Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/

Economic values for production, functional and fertility traits in milk production systems in Southern Brazil

Cervo, H.J.[1]; Barcellos, J.O.J.[1]; Peripolli, V.[2@]; Colle, G.[3] and McManus, C.[4]

[1]Federal University of Rio Grande do Sul. Faculty of Agronomy. Department of Animal Science. Porto Alegre, RS. Brasil.
[2]Federal Catarinense Institute. Abelardo Luz Campus. Abelardo Luz, SC. Brazil.
[3]Sebrae Planalto. Passo Fundo, RS. Brazil.
[4]University of Brasilia. Biological Sciences Institute. Darcy Ribeiro Campus. Brasilia, DF. Brazil.

SUMMARY

The objective of this study was to predict the economic values for production, functional and fertility traits, as well as to rank them in order of economic importance for milk production systems in southern Brazil. For this, two clusters were formed according to their production and the characteristics considered were: milk production (MP), lactation persistency (LP), milk fat (FAT), milk protein (PROT), somatic cell count (SCC), age at first calving (AFC), calving interval (CI), feed intake (Intake), mortality (MORT) and cow weight (CW). Revenue was based on the sale of milk, surplus heifers and cull cows and the actual operating costs were used to calculate profit and gross margin. The profit function used to calculate the economic values was based on a 100-cow farm. The average economic values of the characteristics that affect the profit of the producer were in order: FAT: US $ 3,776.07; PROT: US $ 1,888.03; MP US $ 1,258.69, LP: US $ 1,258.69; CW: US $ 124.03; MORT: US $ -14.30; Intake: US $ -614.01; CI: US $ -1,023.62; AFC: US $ -2,724.29; SCC: US $ -3,146.87. Therefore, the economic values calculated for the volume of milk, fertility, milk quality, disease resistance and feed intake addressed that the use of these traits as selection objectives in breeding programmes should result in an increased profitability for the farmer.

ADDITIONAL KEYWORDS

Economic goal.
Economic value.
Selection.
Profit function.

Valores econômicos para as características de produção, funcionais e de fertilidade em sistemas de produção de leite no Sul do Brasil

RESUMO

O objetivo deste estudo foi prever os valores econômicos para características de produção, funcionais e de fertilidade, bem como para classificá-las em ordem de importância econômica para os sistemas de produção de leite no sul do Brasil. Para isso, dois grupos foram formados, de acordo com a sua produção, e as características consideradas foram: a produção de leite (L), a persistência da lactação (PL), a gordura do leite (GOR), a proteína do leite (PROT), a contagem de células somáticas (CCS), a idade de primeiro parto (IPP), o intervalo entre partos (IP), o consumo de ração (Consumo), a mortalidade (MORT) e o peso da vaca (PV). A receita baseou-se na venda de leite, de novilhas excedentes e de vacas de descarte, e os custos reais de operação foram utilizados para calcular o lucro e a margem bruta. A função de lucro utilizada para calcular os valores econômicos foi baseada em uma fazenda de 100 vacas. Os valores econômicos médios das características que afetam o lucro do produtor foram em ordem: GOR: US $ 3.776,07; PROT: US $ 1.888,03; L US $ 1.258,69, PL: US $ 1.258,69; PV: US $ 124,03; MORT: US $ -14,30; Consumo: US $ -614,01; IP: US $ -1.023,62; IPP: US $ -2.724,29; CSS: US $ -3.146,87. Os valores econômicos calculados para o volume de leite, fertilidade, qualidade do leite, resistência a doenças e consumo de ração, indicou que o uso dessas características como objetivos de seleção em programas de melhoramento deve resultar em aumento da rentabilidade para o produtor.

PALAVRAS-CHAVE ADICIONAIS

Função lucro.
Objetivo econômico.
Seleção.
Valor econômico.

INFORMATION

Cronología del artículo.
Recibido/Received: 10.03.2016
Aceptado/Accepted: 18.04.2017
On-line: 15.07.2017
Correspondencia a los autores/Contact e-mail:
vanessa.peripolli@hotmail.com

INTRODUCTION

Dairy farming is one of the main agribusinesses in Brazil, generating 10% of the income generated by Brazilian agriculture, and 76% of income from livestock. In 2013, the growth of agribusiness agribusiness gross domestic product (GDP) was 3.6%, and its share in the Brazilian GDP was 22.8% (FAO, 2010).

