Selection for Economic Feed Conversion Efficiency of Dairy Cattle under Co-operative Dairy Conditions in the North of Argentina

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ABSTRACT: A group of co-operative dairy farmers from the north of Argentina started a breeding program for the genetic improvement of their cows in 2005. The breeding goal was to improve the genetic ability of the cow to convert dry matter (DM) into farm profit. The cows predominantly graze alfalfa (*Medicago sativa L.*) all year and are under high heat stress during summer. The selection scheme is based on a nucleus herd of bull mothers selected on an economic selection index that estimates the genetic superiority of a cow for farm profit per ton of DM. The genetic superiority of the nucleus herd cows compared to the population cows was $AR60/ton DM.
Keywords: dairy cattle; economic feed conversion efficiency; heat stress

Introduction

Milk production systems in the northwest of Santa Fe province and the south of Santiago del Estero province, Argentina, are characterized by grazing herds, with 50 to 70% of the diet being grazed alfalfa (*Medicago sativa L.*) and the remainder grain-based concentrates. The main breed is Holstein derived from North America. Within this region, there is a co-operative of 30 dairy farmers operating as "Cooperativa Tambera y Agropecuaria Nueva Alpina Ltda (COTANA)" that started a breeding program for the genetic improvement of their dairy cattle in 2005. The climatic conditions in this area are adverse for milk production. The temperatures in summer can reach 40°C, causing heat stress and reducing grazing time and dry matter (DM) intake. During winter, the temperatures can reach -5°C with farmers generally not providing shelter and cows remain out grazing. This paper describes the systematic approached used to develop a low cost breeding program to improve the genetic capability of cows to increase economic feed conversion efficiency under adverse climatic conditions for milk production based on grazed alfalfa.

Materials and Methods

Production system. The co-operative is located in the north of Argentina, 30°5' south latitude and 62°3' west longitude. COTANA was founded 60 years ago in the south east of Rivadavia county, Santiago del Estero province in Argentina. Mean temperature during summer is 25º C with extreme values up to 40º C; mean temperature during winter is 12.9º C with extreme low values down to -5°C. Milk production is based on Holstein cows grazing alfalfa most of the year with strategic use of forage supplements, mainly maize silage, sorghum silage and concentrates (maize and sorghum grain). The use of concentrates and supplements is influenced by pasture availability and market conditions.

On COTANA farms, fertility of cows during summer months (December to April) is low mainly due to heat stress; dairy farmers prefer to avoid mating during these months causing a seasonal calving pattern. These characteristics create a particular system for selecting cows to improve efficiency of transforming feeds to farm profit, at variable climatic, feed and market conditions.

Breeding goal. The breeding goal is to improve the genetic ability of the cow to convert dry matter (DM) into farm profit.

Genetic evaluation. The cow population of the co-operative is about 5,300 cows distributed in 30 farms but only 11 famers have adopted a recording system that provides an average of 1,920 lactations records per year to the central data base. Card records were transferred into the electronic system in 1994 and by July 2013 the data base consisted of 40,071 completed lactations from 13,056 cows. The pedigree file included 94 sires, 2,553 dams, 55 grand sires and 575 grand dams.

A system of genetic evaluation was implemented to produce estimated breeding values (EBV) for lactation yields of milk, fat, protein, cow mature live weight (LWT) and days open for all animals with a multi-trait repeatability animal model using ASReml (Gilmour et al. (2009)). The mixed model included the fixed effects of contemporary group (cows calving in the same herd, year and two-month period), lactation number and the random effects of animal additive genetic, permanent environmental effect of cow and residual errors.

Selection index. The ranking of bulls and cows is based on an economic selection index called MEGEL (Mérito Genético Económico Lechero), which measures the genetic superiority of an animal to convert 1 ton of DM into farm profit, calculated as

$$\begin{aligned} \text{MEGEL} = {} & \text{AR\$0.081} \times \text{EBV milk} \\ & + \text{AR\$1.238} \times \text{EBV fat} \\ & + \text{AR\$1.950} \times \text{EBV protein} \\ & - \text{AR\$0.048} \times \text{EBV live weight} \\ & - \text{AR\$0.105} \times \text{EBV days open} \end{aligned}$$

The economic values for each of the traits included in MEGEL are updated each year using a farm model that evaluates the change in cow profit per ton of DM per unit change of the trait. The model takes into consideration revenues from milk and beef and feed and farm costs. Dry matter intake is calculated based on requirements of metabolisable energy (ME) for production and maintenance using formulae from AFRC (1993) assuming that the average content of ME of alfalfa and feed supplements is 10.8 MJ.

