Livestock Science 164 (2014) 35–38

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Short communication

Residual feed intake as selection tool in South African Bonsmara cattle

Y. Steyn, E. van Marle-Koster *, H.E. Theron

University of Pretoria, Private bag X20, Hatfield, Pretoria, 0028, South Africa

ARTICLE INFO

Article history:
Received 4 December 2012
Received in revised form
5 March 2014
Accepted 9 March 2014

Keywords:
Feed efficiency
Residual feed intake
Feed conversion ratio
Kleiber ratio
Bonsmara

ABSTRACT

In South African Bonsmara cattle, feed conversion ratio (FCR) is mostly used as a measure of feed efficiency in selection programs but has the disadvantage of being a ratio trait and unfavourably correlated to weight and mature size. Residual feed intake (RFI) overcomes both these disadvantages. The purpose of this study was to evaluate RFI as a potential trait in a selection programme by determining its correlations with growth related traits as well as other efficiency traits. Data of 5981 Bonsmara bulls that participated in centralised growth tests was analysed. In this study, RFI was calculated within contemporary groups of more than ten animals. The h^2 for RFI, FCR and KR were 0.27 ± 0.02, 0.23 ± 0.02 and 0.18 ± 0.02 respectively. The genetic correlation between RFI and FCR, and RFI and KR were 0.65 ± 0.04 and 0.12 ± 0.07 respectively. Correlations approaching zero were estimated between RFI and shoulder height (SH), body length (BL), scrotal circumference (SC), average daily gain (ADG), weaning weight (WW) and metabolic mid-weight (MMW), and a strong correlation of 0.79 ± 0.03 with daily feed intake (DFI). This study shows sufficient genetic variation for RFI to be considered by the Bonsmara breed as a measure of feed efficiency and confirms its independence from growth and size traits.

1. Introduction

In 2010 the total number of beef cattle in South Africa was estimated to be 14.1 million, of which 60% were owned by commercial farmers. There are approximately 70 feedlots and 495 abattoirs, with the largest feedlot accommodating 120,000 cattle and processing 1600 carcasses daily (Department of Agriculture, Forestry and Fishery, 2010). Feed efficiency is therefore an important trait to consider as feeding costs is by far the largest expense in the beef industry, comprising about 55–75% of the total costs associated with beef cattle production (Arthur et al., 2001a). Selection for higher feed efficiency in beef cattle using RFI holds potential for less dry matter intakes (DMI), less manure production and less methane emissions while maintaining body weights similar to those of less efficient cattle (Nkrumah et al., 2006; Hegarty et al., 2007). The measures of feed efficiency used in South Africa are feed conversion ratio (FCR) and Kleiber ratio (KR). Both these measurements have the disadvantage of being ratio traits, and FCR's strong association with growth rate (Bishop et al., 1991; Koots et al., 1994) has partly contributed to an increase in mature size and consequently higher maintenance cost of the breeding herd (Liu et al., 2000). Residual feed intake (RFI) is a linear trait and has been shown to be independent from mature weight and average daily gain (ADG) while being highly correlated to feed intake (Archer et al., 1999; Herd et al., 2003; Crews, 2005; Nkrumah et al., 2007). Studies have reported heritability estimates for RFI varying from 0.14 to 0.58 (Fan et al., 1995; Crews et al., 2003). In South Africa, RFI is currently not used as a feed efficiency measure in selection

* Corresponding author. Tel.: +27 12 420 3612; fax: +27 12 420 3290.
E-mail address: evm.koster@up.ac.za (E. van Marle-Koster).

http://dx.doi.org/10.1016/j.livsci.2014.03.007
1871-1413/

programs. The purpose of this study was to determine the association of RFI with growth related traits and feed efficiency traits, with potential inclusion of RFI in a selection programme.

