Development of selection indexes for a beef cattle production system from available EPDs

Pravia, M. I*†; Ravagnolo, O.*; Urioste, J.†
*Instituto Nacional de Investigación Agropecuaria. INIA, Uruguay†Facultad de Agronomía. Universidad de la República. Uruguay

ABSTRACT: Due to the complexity of selection in beef cattle, where numerous traits are involved, identification of breeding objectives and developing a selection index to improve a global goal is required. A selection index was developed to maximize genetic gain for a beef cattle operation system. The breeding objective included calving rate, carcass weight, calving ease, feed intake, direct and maternal weaning weight. Indexes were constructed from traits for which EPDs are available so it can be implement to make comparisons between animals with different genetic merit. Genetic responses obtained from the use of the proposed index were compared with other simpler indexes. Selection based on the proposed index achieved higher genetic progress in the breeding objective and resulted in an increased economic return to the system. The lack of national genetic parameters for some of the most important traits is a limitation and some implications were discussed.
Keywords: Beef cattle; Breeding objectives; Selection index

Introduction

Breeding societies have genetic evaluations and EPD (Expected Progeny Differences) for growth, reproductive and carcass traits. Multi trait selection indices proposed by Hazel (1943) are the most efficient method to maximize the genetic progress in a breeding objective. The aim of this study was to develop a selection index that maximizes the genetic progress of a breeding objective for a beef cattle production system defined previously (Pravia et al., 2014).

Materials and Methods

A beef cattle operation and its breeding objectives were defined by Pravia et al. (2014). These consist of increasing the calving rate (CR), carcass weight (CW) and calving ease (CE), reduce dry matter intake (DMI), and reduce weaning weight direct and maternal (WWd, WWm). The economic values (EVs) for breeding objectives traits where 96.0, 23.9, 20.4, -1.9, -1.1 and -3.8 USD for CR (%), CW (kg), CE (subjacent scale), DMI (dry matter intake, kg), WWd and WWm(kg) , which represent the profit generated by a one unit increase in each trait when the other traits are kept constant.

Index development. Selection indexes were developed to predict the aggregate genotype based on EPD. The proposed selection index (**IGRB**) was constructed from traits which have EPDs available: scrotal circumference (SC), birth weight (BW), weaning weight direct and maternal (WWd,m), 18 months weight (18mW), rib eye area (REA) and backfat (FAT) as:

$$\mathbf{IGRB} = b_1{*}SC_{EPD} + b_2{*}BW_{EPD}\ b_3{*}WWd_{EPD} + b_4{*}WWm_{EPD} + b_5{*}18mW_{EPD} + b_6{*}REA_{EPD} + b_7{*}FAT_{EPD}$$

Index coefficients (b were calculated for $_{1\text{-}7}$ trait according to Schneeberger et al. (1992) as: $\mathbf{b' = G_{11}^{-1}\, G_{12}\, v}$ where: $\mathbf{G_{11}}$ is the genetic variance-covariance matrix between the EPDs in the index; $\mathbf{G_{12}}$ is the genetic covariance matrix between the traits in the index and the traits considered in the objective; **v** is the vector of economic values for the breeding objective traits.

Genetic gain (**GG**) in each economically relevant trait (n traits), expressed in units of each trait, was calculated as: $\mathbf{GGn = (S/S^2_I)\ G_{21}\ G_{11}^{-1}\ Var_{(\tilde{u}i)}\ b}$, where **S** is the selection differential resulting from the use of the index to a selection intensity of 1, $\mathbf{S^2_I}$ is the variance of the selection index, calculated as $\mathbf{S^2_I{=}b'Var_{(ui)}b}$, where $\mathbf{Var_{(\tilde{u}i)}}$ is the covariance matrix of the predicted EPD, and others are as defined earlier. $\mathbf{Var_{(\tilde{u}i)}}$ is estimated as $\mathbf{Var_{(\tilde{u}i)}{=}B'P_{11}B}$ and $\mathbf{B{=}P_{11}^{-1}\ G_{11}}$ where **B** is matrix of index weight for each breeding value to be predicted, and P_{11} the phenotypic matrix of variance and covariance among criteria as described by Schneeberger et al. (1992).

Economic genetic gain (EGG) in each trait is the GG multiplied by their economic value. The Total economic return (TER) was calculated as the sum of individual EGG. GG and TER were compared between alternative indexes.