The most widely used method for obtaining improved animals is through artificial insemination; 89.69% of dairy herds in southern Brazil use this resource, higher than the national average of 13.7% (Baruselli *et al.*, 2012). In most cases, selection criteria are for the increase in production volume, without perception of other correlated traits, such as functional and fertility traits that can indirectly influence the productivity of the animals.

Selection aiming only at improving the animals, often does not lead to profit for the farmer. Therefore, one must consider, not only animal breeding, but also the environmental interference and production level. Bioeconomic models were developed to identify the selection objective traits, to maximize the economic genetic gain (Hazel, 1943). There is little knowledge of these evaluations for the selection of cattle in tropical countries such as Brazil, where the traits of interest may have different importance compared with developed temperate countries (Usman *et al*., 2013).

Despite the importance of this issue, in Brazil, there are no studies that determine the objectives of selection in dairy cattle and most are limited to the calculation of economic values for a limited number of economically important traits (Cardoso *et al*., 2004; 2014). The southern region has the second largest dairy herd and highest productivity so studies are necessary in this area, to make this activity more profitable and competitive.

The objective of this study was to predict the economic values for production, functional and fertility traits, as well as calculate selection objectives for dairy cattle in southern Brazil.

MATERIALS AND METHODS

On farm data were collected by technicians of the Brazilian Service of Support for Micro and Small Enterprises (Sebrae), through monthly monitoring of husbandry and economic data on 61 properties belonging to the microregion of Passo Fundo – Rio Grande do Sul State, Brazil, between 2009 and 2011. The properties were randomly chosen and the owners agreed to monthly collections of production and economic data. The properties were chosen due to the existence of SEBRAE technicians in the micro-region municipalities, who collected the data on-farm.

Cluster	(1) High production								(2) Medium-high production							
Pregnancy rate	85								82							
Offspring	85								82							
Mortality rate	0								8							
Survival	85								76							
Cow age	2	3	4	5	6	7	8	9	2	3	4	5	6	7	8	9
Nº animals= 100	15	14	13	13	12	12	11	10	17	16	15	14	13	12	11	10

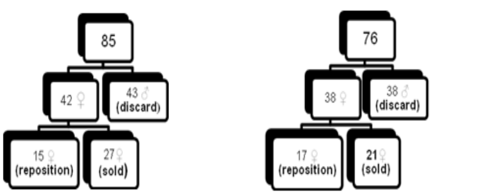

Figure 1. Structure of a 100-cow herd based on true indexes of the high and medium-high production herds (Estrutura do rebanho baseado em 100 vacas sobre os índices verdadeiros dos rebanhos de alta e média-alta produção).

Two groups were formed in the cluster analysis, representing medium and high production efficiency of the properties in the study, based on number of dairy cows and total number of animals, through FASTCLUS procedure of SAS ® (Statistical Analysis System Inc, Cary, NC, USA). The herd size was standardized to a 100-cow farm. The FACTOR procedure was used in a factor analysis, to understand the correlation structure and the sources of data variation.

Analyzes of variance were performed using the GLM procedure for economic and related milk production variables to differentiate between the clusters formed. The variables were normalized, standardized by the STANDARD procedure, assuming mean zero (0) and variance one (1), and adjusted means by the least squares method (LSMEANS). To compare means, we used Duncan's test at 10% of probability ($p<0.10$).

Clusters 1 and 2 were designated high and medium-high output respectively, which served for calculation of economic values **(figure 1)**. Production systems were considered specialized in dairy production (Vance *et al*., 2012). Sales included milk, cull females with an average weight of 550 Kg and non-pregnant and pregnant heifers weighing 330 Kg. Males were culled at birth because they lacked commercial value. This procedure was adopted because the region is specialized in milk and not meat production.

Herd structure **(figure 1)** was based on a 100-cow farm for each production systems, and the number of cows in each age group as well as those available for culling and replacement needs were determined by the equation $HS = a(1-r^n)/1-r$, where, HS is the herd size; r is the survival rate; a is the number of animals; and n is the dam age (McManus *et al*., 2011). For example, for a 100-cow herd and mean herd life of eight years, with a survival rate of 0.92, we find a number of replacement cows per year equal to 17.

The costs were calculated based on the actual operating cost structure (OCS) conceptualized by Thomasen *et al*. (2014), where the profit identifies the return on sales income, calculated by dividing operating income (OI) by total gross income (TGR). Profitability is the percentage of return or gain obtained by the farm through sales minus the operational production costs.

Income (I) and expenses (E) were combined in different ways to estimate the economic value of their respective characteristics that affect the profit of the dairy activity **(table I)**.