The milk payment system includes a differential payment for fat and protein and a bonus for volume, plus penalties or premiums for bacterial and somatic cell counts, temperature, free of brucelosis and tuberculosis status, and the final use of the milk: internal market or export. The values per kilogram of fat, protein and litre of milk volume used for the genetic evaluation in July 2013 were AR$16.20, AR$18.91 and AR$0.889, respectively.

Selection scheme. A basic selection scheme was implemented in 2006 after the first genetic evaluation. The top 100 cows ranked on MEGEL were inseminated with semen from bulls that were available in the market. This selection scheme was repeated until the co-operative established an artificial insemination center in 2007 and COTANAs own bulls were used to produce heifer and bull replacements. In 2012 a nucleus herd was created with the best 64 cows in the co-operative selected based on MEGEL. These cows will be used as bull mothers and will be measured more intensively for traits related to fertility and heat stress.

Productive performance and feed conversion efficiency. Lactation yields of milk, fat and protein, LWT and days open were extracted from the data base. Lactation yield of milk solids was calculated as the sum of lactation yields of fat and protein. Biological efficiency (BE) was calculated as BE = lactation yield of milk solids/100 kg LWT. Feed conversion efficiency (FCE) was calculated as FCE = lactation yield of milk solids/ton of DM intake. Dry matter intake was assumed equal to DM requirements which weres calculated based on requirements of ME for production and maintenance.

Means and standard errors of all phenotypic variables and EBVs for the cow population and nucleus herd were obtained using the GML procedure of SAS (2010).

Lactation curves for daily yields of milk solids were derived from monthly herd-test records for milk, fat and protein recorded in the nucleus herd during the year 2013. Lactation curves were derived with random regression third order orthogonal polynomials using ASreml (Gilmour et al. (2009)).

Results and Discussion

Phenotypic performance of the cow population and nucleus herd is presented in Table 1. Milk production per cow of the cow population of this cooperative (4,497 kg) was lower than the national average of Argentina (5,560) obtained from all farms supplying milk to dairy companies of country in 2013 (Yankelevich 2013). This difference could be explained by the fact that the milk production of this co-operative group is based on grazed alfalfa and under heat stress during summer, whereas the national average is made up of many suppliers that produce milk in indoor systems with total-mixed rations. The cows selected as bull mothers in 2012 were allocated to a nucleus herd but the productive performance shown in Table 1 was achieved when they were milked in the commercial herds. Compared to the COTANA cow population, the nucleus-herd cows were lighter and had higher lactation yields of milk, fat and protein and, consequently, the nucleus-herd cows had higher BE and FCE. Prendiville et al. (2009) reported a value of 79 kg milk solids/ton DM in Holstein-Friesian cows under grazing conditions of Ireland, which is similar to the value of 79.8 estimated in this study for the entire cow population. The nucleus-herd cows had a significantly higher value of FCE (84.0 vs 79.8) which provides evidence that significant progress on FCE can be achieved if the cow population is eventually changed by selection to the same type of cow as cows in the nucleus herd. It is important to note is that the nucleus-herd cows had similar days open to the cow population. The negative economic value for days open EBV must be increased to put more selection pressure on this trait as implemented in Ireland (Berry et al. (2007)) and USA (VanRaden (2004)).

Table 1. Means (and standard errors) of production, efficiency and fertility traits for the cow population (n=12,992 cows) and the nucleus herd (n=64 cows) of co-operative dairy cattle in the north of Argentina.

Trait[§]	Population	Nucleus	P
Milk, kg	4,497 (8)	5,655 (117)	<0.001
Fat, kg	155.2 (0.3)	186.9 (4.5)	<0.001
Protein, kg	159.2 (0.4)	180.2 (4.2)	<0.001
LWT, kg	514 (1)	503 (9)	0.2362
DMr, kg	4,070 (7)	4,346 (62)	<0.001
BE	64.5 (0.2)	73.6 (1.8)	<0.001
FCE	79.8 (0.11)	84.0 (1.04)	<0.001
Days open	138.7 (0.6)	141.7 (8.0)	0.7067

[§]LWT = live weight, DMr = dry matter requirements, BE = biological efficiency ((kg fat + kg protein)/LWT), FCE = feed conversion efficiency ((kg fat + kg protein)/DMr)×1000).