Evaluation of alternative indexes: Three additional indexes were evaluated and compared to the proposed index: IG (includes EPDs for only growth traits), IGR (EPDs for growth and reproductive traits), the index proposed IGRB (EPDs for growth, reproductive and beef ultrasound traits) and IGRB + C (IGRB index plus calving rate EPD).

Table 1. Mean phenotypic values, heritability, phenotypic deviations for breeding and criteria traits; additive correlations (above diagonal) and phenotypic correlation (below diagonal)

	Calving %	Calv. Ease suby.scale	SC Cm	BW Kg.	WWd Kg.	WWm Kg.	18mW Kg.	CCW Kg.	FI Kg.	REAu cm2	FATu cm
Mean	78	96	32	35	173	173	359	258	3600	44.2	3.1
h^2	0.05	0.1	0.39	0.49	0.2	0.17	0.27	0.58	0.34	0.41	0.49
σ_p	43.3	0.3	2.7	4.3	25	29	38	25	226.2	7.00	2.6
	Calving	Calv. Ease	SC	BW	WWd	WWm	18mW	CCW	Feed Inteke	REAu	FATu
Calving		0.05	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Calv. Ease	0.15		0.00	-0.31	-0.21	0.00	-0.15	-0.15	0.00	0.00	0.00
SC	0.00	0.00		0.04	0.19	0.19	0.39	0.35	0.10	0.06	0.06
BW	0.00	-0.30	0.11		0.50	-0.14	0.55	0.60	0.20	0.15	-0.24
WWd	0.05	-0.20	0.34	0.46		-0.16	0.70	0.55	0.45	0.49	-0.01
WWm	0.10	-0.20	0.37	0.34	-0.16		0.00	0.00	0.80	0.00	0.00
18mW	0.00	-0.15	0.36	0.38	0.70	0.00		0.91	0.79	0.51	0.32
CCW	0.00	-0.15	0.41	0.41	0.55	0.00	0.85		0.60	0.48	0.29
FI	0.10	0.00	0.00	0.00	0.45	0.20	0.64	0.62		0.00	0.44
REAu	0.10	0.00	0.06	0.10	0.20	0.00	0.35	0.45	0.00		-0.10
FATu	0.00	0.00	0.06	-0.09	0.20	0.00	0.30	0.37	0.00	-0.11	

Abbreviations: Calving % = calving rate; Calv.Ease= calving ease; SC= scrotal circumference, BW= birth weigth, WWd, WWm= weaning weight direct and maternal; 18mW= 18month weight; CCW= carcass weight; FI=Feed intake, REAu= ultrasound rib eye area ; FATu=ultrasound subcutaneous fat; h^2 = heritability; σ_p = phenotypic standard deviation.

Assumptions. Genetic parameters were obtained from the National Hereford Evaluation (Ravagnolo, 2009 pers. comm.) for SC, BW, WWd, WWm, 18mW, REA and FAT; from Urioste et al. (1998) for CR and CE; from Meyer et al. (2004) for CW, and from Koots et al. (1994 a,b) for feed intake. Genetic parameters are presented in 1. Correlations between different traits were assumed as if they were estimated by a multitrait model. To facilitate calculations, individual selection was assumed, which means that every animal express all traits, included those associated to one sex.

Results and Discussion

The index coefficients "b" for the proposed index (IGRB) were 405.3 (SC), 161.0 (BW), -7.2 (WWd), -26.1 (WWm), -54.0 (18mW), 136.8 (REA), 302.8 (FAT). The most important breeding objective traits were not always reflected in a higher index coefficient. This can be explained firstly because the index traits differ from the breeding objective traits defined in the aggregate genotype. Secondly, the "b" coefficients are the result of matrix multiplications, which involve variances and covariances with different units (%, kg, cm, mm).

The GG, EGG achieved in each breeding objective trait, and the TER as a consequence of using the proposed index are presented in Table 2, as well as alternative indexes. Comparing the responses obtained with average values of phenotypic traits (Table 1), selection using the proposed index IGRB with a selection intensity of 1 achieved a genetic progress of 0.99% in CR%, which represents a 1.3% increase from the average phenotype, a decrease of 0.01 CE on the underlying scale, equivalent to 0.01% of the phenotype mean, an increase in WWd of 1.85 kg, and a decrease wwof 4.18 kg of WWm, representing a 1 and -2.4% change in average phenotype. For CW, the increase of 5.74 kg represented an improvement of 2.2% and the decreased of 46.61 kg for FI per year represents an improvement of 1.3%. These responses are achieved in one cycle of selection, at 4.64 years, which is the average age of parents when the progeny are born. The TER obtained for a standard animal after a selection cycle was USD 334.7 and was determined by the sum of GG in each trait multiplied by their EV. This index value represents the potential profit that should be generated in the production system by the use of each particular animal. The bulls can be ranked according this index and selected depending on how much money they are going to generate.