Economic values were calculated from SEBRAE data per cluster, where revenue was due to the sale of milk, cull cows and young heifers **(table II)**. Variable costs included those related to feeding (concentrate, mineral, silage, hay and pasture), and management (labor, medicines, energy and fuel, taxes, semen, cleaning materials, milk transportation, outsourced services, powdered milk and milk replacers to feed the calves).

Three scenarios were considered to calculate the economic values of traits related to milk quality (fat, protein and somatic cell count): scenario I, where the dairy industry does not give bonus and penalize the quality of milk, and therefore has an economic value

Table I. Average production, economic (US $) and annual performance indexes for high and medium productivity clusters, standardized to a 100-cow herd (Produção média, índices de desempenho econômico (US $) e anuais para os clusters de alta e média produtividade, padronizados para um rebanho de 100 vacas).

Traits	Cluster			Indexes	Cluster		
	Ab	High (9)	Medium (52)		Ab	High	Medium
Property area (ha)	PA	37.16[a]	22.26[b]	Cows in production (head)	PC	100	100
Area used for dairy farming (ha)	ADF	23.15[a]	8.40[b]	Number of lactating cows (head)	LC	85.03	82.26
Number of cows in milk (head)	LC	85.03[a]	82.26[b]	Number of dry cows (head)	DC	14.96	17.73
Number of dry cows (head)	DC	14.96[b]	17.73[a]	Percentage lactating cows (%)	LC%	85.03	82.26
Total number of animals (head)	TA	177.39[a]	170.01[b]	Percentage cows in the total herd (%)	CTH%	48	48
Value of a liter of milk (US $)	VLM	0.34	0.33	Calving rate (%)	CR	85	82
Income from the sale of milk (US $)	ISM	138487.86[a]	113250.71[b]	Calving interval (months)	CI	14	14
Total income of dairy farming (US $)	TIDF	151724.12[a]	124446.57[b]	Age at first calving (months)	AFC	26	26
Total operating expenses (US $)	TOE	87180.24[a]	79429.33[b]	Lactation persistency (days)	LP	365	365
Expenses with concentrate (US $)	EC	52569.69[a]	48150.06[b]	Productivity per lactating cow (L in 365 days)	PLC	4601.94	3998.86
Investment in purchase of animals (US $)	IPA	1236.82	487.24	Productivity per total cow (L in 365 days)	PTC	3916.61	3306.19
Total investment (US $)	TI	6905.93	8943.19	Production per cow milked day^{-1} (L in 365 days)	PCM	12.6	10.95
Annual income (US $)	AIN	151724.12[a]	124446.57[b]	Production per total cow day^{-1} (L in 365 days)	PTC/ day	10.73	9.06
Annual expenses (US $)	AE	87180.24[a]	79429.33[b]	Annual Milk production (L year^{-1}herd^{-1})	AMP	337877.6	336543.0
Gross margin (US $)	GM	64543.88[a]	45017.24[b]	Total mortality of animals (%)	TMA	0	8
Annual investments (US $)	AINV	6905.93	8943.19	Number of animals sold (discard and young) (head)	NAS	37	31
Annual balance (US $)	AB	57637.95[a]	36074.05[b]	Young female replacements (head)	YFR	15	17

Ab: Abbreviation; Means followed by different letters in the row differ according to Duncan's test ($p<0.10$).

of zero. Scenario II and III, the economic values were calculated by the minimum and maximum bonus, respectively, performed by a dairy industry in the region, according to the White Paper 62 - Brazil, 2011. Economic values were also determined for traits related to milk production (milk volume and duration of lactation), fertility (calving interval and age at first calving), weight, food consumption and mortality.

Bioeconomic models (BEM) or profit equations (profit functions) were used for the economic value calculation. The results were given by the difference between the average profits before (Pa) and after the improvement (Pa'), by the equation Sp = Pa' - Pa, where (Sp) is the average profit of the system, after each characteristic increased 1%, while maintaining the other mean traits unchanged (Ponzoni and Newman, 1989). We used one percent increase (1%) to standardize the scale of each trait. The values were dollarized by the average of the years 2009 to 2011, resulting in US $ 1.00 for each R $ 1.81.

Sensitivity analyzes were performed to assess the impact of possible changes in the variations of dietary components in ± 25 and ± 50% on the profit, when there is an increase of 1% in expression of the traits examined.

