BeefTader (part I): optimal economical endpoint identification using mixed modeling approach decreases greenhouse gases emission and other pollutants for livestock farmers

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Introduction

The database for beef cattle real time individual monitoring assessed by decision support system (DSS) should provide a fast identification of more profitable animals in the future. Animals identification with information about their optimal economical endpoint (OEE; most profitable slaughter date) in commercial beef cattle feedlots owned by farmers could minimize pollutants by kg of meat. This study aimed to identify the OEE in cattle. The hypothesis of the study was: traditional slaughter endpoint (TSE, currently used in commercial feedlots) vs. OEE methods have different marginal net profit (MNV), GHG emission, water intake and manure production per kg of meat produced. The current study is the first from three sequential abstracts based on BeefTrader DSS to maximize profitability of farmers and the meat industry.

Material and Methods

Feedlot data from experimental dataset [DS1; formed by variables: diet chemical composition, intake, daily weight gain and body composition] was used to parameterize a growth model. Based on DS1 a second dataset (DS2) was created using exogenous information (i.e., commercial prices, GHG emission factors, manure and water functions) to predict OEE, MNV, GHG, water intake and manure production. Data was analyzed for the following procedures: i) DS1: after weaning (225 ± 14 days) data from 30 crossbred cattle [10 Red Angus × Nellore (5 male, M; 5 female, F) and 20 ½ Red Angus × ¼ Caracu × Nellore (10 M; 10 F)] evaluated in individual stalls (mixed diet: 2.84 Mcal ME/kg DM, 13.9% CP). Animals were slaughtered when they reached ~ 6 mm of subcutaneous fat in the 12-13th ribs (feedlot maximum period was 147 days); ii) DS2 (exogenous information): the MNV, R$/day (marginal value – marginal cost, MV - MC) from market prices and animal data observed (DS1) was predicted. The daily weight gain (DWG, kg/d) × weight gain value (R$/kg) and DM intake (DMI, kg MS/day) × diet price (R$/kg) + overhead (R$/day) were used to calculate MV and MC, respectively. Manure (kg/day) production from diet indigestibility was estimated. Water intake (kg/day) according to Hicks et al. (1998) was calculated. Enteric methane (kg CH_4/day) and manure (kg N_2O and CH_4) emissions converted in CO_2 equivalent (CO_2-eq) were estimated according to Medeiros et al. (2014) and IPCC Tier 2 methodology, respectively; iii) DS2 (animal growth and body chemical composition modeling): the system of differential equations using Davis Growth Model to represent cattle growth parameterized by Biase et al. (2016) were used to predict daily shrunk BW gain (kg/d) and fat deposition [% fat in the empty body weight (EBW)] during the feedlot. The TSE method was performed considering all the feedlot experimental period, however, OEE period was based on positive MNV values; iv) statistical analysis: using SAS (SAS Inst. Inc., Cary, NC) two linear mixed- effect (LME) model were created: using DS1 variables, the LME1 was created using effects [gender, breed (M; F), gender

× breed interaction and pre-weaning phase (system)] as fixed. The LME2 was created using the same fixed effects structure as LME1, however; method levels (OEE; TSE) and interaction (method × gender) to analyze DS2 was included. The least square means and probabilities were performed by SAS *lsmeans* statement, including gender and method effects for DS1 (by LME1) and DS2 (by LME2). Approximate *t* test was used to test the null hypothesis and the probability between TSE and OEE.

Results and Conclusions

The least square means (± standard error, SE) feedlot period, DM intake, initial and final shrunk BW (SBW), BW gain, slaughter backfat thickness, final fat concentration in the EBW (for F, M, respectively) were: 81, 115 ± 9 days; 7.7, 8.7 ± 0.30 kg DMI/day; 284, 329 ± 8.80kg; 375, 489 ± 10.1 kg; 1.17, 1.45 ± 0.063 kg/day; 8, 5 ± 0.50 mm; 19, 16 ± 0.3% fat EBW. After elimination of negative values for daily MNV based on each animal (Figure 1) to calculate OEE the values for study variables were predicted and analyzed.