2. Materials and methods

The data for this study was obtained from growth tests performed at the centralised test stations of the Agricultural Research Council (ARC) and private stations in South Africa from 1999 to 2010. The data used for this study was stored on INTERGIS, a database for South African data recording, and consisted of Bonsmara bulls that met breed standards as set by the Bonsmara breeders' society and took part in centralised testing. There was an adaptation period of 28 days and a test length of 84 days. Bulls were individually fed *ad lib* with a standard, complete growth ration prescribed for all stations as described by Archer and Bergh (2000). Each bull had a transponder around its neck which opens a specific trough, making it possible to determine individual feeding. Weekly intakes were determined by subtracting the weight of feed remaining in the bunk from the total weight of feed given during that week. Body weight was taken at weekly intervals after a 12 h overnight fast. Measurements taken at the end of the test are shoulder height (SH), body length (BL), skin thickness and scrotal circumference (SC). Data entries with weekly intakes outside three standard deviations were deleted, and the same applied for age, initial weight, ADG, SC, SH, BL and weaning weight (WW). Animals had to comply with requirements for all traits to be included. Contemporary groups included a concatenation between test station, test year, season (test number) and test phase (C1, C2 and C3). The calculation of RFI depends on the predicted feed intake that was determined by regressing actual feed intake against metabolic mid-weight and ADG (Koch et al., 1963). Contemporary groups with less than 10 animals were discarded to be able to obtain a more representative regression. The remaining 270 groups (total of 5981 animals) had an average size of 22 and were available for further analysis. Pedigree information and recordings covered four generations, a total of 20,398 animals, with 3851 sires and 14,520 dams.

To calculate RFI, metabolic mid-weight (MMW), ADG, actual DFI and expected DFI were required. Measurements for DFI were on as is basis. These traits were calculated using the following formulas:

$$\text{MMW} = ((\text{Initial weight} + \text{Final weight})/2)^{0.75}$$

$$\text{ADG} = (\text{Final weight} - \text{Initial weight})/\text{Test length}$$

$$\text{DFI} = \text{Total Feed Intake}/\text{Test length}$$

Actual DFI was regressed against MMW and ADG for each contemporary group using PROC REG of SAS 9.1.3 (2006). The fitted model to calculate expected DFI was $Y_i = \beta_0 + \beta_1 \times \text{ADG}_i + \beta_2 \times \text{MMW}_i + e_i$ (Koch et al., 1963), where Y_i is the expected daily feed intake of animal i, β_0 is the regression intercept, β_1 is the partial regression coefficient of feed intake on ADG of animal i, β_2 is the partial regression coefficient of feed intake on MMW and e_i is the error. RFI was calculated by subtracting expected DFI from actual DFI (Koch et al., 1963), KR by dividing ADG with MMW (Kleiber, 1947) and FCR by dividing DFI by ADG.

The phenotypic Pearson correlations between all traits were determined using PROC CORR of SAS 9.1.3 (2006). The PROC GLM procedure was used to identify fixed effects for the estimation of estimated breeding values (EBV). Effects tested to include in the model (at significant level of $P < 0.05$) were contemporary group (270 levels), herd (123 levels), age, age^2, (dam age), and (dam age)^2. All effects were included as fixed effects in the model for WW, BL, SC and MMW. All but age^2 was included for DFI, ADG and SH. Herd and age were included for RFI. Animal was included as a random effect in all models and random maternal effects were assumed to be zero. Variance components, heritabilities and genetic correlations for all traits were estimated by multitrait restricted maximum likelihood (REML) procedures using VCE 6 (Groeneveld et al., 2010), and EBV's estimated using PEST 2 (Groeneveld et al., 2010). The animal model used is described as $Y_i = X\beta_i + Z\mu_i + e_i$, where Y_i is the vector of trait i (RFI, FCR, KR, ADG, DFI, WW, MMW, SH, BL, SC), X is the matrix relating observations to fixed effects, B_i is the vector of fixed effects associated with trait i, Z is the matrix relating observations to random effects (which is animal for all traits), μ_i is the vector of random effects associated with trait i and e_i is the unexplained residual effects for trait i.

Table 1
Means, standard deviations (SD), minimums and maximums for age, dam age, growth, body measurements and efficiency traits.

Trait	Mean	SD	Min	Max
Age (days)	329	23	261	392
Damage (days)	2209	1059	676	6080
Average daily gain (g)	1744	267	760	2654
Weaning weight (kg)	237	32	140	376
Metabolic mid-weight (kg)	78	7	57	102
Daily feed intake (kg)	10.2	1.3	5.3	14.7
Shoulder height (mm)	1168	29	1030	1300
Body length (mm)	1362	45	1140	1550
Scrotal circumference (mm)	334	28	200	470
Residual feed intake (kg)	0	0.63	−3.09	3.49
Kleiber ratio (g/kg)	22.34	3.10	12.01	32.74
Feed conversion ratio (kg)	5.93	0.84	3.34	10.86