A phenotypic and genetic (co)variance matrix **(table III)**, positive defined (Van Der Werf, 1999), was estimated using the phenotypic and genetic parameters from national and international literature (Andrade *et al.*, 2007; Prata *et al.*, 2015; Pritchard *et al.*, 2013; Campos *et al.*, 2015; Cobuci and Costa, 2012; Petrini *et al.*, 2016). This was then used to calculate the discounted economic value by multiplying the economic value by the cumulative discounted expression (Brascamp, 1978) to and then a linear selection index, which predicts the breeding goal as accurately as possible, given the information that is available in the form of EBV for individual traits:

$$I=b_1EBV_1+b_2EBV_2+\ldots+b_iEBV_{iI=b1EBV1+b2EBV2+\ldots+biEBVi}$$

where EBV_i is the estimated breeding value for trait *i*; and b_i is the index weight on EBV_i.

The MTINDEX program (Van Der Werf, 1999) was used to estimate the indices weight. The gene flow

Table II. Component characteristics of income and expense that affect the profit of dairy cattle breeding systems (Características dos componentes de receitas e despesas que afetam o lucro do sistema de criação de gado leiteiro).

	Source of income and expenses	Characteristics
Income	Milk:	Quantity of milk, Fat and protein in milk, persistency of lactation, somatic cell count, total bacterial count, weight, calving interval, age at first calving, mortality and food consumption.
	Rearing and reproduction in females:	Mortality, age at first calving, weight and feed intake.
	Pregnant females:	Mortality, weight and feed intake.
Expenses	Nutrition:	Amount of milk, persistency of lactation, calving interval, age at first calving, mortality, feed intake and weight.
	Housing:	Amount of milk, persistency of lactation, calving interval, age at first calving, mortality, feed intake and weight.
	Labor:	Amount of milk, persistency of lactation, calving interval, age at first calving, mortality, food consumption and weight.
	Health:	Forming colonies unit, somatic cell count, total bacterial count and weight.
	Marketing	Amount of milk, persistency of lactation, milk fat, milk protein, somatic cell count, total bacterial count, weight, calving interval, age at first calving, mortality and feed intake.

discounted was given by GFLOW program (Brascamp, 1975; Hill, 1974).

RESULTS

The high production system (cluster 1) had higher production ($p<0.10$) than the medium-high production system (cluster 2) as expected. Economically, it also has higher income from the sale of milk (ISM) and the total income of dairy activity (TIDF), which resulted in higher gross margin (GM) for the high production system **(table I)**.

Table III shows the annual economic indices for clusters 1 and 2, equalized to a 100-cow farm. High cluster had 22% higher annual income (sale of milk and animals) than the medium cluster. At the same time, the operating cost for production increased in smaller proportions (10%) determining higher gross margin (GM) (43%) and increased profitability (15%) compared to the medium cluster.

Table IV shows a similar distribution of actual operating costs (AOC), between the two production systems, and the higher cost is due to the animal feed (concentrate and roughage), with 75% of operating cost, for both high and medium clusters.

The second largest cost is due to the payment of labor, with an average of 12% of the operating cost. Cow and heifer weight were less expressive, because the focus of this activity is on income coming from milk production. Likewise, mortality had a low economic value, being within acceptable parameters and does not significantly influence the producer profit.

The economic values calculated for the traits studied and the scenarios I, II and III are shown in **figure 2**. Scenario I shows payment by the companies that do not consider milk quality (set out in White Paper 62 - Brazil, 2011), which represents the vast majority in this region. In scenario II, payment was considered taking into consideration bonus or penalty for milk quality using the lower (scenario II) and higher (scenario III) ranges used by a manufacturing company in the region. Considering scenario III, where all traits can contribute to the maximum producer profit, the higher economic values, for a 100-cow farm, were found for FAT (US $ 4,154.63 and US $ 3,397.51), SCC (US $ -3,462.19 and US $ -2,831.26), PROT (US $ -2,077.32 and US $ 1,662.03), AFC (US $ -2,997.40 and US $ -2,451.18), MP (US $ 1,384.87 and US $ 1,132.50), CI (US $ -1,187.03 and US $ -860.22), Intake (US $ -641.20 and US $ 586.82), Weight (US $ 125.26 and 122.81) and MORT (US $ 0.00 and US $ -28.61), for high and medium clusters, respectively. The mean values considering both clusters were FAT: US $ 3,776.07; SCC: US $ -3,146.87; PROT: US $ 1,888.03; AFC: US $ -2,724.29; MP US $ 1,258.69, LP: US $ 1,258.69; CI: US $ -1,023.62; Intake: US $ -614.01, Weight: US $ 124.03 and MORT: US $ -14.30.