Evaluation of alternative indexes. Alternatives indexes are presented in Table 2. When comparing, the IGRB had a greater genetic progress in the breeding objective traits and a higher total economic return compared with IG and IGR (72% and 85% respectively). The inclusion of calving rate in the index IGRB + C doubled the genetic progress in the traits and the economic return, which encourages farmers to include this information in the records. The major limitation in the development of selection indexes is the lack of proper estimation of genetic and phenotypic correlations between growth traits, feed intake, reproduction and carcass composition and the robustness of the assumptions used in the model formulation. Modelling feed intake in the system as a cost associated to genetic progress

Table 2. Comparison of Genetic Gain (GG) and Total economic return (TER) between alternatives indexes.

	Index proposed		Alternative indexes		
	IGRB	**G.G.E.**	**IG**	**IGR**	**IGRB + C**
Breeding objective traits	*GG*	*USD*	*Genetic gains (in trait units)*		
Calving Rate (%)	0.99	95.42	0.00	0.98	2.20
Calving Ease (us)	-0.01	-0.27	-0.02	-0.01	-0.01
Weaning weight direct (kg)	1.85	-2.04	2.29	1.28	1.21
Weaning weight maternal (kg)	-4.18	15.88	-4.60	-4.08	-3.84
Carcass weight (kg)	5.74	137.19	4.65	4.79	4.86
Feed intake (kg)	-46.61	88.56	-28.91	-46.41	-42.47
Weaning weight direct (kg)	1.85	-2.04	2.29	1.28	1.21
Total Economic Return (USD)		334.7	180.7	310.1	420.9

References: Index IG includes birth weight, direct and maternal weaning weight and 18month weight EPDs. Index IGR includes previous EPDs plus Scrotal Circumference EPD. Index IGRB includes previous EPDs plus rib eye area and subcutaneous fat EPD. Index ICGB+C, includes all previous EPD plus Calving Percentage EPD

in the other breeding traits, is a practical recommendation until genetic parameters are available. Including adult cow weight seems a reasonable alternative, since it has been recorded in recent years and a new EPD will be available, aiming to capture information on maintenance energy in the breeding herd.

Conclusions

The major role of economic selection indexes is to provide a simplified basis to make optimal decisions. This facilitates breeders to identify animals that generate greater profit in their production circumstances, because traits are weighted according to their economic relevance. The assumptions made (genetic parameters and correlations, individual selection) may have affected the results and the accuracy of the responses in each trait, so the potential of the proposed indices are limited to the production and the circumstances considered. These indexes can be improved once national genetic parameters for reproductive and mature cow weight traits were available.

Literature Cited

Hazel, L. 1943. Genetics 28:476-490.

Koots, K. R., Gibson, J. P., Smith, C., Wilton, J. W. 1994a. Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. Anim. Breed. Abstr. 62:309–338.

Koots, K.R., Gibson, J.P., Wilson, J.W. 1994b. Analyses of published genetic parameter estimates for beef production traits. 2. Phenotypic and genetic correlations. Anim. Breed. Abstr. 62: 825-853.

Meyer, K., Johnston, D., Graser H. 2004. Estimates of the complete genetic covariance matrix for traits in multi-trait genetic evaluation of Australian Hereford cattle. Australian Journal of Agricultural Research. 2004, 55, 195-210.

Pravia, M., Ravagnolo, O., Urioste, J. 2014. Livestock Sci. 160 (2014): 21-28

Schneeberger, M., Barwick, S., Crow, G., Hammond, K. 1992. J. Animal Breeding and Genetics: 109 (1992), 180-187.

Urioste, J.I., Ponzoni, R.W., Aguirrezabala, M., Rovere, G., Saavedra, D. 1998. Breeding objectives for pasture-fed Uruguayan beef cattle. J. Anim. Breed. Genet.115:357-373