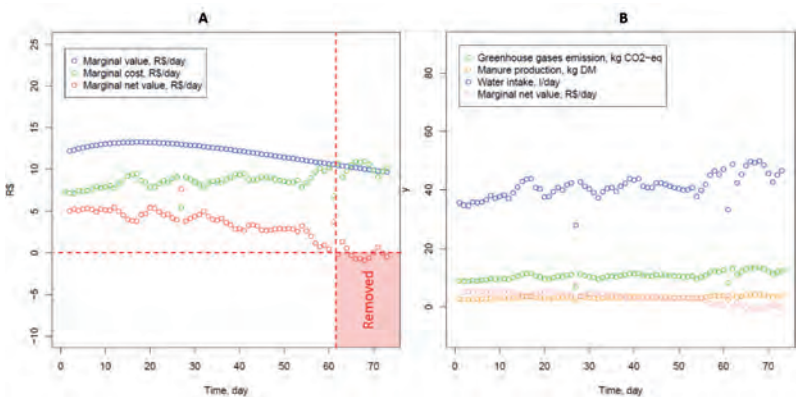

Figure 1. Left side (A): the daily economic performance during feedlot is presented based on marginal value (MV, R$/day), marginal cost (MC, R$/day) and marginal net value (MNV = MV − MC; R$/day) for a Red Angus × Nellore female (ID 941). Dashed red lines intersection indicates (red rectangle) the negative daily MNV removed to calculate the optimal economical endpoint period. Right side (B): greenhouse gases emission (CO_2-eq/day), manure production (kg DM/day); water intake (l/day) and marginal net value (R$/day) for animal ID 941.

The profitability increased (2 to 6 times) based on marginal net value/DWG ratio (R$/kg gain). The GHG emission and the manure production were minimized in 2 to 3 times while water demand 3 to 4 times (Table 1), regardless of the gender in the methods, where OEE was better ($P < 0.05$).

Table 1. Least squares means (± SEM) of performance variables from evaluation of optimal economical endpoint and traditional slaughter endpoint of 30 crossbred cattle (both genders)

Variable (accumulated[1])	Treatment						SEM[4]
	Female			Male			
	OEE[2]	TSE[3]	*P-value*	OEE	TSE	*P-value*	
Daily weight gain, kg	79	110	< 0.01	123	185	< 0.01	8.2
Daily marginal net value, R$	195	44	< 0.01	352	301	0.22	30.9
Marginal net value/DWG[5] ratio, R$/kg gain	99	- 15	< 0.01	110	47	0.07	26.2
GHG[6] emission, kg CO_2-eq	392	806	< 0.01	611	1,282	< 0.01	80.0
GHG/DWG ratio, kg CO_2-eq/kg gain	197	624	< 0.01	341	923	< 0.01	81.6
Manure production, kg DM	116	241	< 0.01	184	388	< 0.01	22.6
Manure/DWG ratio, kg DM/kg gain	58	187	< 0.01	102	279	< 0.01	24.4
Water intake, l	1,528	3,115	< 0.01	2,343	4,848	< 0.01	277.9
Water intake/DWG ratio, l/kg gain	769	2,411	< 0.01	769	3,491	< 0.01	316.1

[1]Accumulated is the sum of observations of the variable in the period according the TSE and OEE metrics.[2]Optimal economical endpoint (OEE, period was calculated after elimination of negative values for marginal net values). [3]Traditional slaughter endpoint (TSE, period defined when animals reached ~ 6 mm of subcutaneous fat in the 12-13th ribs in the experimental feedlot). [4]Least squares means standard error. [5]Daily weight gain, kg/day. [6]Enteric methane (kg CH_4/day) and manure (kg N_2O and CH_4) emissions were converted in CO_2 equivalent (CO_2-eq).

Thus, BeefTrader mathematical and statistical models based on individual growth identification, coupled with optimal economical endpoint decision, improved the profitability and reduced environmental impacts when compared with current experimental dataset. However, what is the influence of BeefTrader metrics over optimal economical endpoint in commercial feedlots of livestock producers in the farm boundary? The answer to this question will be presented in abstract II.

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