The decrease in the diet costs caused an increase in the profit percentage **(table V)** (up to 41% for FAT^{II} in the medium cluster with 50% decrease in diet costs). On the other hand, the increase (+25 and +50%) in the diet costs, would cause a decrease in farm profits (up to 25% in AFC with 50% increase in diet costs).

The selection index (accuracy of 0.865) calculated was

$$I = 18.24*Fat+21.02*Prot+892*MP+0.00*Mor-0.92*Intake+0.00*SCC+5.91*LW-0.29*AFC-0.37*CI-0.04*LP$$

DISCUSSION

The micro-region of Passo Fundo has the highest percentage of herds in agriculture and production within the northwestern mesoregion of Rio Grande do Sul State. It is the second in milk production and first in milk productivity in Brazil.

Observing the performance indexes, the high and medium-high production clusters were considered specialized in milk production due to their production le-

Table III. Annual economic indices (US $) for high and medium production clusters standardized to a 100-cow herd (Índices econômicos anuais (US $) para clusters de alta e média produção padronizados para um rebanho de 100 vacas).

Economic indexes	Clusters		
	High (H)	Medium (M)	(H/M)*100
Income milk sold	138487.86	113250.71	122.28
Income animals sold	13236.25	11195.86	118.22
Total income	151724.12	124446.57	121.91
AOP	87180.24	79429.33	109.75
GM	64543.86	45017.24	143.37
Profitability (%)	42	37	115

AOP: actual operating cost; GM: gross margin.

vels and feed management (Vance *et al*., 2012). Thus, if environmental effects in this microregion are the same, most production differences are based on process management (Giordano *et al*., 2012) and the use of genetic (Vance *et al*., 2012), nutritional (Auldist *et al*., 2013) and herd health (Roelofs *et al*., 2010) technologies.

Economic values were calculated from an economic analysis of on-farm production systems in Southern Brazil. More intensive systems were seen to be more economically profitable in line with other authors (Wolfová *et al*., 2007), since they tend to have more efficient management process (Inchaisria et al., 2010; Giordano *et al*., 2012). In this study, the highest operating cost was due to the animal feed (concentrate and roughage), and the second due to the payment of labor. Similar results for operating costs in dairy farming were found by Wolfová *et al*. (2007). This cost distribution shows that the most productive and economic efficiency of the high cluster is related to better management of production processes. The management of animal welfare (Grandin, 2015), factors that reduce days open (Piccardi *et al*., 2013), nutrition (Haresign, 2013), genetics (Lean *et al*., 2013) and environmental effects on animal stress are crucial to the intensification of the processes as well as increase production and economic efficiency of production systems.

The economic values for the traits of economic selection objectives for the two clusters of milk producers, were similar. However, the magnitude of the economic values in the high cluster were higher due to higher gross margin and profitability.

The selection of traits to meet the economic objectives also depends on the form of payment received. Thus, the economic values in accordance with the milk payment by companies, and in order of economic importance, were considered in the present study. The economic values for milk production were positive, indicating that selection for this trait would imply in economic gain for the producer. These values are consistent with those reported in other studies (Komlósi *et al*., 2010; Prata *et al*., 2015), even though, at the time when these studies were developed, the economic scenarios were different. As in the literature, the results of this study were expected, since there is still greater emphasis on payment by volume of milk produced and not quality.

Lactation persistency also showed positive economic values and, similar to milk production, its selection would result in greater profit to the producer (Shook, 2006; Chen *et al*., 2009). According to Togashi and Lin (2009), under the economic point of view, lactation persistency is the most important characteristic of the lactation curve so selection for this trait is important.

The economic values for age at first calving (AFC) was negative for the two clusters studied, showing that for the producer to increase this profit, selection should be for the early calving animals (Wolfová and Pribyl, 2007). As it is of greater economic magnitude than milk production traits, inclusion of AFC as a criterion for selection of economic objectives in genetic improvement programs for dairy herds is important. With smaller magnitude, calving interval (CI) should also be included in the economic selection objectives. This is justified because animals with lower calving interval and age

