GENETIC IMPROVEMENT OF FEED EFFICIENCY AND CARCASS AND MEAT QUALITY OF HEREFORD CATTLE BY GENOMICS

Elly A.Navajas[1*], María I. Pravia[1], Mario Lema[2], Juan Clariget[2], Ignacio Aguilar[3], Olga Ravagnolo[2], Gustavo Brito[2], Pablo Peraza[1], Marco Dalla Rizza[1], Fabio Montossi[2]

1 INIA, Biotechnology Unit, Uruguay

2 INIA, Meat and Wool Research Program, Uruguay

3 INIA, Dairy Research Program, Uruguay

*enavajas@inia.org.uy

Abstract – Feed efficiency and carcass and meat quality are economic relevant traits which have not been included in beef cattle breeding programs because of difficulties and high costs of phenotypic recording. Genomic selection has the potential of genetically improve these traits. Major favorable impacts on the economic and environmental sustainability of the beef industry are expected through lower production costs and more efficient beef production with reduced greenhouse gas emissions per unit of improved quality. This paper presents the design of the training population for genomic selection of these traits. Bulls from twenty five percent of the Uruguay Hereford breeder are being recorded in the feed efficiency trial. Preliminary results for feed efficiency are presented and discussed.

I. INTRODUCTION

Within-breed selection based on estimations of genetic merit such as Expected Progeny Differences (EPD) has proved to be an effective genetic improvement tool. Uruguayan information of genetic trends in Hereford and other breeds reported by Ravagnolo *et al*.[1] are examples of genetic improvement of economically relevant traits. Besides these significant contributions to a sustainable and profitable beef industry, outputs from "traditional" selection can be enhanced by genomic information. Genomic selection increase genetic gain by achieving higher EPD accuracies at younger ages of those traits already in the genetic evaluation [2]. It also provides the opportunity of incorporating economically relevant traits that cannot be recorded at an industry-wide basis, such as feed efficiency and carcass and meat quality traits [2].

Feed costs represents in Uruguay between 50% and 70% of the total beef cattle production costs (Soares de Lima, personal communication). Given this large impact on profitability, improving feed efficiency will have a high and favorable economic effect [3]. From the animal breeding point of view, the opportunities of genetic improvement by traditional breeding approaches were limited by the difficulties and high cost of measuring individual feed intake in large number of animals that would allow significant selection intensity [2]. Similarly, carcass and meat quality traits have received little emphasis in breeding programs, beyond the relevance of quality to improve/maintain competitiveness in the international market.

A large national project with the main goal of enhancing competitiveness of the Uruguayan beef industry by implementing genomic tools to genetically improve feed efficiency and carcass quality was launched in 2013. One of the tasks is building the training population for feed efficiency and carcass and meat quality traits needed for the implementation of genomic selection by 2017. Improving feed efficiency, carcass and meat quality will have an important impact on the beef industry economic and environmental sustainability. Working simultaneously on both groups of traits enables reducing costs of a final product more suitable for the market, as well as, decreasing greenhouse gas emission and environmental load per unit of meat produced.

The project is carried out by a multi institutional team that includes public and private organizations: the Uruguayan Hereford Breed Association (SCHU), the National Agricultural Research Institute of Uruguay (INIA), the Ministry of Livestock, Agriculture and Fishery (MGAP), the National Meat Institute (INAC), the Rural Association of Uruguay (ARU) and the Institute of Biological Research Clemente Estable (IIBCE). The research team comprises several disciplines from animal nutrition, quantitative genetics to biostatistics and genomics. A unique attribute of this project is the inclusion of information recorded by national

governmental institutions. The national traceability system from farm of origin to the consumer, which is under the responsibility of the National Livestock Information System [4] (MGAP) and the Electronic Information System for the Beef Industry (SEIIC) [4] developed by INAC will provide access to individual carcass data that is routinely recorded in all slaughterhouses and can be traced back to the farm where the animal was born. In addition, facilities were built and equipment installed in order to record individual feed intake to asses feed efficiency. This paper presents a detailed description of the design and preliminary results of feed efficiency measured in the first group of yearling bulls.

II. MATERIALS AND METHODS

Feed Intake. A training population for feed efficiency of 1000 Hereford bulls and steers will be built by the end of 2016. Individual feed intake data will be recorded using the Growsafe system installed at the Kiyú test station of SCHU, where three intake trials of 100 days per year will be run. Numbers of animals per category and birth season are in Table 1. Protocols were established according to recommendations of the Beef Improvement Federation (BIF) [5,6]. Animals should have a minimum age of 240 days at the beginning of trial and a maximum of 390 days of age at the end.

Table 1. Number of bulls and steers in the training population for feed efficiency

Animals	Total
Yearling Bulls (autumn calving)	180
Young Bulls (spring calving)	384
Steers (late spring calving)	480
Total	1044

A pre-conditioning period was defined before starting the trial with the objective of allowing animals to acclimatize to animals of different origin, the facilities and diet. This period includes: 10 days on pasture, 10 days on warming-up in a pen with traditional bunk and 15 days of warming-up in Growsafe system bunks. Diet is formulated for post weaning animals. The test period is of 70 days when the animals will be fed *ad libitum* to avoid data bias due to restricted feeding. Individual intake is daily recorded by the Growsafe system though electronic scales inside the feed bunks which record every time the animal eats and the quantity. Live weights will be recorded every 2 weeks. Ultrasound measures (rib eye area, fat thickness, rump fat and intramuscular fat) will be taken at the beginning and end of the trial.

