Biophysical, grazing-season management, and animal traits effects on individual animal performance of cow-calf systems: Insights from a long-term experiment in the US Western Great Plains

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Keywords: Harmonized LANDSAT; Individual weight gain; Northern mixed-grass prairie; Precipitation; Temperature.

Abstract. Beef grazing systems require information on management, biophysical, and individual animal influences on performance metrics. However, long-term controlled experiments are lacking to comprehensively ascertain these individual and likely interacting influences. We used a legacy data set from the USDA Agricultural Research Service where individual weight gains were determined from on and off weights of Hereford cows and calves grazing native northern mixed-grass prairie, during the June through September season, from 1975-2001 near Cheyenne, Wyoming, USA. The herd size varied from a minimum of 10 to a maximum of 48 pairs across years. Management (on and off grazing dates and stocking rate, kg BW/ha), biophysical (forage production estimated through NDVI LANDSAT time series, temperature, and precipitation variability), and individual animal (cow age, cow body weight at beginning of grazing season, and calf gender) influences were evaluated for effects on calf weight gain (WG, kg/head). Linear mixed models were used for analyses where the above mentioned were fixed factors, and year and individual cow were random ones. Calf performance was influenced by three animal traits: gender with steer WG 4 kg more than heifer, cow body weight with calf WG increased 2kg for each 100kg of cow body weight, and cow age as optimum calf WG occurred with 5-year-old cows. Management influenced calf WG through the on and off dates. Delaying the start of a grazing season decreased calf WG by 0.80 kg per delayed day. On the contrary, extending the grazing season increased calf WG by about the same amount. Biophysical effects on calf WG were not significant suggesting that the cow performance was mitigating these effects of variability. Results suggest that calf individual performance in this resilient rangeland ecosystem relies on cows' body weight at beginning of the grazing, their age, and the timing to enter and remove animals from pastures.

Introduction

Calf weight is among the most important variables determining profitability for cow-calf operations (Miller et al. 2001). Calf performance is influenced by biophysical, cow individual traits (Miller et al. 2001; Reeves et al. 2013), management, and complex interactions among these factors. In the North American northern mixed grass-prairie, precipitation and temperature influence cow-calf beef production (Reeves et al. 2013; Hamilton et al. 2016). Cow size has an expected interaction with age, but also interacts with climate. Younger cows, below three years old, have lower live weight calves at weaning compard to older cows, as these younger cows are still growing. During drought periods, smaller cows have a higher calf:cow weight ratio than larger cows, indicating they are more efficienty and better adapted to harsh environmental conditions (Scasta, Henderson, and Smith 2015). Management affects individual cow-calf performance, with the length of a grazing season being highly influential (Kearney et al. 2021; Irisarri et al. 2019). Changes in forage quantity and quality occur across the grazing season (Kearney et al. 2021). Long-term studies are needed to disentangle the influences of management, biophysical, and individual animal effects on weight gains of cow-calf systems.

Cow–calf production data from 1975 to 2001 collected at the USDA—Agricultural Research Service (ARS) High Plains Grasslands Research Station near Cheyenne, WY, USA provides a unique opportunity to test the combined effects of biophysical, animal traits, and management effects on calf individual weight gain. Here we analyzed individual weight gains from on and off weights of Hereford cows and calves grazing North

American native northern mixed-grass prairie during the June through September grazing seasons for the 27 years. We specifically looked at the effect of three groups of factors: (i) biophysical - precipitation, temperature, and remotely sensed estimations of forage production; (ii) animal traits - cow on pasture weight as a proxy of its body condition, cow age, and calf gender, and (iii) management - on and off grazing dates and stocking rate.

Methods

Hereford cow-calf pairs provided by the University of Wyoming, Laramie, WY, USA were used in this experiment from 1975 to 2001. All cows and calves were individually weighed each year at the beginning and end of the grazing season. Across the 27 years, the herd size varied from a minimum of 10 to a maximum of 48 pairs. Calf individual weight gains for the grazing season were determined from subtracting on from off weights. Cow on weight and age were collected each year. Management, through on and off grazing dates, were also recorded. Stocking rate, expressed in kg BW/ha was determined as the sum of individual on weights divided by the grazing area (see details in Reeves et al. 2013). Biophysical attributes, specifically temperature and precipitation were obtained using site records. Forage production was estimated through NDVI LANDSAT harmonized time series (Roy et al. 2016; Vogeler et al. 2018) using algorithms detailed in Gaffney et al. (2018) and Irisarri et al.(2019) to convert NDVI time series into forage production.

We used linear mixed models to evaluate the effects of animal traits (cow weight on and age, and calf gender), management (on and off grazing dates), and biophysical attributes (temperature, precipitation, and forage production) on the individual weight gain of calves. All the above mentioned were fixed factors, with year and individual cow random ones. Biophysical variables were standardized against their mean. Linear mixed models were fitted in R 3.4.4 (R Core Team 2020) using the "lmer" package (Pinheiro et al., 2013).