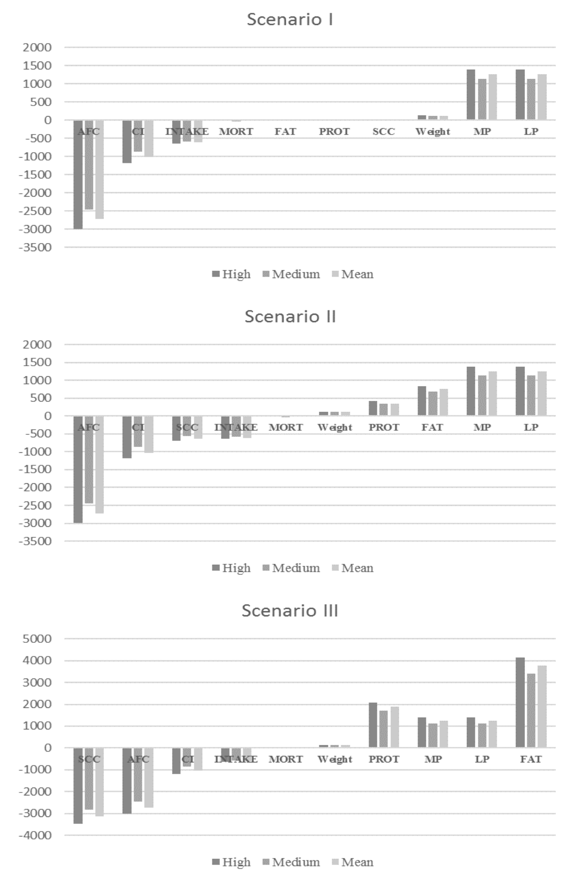

Figure 2. Economic value (US $) for production, fertility, quality, consumption, weight and mortality traits, with the company scenarios that do not bonus/penalize (I), which bonus or penalizes the lower range (II) and the higher range (III), standardized to a 100-cow herd (MP: total milk production; LP: lactation persistency; CI: calving interval; AFC: age at first calving; MORT: mortality; FAT: milk fat; PROT: milk protein and SCC: somatic cell count).

(Valor econômico (US $) para características de produção, de fertilidade, de qualidade, de consumo, de peso e mortalidade, com os cenários das empresas que não bonificam/penalizam (I), que bonificam ou penalizam a faixa inferior (II) e a faixa mais alta (III), padronizado para um rebanho de 100 vacas.

Table IV. Distribution of annual expenses for milk production between the clusters formed and standardized to 100-cow herd (SEBRAE, 2011) (Distribuição das despesas anuais para a produção de leite entre os clusters formados e padronizados para um rebanho de 100 vacas (SEBRAE, 2011)).

Expenses	Cluster				
	High (US $)	%	Medium (US $)	%	(H/M)*100
Concentrate	52569.69	60	48150.06	60	109.18
Roughage	11551.38	13	10532.04	13	109.68
Labor	10592.39	12	9610.95	12	110.21
Medicine	3740.03	4	3359.86	4	111.32
Energy and fuel	2353.86	3	2104.87	3	111.83
Taxes and fees	1691.29	2	1517.09	2	111.48
Semen inseminator	1438.47	2	1294.69	2	111.10
Cleaning supplies	1081.03	1	961.09	1	112.48
Milk transportation	958.98	1	834.00	1	114.98
Out sourced services	636.41	0.7	563.95	0.7	112.85
Powdered milk	575.39	0.6	508.34	0.6	113.19
Total	87180.24	100	79429.33	100	109.76

at first calving are more fertile and therefore more productive (Chen, 2009). The inclusion of these non-yield traits in selection indices has been seen as important factors in farm profits but wide variation exists among countries in traits included in selection indexes and in relative economic weights (Shook, 2006).

At the same time, the negative correlation between these characteristics and milk production should be noted (Seno *et al.*, 2010). There are several studies showing that higher productivity determines lower female fertility, increased metabolic clearance of reproductive hormones (Berg *et al.*, 2010), due to the productive stress (Piccardi *et al.*, 2013) or negative energy balance (Esposito *et al.*, 2014). Lower fertility increases the calving interval, and consequently decreases production. Thus, appropriate management for the reduction of environmental effects that contribute to decreased fertility (López-Gatius, 2012) and the use of technologies for the manipulation of fertility (Herlihy *et al.*, 2013; Hasler, 2014), become essential for the inclusion of these traits in the economic selection objectives.