Bulls and Steers. Pre-requisites were defined for bulls and steers in terms of information needed (in agreement with BIF guidelines [5, 6]) and with genetic links to the Hereford population in the genetic evaluation database: (1) all bulls must have date of birth, birth weight and pedigree data known; (2) three or four yearling bulls per herd will be admitted from a minimum of two sires, and belonging to the same contemporary group at weaning. The selection of herds and bulls is optimized to get variation and maximize the genetic link between overall population and training population. In the case of the steers: (1) all animals should have date of birth, birth weight and sire identification, which will be previously confirmed by DNA parentage test, (2) more progeny per sire will be accepted with a maximum of 10 steers per sire; (3) steers should be of at least 2 sires per farm.

Feed Efficiency. There are several indicator of feed efficiency, which will be evaluated during the project. However, studies will start by Residual Feed Intake (RFI), which is the preferred indicators used in beef cattle genetic evaluations [5,6]. Alternative equations to estimate RFI will be evaluated [7]. RFI is defined as the difference between an animal actual feed intake and its expected feed requirements for maintenance and growth [8,9]. Results presented here were estimated as:

$$RFI = FI - E(FI)$$

$$E(FI) = b_o + b_1\ ADG + b_2\ MWT$$

where FI is feed intake, E(FI) Estimated feed intake, b_o is the intercept of the regression, b_1 and b_2 the coefficients for Average daily gain (ADG) and Mid-test metabolic weight (MWT= Mid test weight^0.75). Significance of b_o, b_1 and b_2 where tested by ANOVA analysis [10]. Factors that significantly affected each of the performance and efficiency traits (herd, sire, age of dam and age of the bull at the end of test) were determined using linear models in GLM procedure [10].

Results of other analysis as estimation of repeatability and variances components, genome wide association studies will be only presented later in the project, when enough data is available.

Carcass and Meat Quality. This project will contribute data of 480 steers to the carcass and meat quality training population. After the feed intake trial, steers will be finished at Kiyú and slaughtered in a commercial slaughterhouse. Slaughter criterion will be an average final weight of 500kg of the whole group. The following carcass and meat quality traits will be directly measured by INIA and INAC staff: hot and cold carcass weight, conformation and fatness grades, quarters, primal and cuts weights. Additionally, samples from the *Longissimus dorsi* will be collected for evaluation of relevant quality attributes of meat: meat and fat color, intramuscular fat percentage, pH, tenderness (Warner-Braztler), and intramuscular fat.

Carcass and cut weights will also be collected by the SEIIC and linked to the animal through the traceability system. Based on these innovative tools, which are already in place, it will be possible to enlarge the training population with minimum phenotyping costs. Procedures to have the information delivered by internet and collated with the genomic database will be developed by INIA, INAC and MGAP. Protocols for accessing, collecting and delivering the information will be developed.

DNA genotyping. Blood samples will be collected of young bulls and steers in the training population and semen or blood samples will also be collected of sires of animals in the training populations. DNA will be extracted at INIA laboratory and samples will also be kept in an Animal DNA Bank. DNA samples of tested bulls and steers will be genotyped with 700k SNP panel. Genomic and enhanced EPDs will be predicted using these genomic and phenotypic data, and in the context of the genetic evaluations of the Uruguayan Hereford breed by INIA. Different approaches will be tested from Bayesian approaches to single step method for GWAS and the estimation of genomics EPD [11].

III. RESULTS AND DISCUSSION

Preliminary descriptive data of the first feed intake trial of 50 bulls are showed in Table 2. The pre-conditioning period of the second trial started in May with 122 bulls of a total of 41 Herford herds participating in the genetic evaluation system. This implies that 25% of the total herds in the national genetic evaluation are already part of the training population. A high representativeness is very relevant of ensure a strong genetic link between the training population and animals that will be genotyped in the future because higher accuracies are expected. Greater accuracies would be expected for selection candidates more related to animals in the training population [12].

Table 2. Descriptive statistics for some traits measured in the Feed Efficiency trial.

Traits	Avg	Min	Max
Start age, d	301	274	316
Finish age, d	387	360	402
Start weight, kg	265	171	336
Finish weight, kg	395	285	477
Mid test weight, kg	326	221	400
Metabolic mid weight, kg	76.0	57.4	89.5

Avg, average; Min, minimum value; Max, maximum value

Distribution of individual RFI estimates is presented in Figure 1. Efficient animals are those that eat less than expected and therefore have negative or low RFI values. On the other hand, inefficient animals present positive or high RFI.