Results and Discussion

Calf individual weight gain (WG) was influenced by three animal traits: 1) gender, with steer WG 4 kg more than heifer, 2) cow body weight, with calf WG increased 2kg for each 100kg of cow body weight, and 3) cow age, as maximum calf WG occurred with 5-year old cows, and the tested model explained 48% of the variability in the observed values (Fig 1). Management influenced calf WG through the on and off dates (Fig 1). Delaying the start of a grazing season decreased calf WG by 0.80 kg per delayed day. On the contrary, extending the grazing season increased calf WG by about the same amount. This is contrary to findings for yearling steers where a delay in the off date did not improve steers gain and decreased potential sale price (Irisarri et al. 2019). Biophysical effects on calf WG were not significant. Reeves et al. (2013) observed that pair (cow plus calf) production per ha was influenced by seasonal weather conditions, suggesting that it is cow performance that is influence by biophysical conditions.

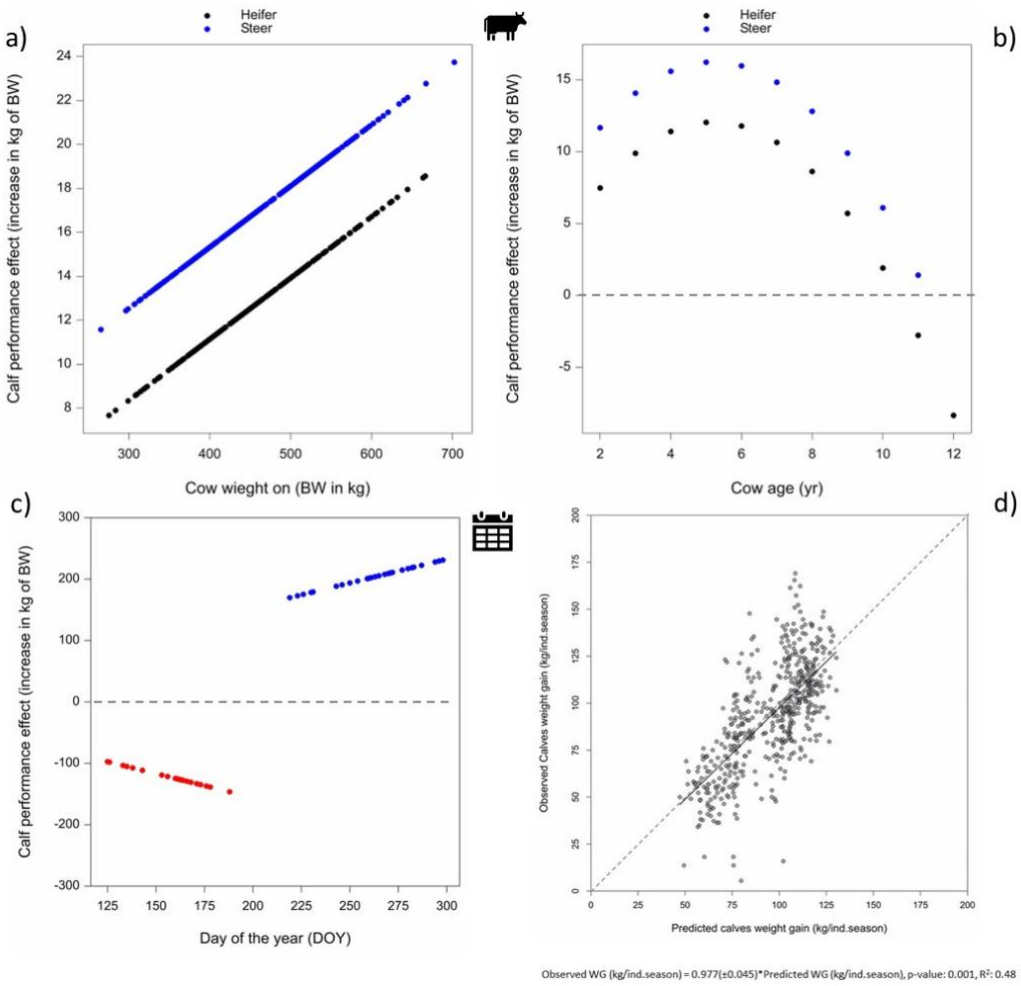

Fig. 1. Predicted effects by fitted models of (a) cow on weight, (b) cow age, and (c) on and off grazing days (expressed in day of the year, where 1 is the 1st of January and 365 is the 31st of December) on calf individual weight gain during the grazing season, and (d) overall performance of the statistical tested model. For figures (a) and (b) the different colour dots differentiate between heifers (black) and steers (blue).

Conclusions and/or Implications

Long-term cow-calf beef production data sets from rangelands are rare, and as such, are quite valuable for determining the influences of a combination of factors on calf WG. We used 27 years of data from Wyoming, USA, to show that Hereford calf WG is highly influenced by cow traits and management decisions, but not biophysical conditions.

Acknowledgements

We acknowledge the foresight by Richard (Dick) H. Hart in beginning this study and his fortitude in continuing the study for the 27 years. We appreciate the efforts of all the technicans and summer students for collecting the weight gain data over the years.

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