In scenario II and III, when there was a bonus or penalty for milk quality by the companies, fat was the trait with higher economic value and protein with the lower. Positive values for these were also seen in the Australian indices (Byrne *et al.*, 2016) where protein had a higher value than fat. In our case the economic value for fat was higher than for protein but when taking into account genetic parameters (selection index), the index showed a higher value for protein than fat, in line with other studies. The economic values for these traits, in scenario II and III, were positive, the increase of their production through selection result in an increase in profit (Wolfová and Pribyl, 2007), and for the companies, higher yield of dairy products (*Seno et al*., 2010). This value indicates that the remuneration applied by companies for these components in milk justify and compensate their inclusion in the economic selection objectives. Cardoso *et al.* (2004; 2014) estimated economic values for milk production traits in Brazil, and also saw positive economic values for including protein and fat in selection indices. The values differ from those seen in the present study due to the methodology used for determining payment for different milk components and the inclusion of different traits in the estimation equation. It should also be

Table V. Sensitivity analysis for percentage change in profit for production, functional and fertility traits depending on cost of diet components (Análise de sensibilidade de variação percentual no lucro para características de produção, funcionais e de fertilidade, dependendo do custo dos componentes da dieta).

Diet variation costs (%)	Cluster	Traits												
		MP	LP	CI	AFC	Weight	Intake	MORT	FAT[I]	PROT[I]	SCC[I]	FAT[II]	PROT[II]	SCC[II]
-50	High	21	21	21	20	21	21	21	21	21	21	22	22	20
	Medium	24	24	23	23	24	24	24	40	40	40	41	42	39
-25	High	11	11	10	10	11	10	11	11	11	10	12	11	9
	Medium	12	12	11	11	12	12	12	28	28	28	28	29	27
0	High	0.5	0.5	-0.4	-1	0.05	-0.4	0.00	0.3	0.2	-0.2	2	0.78	-1
	Medium	0.5	0.5	-0.5	-1	0.06	-0.4	-0.01	0.3	0.2	-0.3	2	0.86	-1
25	High	-10	-10	-11	-12	-11	-11	-11	-10	-10	-11	-9	-10	-12
	Medium	-11	-11	-12	-13	-12	-12	-12	5	5	4	6	5	3
50	High	-19	-19	-20	-21	-19	-19	-19	-21	-21	-21	-19	-20	-23
	Medium	-23	-23	-24	-25	-23	-24	-24	-7	-7	7	-5	-6	-9

MP: total milk production; LP: duration of lactation; CI: calving interval; AFC: age at first calving; MORT: mortality; FAT: milk fat; PROT: milk protein and SCC: somatic cell count; I: company which grants or penalizes the lower range; II: company which grants or penalizes the higher range.

noted that these studies did not calculate the selection index.

The largest economic impact was seen in milk quality traits and disease resistance, followed by precocity and CI, MP, LP and INTAKE. Therefore, the criteria to be considered in the selection objectives result in animals producing milk of better quality, more disease resistant, more fertile and therefore more productive.

Increased somatic cell count had a negative economic value, and fat and protein have an intermediate economic value. These values reflect the need to include these traits in a breeding program when the company practices the rules outlined in White paper 62. However, the interpretation is different, because the increase in SCC gives a negative economic value, which leads the companies to penalize farmers that supply milk with high SCC. Their increase in milk reflected in lower yield in manufactured dairy products and lower shelf life of these products (Murphy *et al*., 2016). Another relevant aspect regarding SCC is related to public health issues, because, according to Kunda *et al*. (2016) as SCC increases the likelihood of antibiotic residues in milk being found also increases. Cardoso *et al*. (2014) did not calculate an economic value for SCC due to discrepancies in payment policies for this trait.

According to Murphy *et al*. (2016), the SCC increase also causes decrease in milk production and its components, which could contribute to the reduction of the annual profit of the herd. Clinical and subclinical mastitis are related to increased production of SCC in milk (Koeck *et al*., 2012) and are also causes of involuntary culling of dairy cows (Roelofs *et al*., 2010) thereby affecting other traits measured in the indices. The study of the inclusion of SCC as a selection criterion to reduce mastitis would be interesting, because as this trait is an indicator of health of the mammary gland (Koeck *et al*., 2012; Urioste *et al*., 2012), the producer would have the herd monitored for this problem.

For producers who sell milk to companies that practice payment with bonus or penalty for milk quality, greater attention should be paid to the correct definition of the criteria in the selection objectives in genetic improvement programs, such as with the construction of an index of selection, these criteria would lead to higher profits to the producer.

For the feed intake, the economic value was significant because of the high cost to feed the animals, which are responsible for an average of 74% of effective operating cost. Selecting animals with better feed efficiency and the proper nutrition management, to reduce costs of diet components and their waste, causes reduction of costs, and consequently, increased income to the producer (Roibas and Alvarez, 2010).

