incidence of some common infectious diseases in this population of Zebu cattle. The most important means of increasing reproductive efficiency in these 36 farms is therefore related to bull management and herd composition. Processing of feed ingredients and incorporation of leguminous leaves result in higher quality and digestibility of feed (Mekoya et al. 2008). It has previously been shown that an increase of feed digestibility has been associated with marked decreases in age at first calving. This is because feed digestibility is related to growth rate in animals (Keady et al. 2012), and the assumption is that growth rate and age at first calving are closely associated (Gerber et al. 2013a). However, the period of the current study did not allow for comparisons of age at first delivery.

6 Conclusion

Milk and meat production in indigenous Zebu cattle can be intensified by supplemental feeding of leguminous leaves during the dry period. Implementing such practices would reduce greenhouse gas emissions per unit of produced food and represents a potential for improved livelihood of smallholder farmers in Malawi.

Acknowledgements The authors would like to thank the Malawian smallholder farmers, who actively participated in this study. We are grateful to Dr. Liveness Jessica Banda and Dr. Fanny Chigwa, Animal Science Department, Lilongwe University of Agriculture and Natural Resources (LUANAR), for their help in laboratory analyses. This study was supported by the project: "Capacity Building for Managing Climate Change in Malawi (CABMACC)", Norwegian University of Life Sciences, Norway.

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

Funding This study was funded by Capacity Building for Managing Climate Change in Malawi (grant number CABMACC).

References

Akinnagbe O, Irohibe I (2014) Agricultural adaptation strategies to climate change impacts in Africa: a review. Bangladesh J Agric Res 39(3):407–418

AOAC (2000) Official methods of analysis. AOAC International, Arlington

Aye P, Adegun M (2013) Chemical composition and some functional properties of Moringa, Leucaena and Gliricidia leaf meals. Agric Biol J N Am 4(1):71–77

Banda LJ, Kamwanja LA, Chagunda MGG, Ashworth CJ, Roberts DJ (2012) Status of dairy cow management and fertility in smallholder farms in Malawi. Trop Anim Health Prod 44(4):715–727

Bhatti MA (2016) Climate change resilience through enhanced reproduction and lactation performance in Malawian Zebu cattle. Masters Thesis: Norwegian University of Life Sciences, Ås, Norway, p 70

Cao Z, Anderson J, Kalscheur K (2009) Ruminal degradation and intestinal digestibility of dried or wet distillers grains with increasing concentrations of condensed distillers solubles. J Anim Sci 87(9):3013–3019

Chang'a JS, Løken T, Mdegela RH, Reksen O (2012) Factors associated with body weight attainment in calves on smallholder dairy farms in Tanzania. Open J Vet Med 2:66–73

Chauhan DS, Ghosh N (2014) Impact of climate change on livestock production: a review. J Anim Res 4(2):223

Colmenero JO, Broderick G (2006) Effect of dietary crude protein concentration on milk production and nitrogen utilization in lactating dairy cows. J Dairy Sci 89(5):1704–1712

Gerber PJ, Henderson B, Makkar HP (2013a) Mitigation of greenhouse gas emissions in livestock production. A review of technical options for non-CO2 emissions. FAO, Rome

Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falcucci A, Tempio G (2013b) Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome

Keady T, Marley C, Scollan N, Kuoppala K, Rinne M, Vanhatalo A (2012) Grass and alternative forage silages for beef cattle and sheep: effects on animal performance. In: Kuoppala K, Rinne M, Vanhatalo A (eds) Proceedings XVI international silage conference. Hämeenlinna, Finland, pp 152–165

Klinedinst PL, Wilhite DA, Hahn GL, Hubbard KG (1993) The potential effects of climate change on summer season dairy cattle milk production and reproduction. Clim Chang 23(1):21–36

Maphane GK, Mutshewa P (1999) Strategies for dry season feeding of animals in Botswana. In: Strategies for dry season feeding of animals in central and southern Africa. Proceedings of a joint ZSAP/FAO workshop held in Harare, Zimbabwe, pp 12–17

Mekoya A, Oosting S, Fernandez-Rivera S, Van der Zijpp A (2008) Multipurpose fodder trees in the Ethiopian highlands: farmers' preference and relationship of indigenous knowledge of feed value with laboratory indicators. Agric Syst 96(1–3):184–194

Ministry of Agriculture and Fishries (2013) Legumes an Ideal Fodder in the Dry Season. Division, L. R. a. I. Bodles Research Station Old Harbour, P. O. St. Catherine, Jamaica, p 2

Morton JF (2007) The impact of climate change on smallholder and subsistence agriculture. Proc Natl Acad Sci 104(50):19680–19685

Nandolo W, Gondwe T, Banda L (2015) Characterisation of breeding systems for Malawi Zebu cattle in Mzimba District, Northern Malawi. Malawi J Agric Nat Res Dev Stud 1:14–20

Thornton PK, van de Steeg J, Notenbaert A, Herrero M (2009) The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. Agric Syst 101(3):113–127

Yan L, Kim I (2011) Evaluation of dietary supplementation of delta-aminolevulinic acid and chitooligosaccharide on growth performance, nutrient digestibility, blood characteristics, and fecal microbial shedding in weaned pigs. Anim Feed Sci Technol 169(3):275–280

Young DL (1972) The estimation of liveweight from heart girth within specified age/sex groups of Kenya range cattle. East Afr Agric For J 38(2):193–200