The lactation curves for daily yields of milk solids during the year 2013 of the nucleus-herd cows compared to the COTANA cow population are presented in Figure 1. The estimates of 305-day lactation yields were 474 and 366 kg for the nucleus-herd and the cow population, respectively. This is a difference of 108 kg, which is much higher than the difference of 52.7 kg observed in the year 2012, when the nucleus-herd cows still were in the commercial herds. These results indicate that the management and feed-

ing in the nucleus herd is better than the management in the commercial herds, allowing better phenotypic expression of the genetic potential of the selected bull mothers.

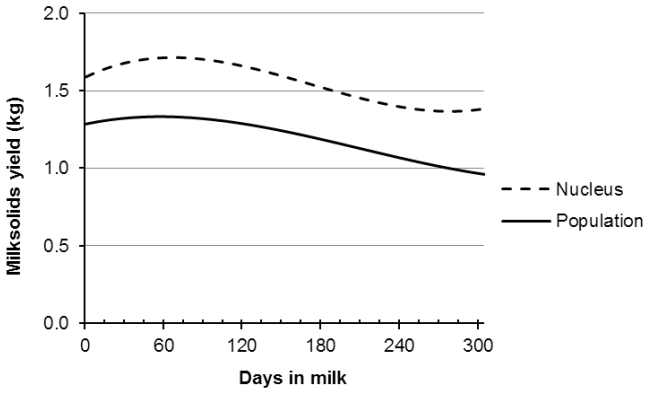

Figure 1. Lactation curves for daily milk solids (fat + protein) yield of cows in a nucleus herd (n=64 cows) and in population (n=12,992 cows) of a co-operative dairy cattle in the north of Argentina.

The genetic differences between the nucleus-herd and the cow population are shown in Table 2. Compared to the cow population, the nucleus-herd cows had a genetic superiority for lactation yields of milk, fat and protein, and they were genetically heavier and with more days open. Compared to the phenotypic performance shown in Table 1, it seems to be a contradiction for live weight. The nucleus-herd cows were phenotypically lighter but genetically heavier than cows in the population.

Table 2. Means (and standard errors) of estimated breeding values for milk production, live weight, days open and economic feed conversion efficiency for the cow population (n=12,992 cows) and the nucleus herd (n=64 cows) of co-operative dairy cattle in the north of Argentina.

Trait[§]	Population	Nucleus	P
Milk, kg	-26 (3)	393 (36)	<0.001
Fat, kg	0.0 (0.07)	5.6 (0.93)	<0.001
Protein, kg	-0.4 (0.08)	9.2 (1.07)	<0.001
LWT, kg	-0.9 (0.09)	6.1 (1.34)	<0.001
Days open	0.2 (0.02)	0.8 (0.23)	0.0193
MEGEL, AR$/ton DM	-3 (0.4)	57 (5.4)	<0.001

[§]LWT = live weight, MEGEL = merito genetico economico lechero = (AR$0.081 × EBV milk) + (AR$1.238 × EBV fat) + (AR$1.950 × EBV protein) – (AR$0.048 × EBV live weight) – (AR$0.105 × EBV days open).

In agreement with the results for BE and FEC, the nucleus-herd cows had higher MEGEl, indicating that selection for MEGEL will improve the genetic capability of the cows from this co-operative to transform grazed alfalfa into farm profit while under heat stress during summer.

Future developments and plans. The breeding program of this group of co-operative dairy farmers has been supported by the local government to build an artificial insemination center. There are expectations that other dairy farmers from this or other regions will become part of the breeding program. In 2013, about 800 dairy farmers, through their organisations, agreed to create a cluster: "Cluster Lechero Regional", with official support from the Interamerican Development Bank. The main objective of the cluster is to maintain the number of small- and medium-size dairy farms to stop the workers involved in milk production migrating to urban areas due to the lack in work opportunities in rural areas. It is expected that about 20 dairy farmers from this cluster will adopt the herd-testing scheme of COTANA adding around 3,000 more cows to the cow population. The technical team of COTANA is evaluating the use of genomic selection to identify cows with superior genetics for FCE, fertility and survival, under the heat stress and grazing conditions of this region.

Conclusion

Improving the genetic capability of cows to transform 1 ton of feed DM into farm profit is the goal of the breeding program of this cooperative of dairy farmers located in the north of Argentina.. The nucleus-herd cows have shown potential to produce young bulls that will transmit a genetic superiority for economic FCE into the commercial cow population.

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