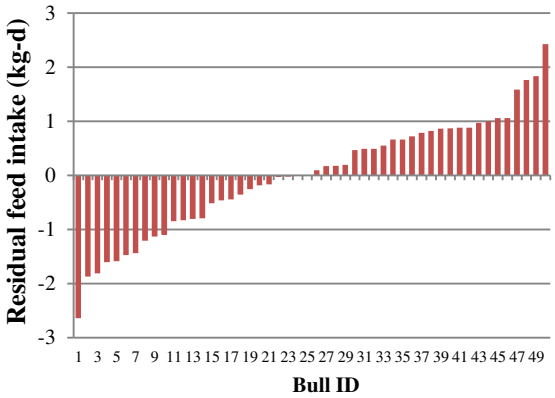

Figure 1. Individual animal variation in residual feed intake of yearling Hereford bulls

This preliminary information suggests that a considerable phenotypic variation exist in RFI,

confirming results published the literature [6,7,8].

In agreement with the literature, RFI show no association with live weight (Figure 2). The lack of correlation between both traits implies the possibilities of improving efficiency independently of adult weight and growth rate. In addition, it would be possible to explore the association at genomic level among growth, feed efficiency and carcass and meat quality traits.

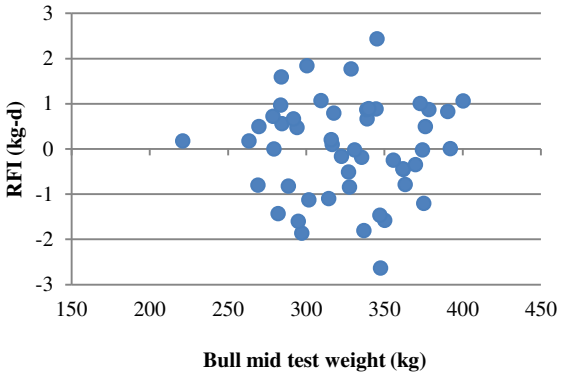

Figure 2. Residual feed intake versus average live weight during the test

IV. CONCLUSION

Uruguay have been able to generate a large multi-institutional project that started in 2014 with the objective of building the training population of feed efficiency and carcass and meat quality traits to implement genomic selection. Feed intake performance of 170 bulls of 41 herds has been measured in the first semester. Preliminary results show phenotypic variability of feed efficiency and a favorable lack of association with live weight. The exploitation of underlying genetic variations of feed efficiency and carcass and meat quality by genomic selections will allow enhancing the beef industry economic and environmental sustainability through lower costs, higher quality and reduced environmental load.

ACKNOWLEDGEMENTS

We thank the institution and their staff for their significant contribution to this collaborative project: Uruguayan Hereford Breeders Association, the Ministry of Livestock, Agriculture and Fishery, the National Meat Institute, the Rural Association of Uruguay and the Institute of Biological Research Clemente Estable. We are also grateful with all technicians participating in this project and specially to Daniel de Mattos. Financial support was provided by the National Agency for Research and Innovation (grant RTS_1_2012_1_3489).

REFERENCES

1. Ravagnolo, O., Lema, M. & Goldberg, V. (2013). Información objetiva para la selección de reproductores en razas carniceras. Revista INIA Diciembre 2013: 9-13.
2. Garrick, D.J. (2011). The nature, scope and impact of genomic prediction in beef cattle in the United States. Genetics Selection Evolution 43: 17-28.
3. Anderson R.V., Rasby R.J., Klopfenstein T.J. & Clark R.T. (2005). An evaluation of production and economic efficiency of two beef systems from calving to slaughter. Journal of Animal Science 83, 694–704.
4. IICA (2009).Un nodo de cooperación sobre: la experiencia de Uruguay en trazabilidad bovina. IICA, pp 56
5. Beef improvement guidelines. Ninth edition. 2010.
6. Crews, D.H. Jr. & Carstens, G.E. (2012). Measuring individual feed intake and utilization in growing cattle. In_ Rodney A. Hill, Feed efficiency in the beef industry (pp 21-28). John Wiley & Sons, Inc.
7. Savietto, D., Berry, D. P. & Friggens, N. C. (2014). Towards an improved estimation of the biological components of residual feed intake in growing cattle. Journal of Animal Science 92:467-476.
8. Koch, R.M., Swiger, L.A., Chambers, D. & Gregory, K.E. (1963). Efficiency of feed use in beef cattle. Journal of Animal Science 22:486–494.
9. Arthur, P.F., Archer, J.A., Johnston, D.J., Herd, R.M., Richardson, E.C. & P.E. Parnell (2001). Genetic and phenotypic variance and covariance components for feed intake, feed efficiency and other post-weaning traits in Angus cattle. Journal of Animal. Science 79:2805–2811.
10. SAS Institute Inc. SAS Software Version 9.2. Cary, NC: 2008.
11. Aguilar, I., Misztal, I., Johnson, D.L., Legarra, A., Tsuruta, S. & Lawlor, T.J. (2010). Hot topic: a unified approach to utilize phenotypic, full pedigree, and genomic information for genetic evaluation of Holstein final score. Journal of Dairy Science 93: 743-75.
12. Saatchi, M., Ward, J. &Garrick, D.J (2011). Accuracies of direct genomic breeding values in Hereford beef cattle using national or international training populations. Journal of Animal Science 91:1538-1551.