The live weight of cows and heifers had a low value due to the focus of this activity on milk production (greater revenue coming from the milk). Mortality had low and negative economic value, but was within acceptable parameters, so this variable did not influence the profit of the producer.

To better understand the economic impact of genetic breeding, changes of ± 25 and ± 50% in the price of the diet ingredients and the consequent changes in the profitability of the systems were studied (Cunningham and Tauebert, 2009). The results show that profit and consequently the economic values, are sensitive to price changes of the diet and, thus, other production costs. They also show that producers must not only to focus on breeding animals for greater profit, but also with environmental factors (Crane *et al*., 2011; Fuhrer *et al*., 2013), management (Giordano *et al*., 2012; Atzori *et al*., 2013; Gerdessen and Pascucci, 2013) and technologies (Thatcher *et al*., 2011), which can interfere with production costs and profit. This analysis provides an important contribution, as when cattle feeding management processes are not suitable the economic values increase or decrease significantly, as shown in **table V**. However, no effect could be observed on the order of importance of the trait for use in breeding programs, but in quantitative values.

The economic values should be calculated based on future prices, since breeding is oriented with a view to the future. As these are not yet known, the use of sensitivity analyses seen here are useful to determine the flexibility of the selection index with price fluctuation. The consequences of the decisions taken in the present will be observed only when the offspring express their productive potential. One of the advantages of using bioeconomic models is the ability to easily assess the impact of the scenario changes in the trait´s economic values, and recalculate these values.

MP was by far the most important trait in the selection index as little emphasis is given in Brazil to milk quality traits. Intake, AFC, CI and LP all showed negative weights as seen in other species in Brazil (Lopes *et al*., 2012). Other production traits in dairy farming related to conformation, longevity, calving ease and growth, among others, could also be included as criteria for selection objectives in breeding programs in this region (Shook, 2006). Lack of information, sufficient data to judge the impacts of different alternatives for selection in animal breeding and their effect on the profitability of production systems as well as the the influence of intangible benefits of different traits (Kosgey *et al*., 2004) cause them to be ignored or forgotten during the selection process. Herd management must compensate for antagonistic effects and balance selection for production while maintaining fertility, udder health and resistance to metabolic diseases to maximize profit without compromising welfare (Egger-Danner *et al*., 2015) and should be taken into account during the selection process. As these authors show, the number of traits that may be included is huge and extensive research is needed on how to extensively phenotype animals at low cost as well as include genomic data in selection indices as this becomes available.

CONCLUSION

The economic values calculated for the characteristics related to volume of milk, fertility, milk quality, disease resistance, feed intake and mortality used in breeding programs resulted in increased profitability for milk production traits (milk yield and persistency of lactation) and weight for any scenario (I, II and III);

increased profitability for milk quality characteristics (milk fat and protein) for scenario II and III (the dairy subsidy) and decreased in profitability for fertility traits (age at first calving and calving interval), consumption and mortality for scenarios I, II and III, and for characteristic related to the milk quality (somatic cell count) in scenarios II and III.

BIBLIOGRAPHY

Andrade, L.M.; El Faro, L.; Cardoso, V.L.; Albuquerque, L.G.; Cassoli, L.D. and Machado, P.F. 2007. Efeitos genéticos e de ambiente sobre a produção de leite e a contagem de células somáticas em vacas holandesas. *Rev Bras Zootecn*, 36: 343-34.

Atzori, A.Z.; Tedeschi, L.O. and Cannas, A. 2013. A multivariate and stochastic approach to identify key variables to rank dairy farms on profitability. *J Dairy Sci*, 96: 3378-3387.

Auldist, M.J.; Marret, L.C.; Creenwood, J.S.; Hannah, M.; Jacobs, J.L. and Wales, W.J. 2013. Effects of different strategies for feeding supplements on milk production responses in cows grazing a restricted pasture allowance. *J Dairy Sci*, 96:1218-1231.

Baruselli, P.S.; Sales, J.N.S.; Sala, R.V.; Vieira, L.M. and Sá Filho, M.F. 2012. History, evolution and perspectives of timed artificial insemination programs in Brazil. *Anim Reprod*, 9:139-152.

Berg, D.K.; Van Leeuwen, J.; Beaumont, S.; Berg, M. and Pfeffer, P.L. 2010. Embryos loss in cattle between days 7 and 16 of pregnancy. *Theriogenology*, 73:250-260.

Brascamp, E.W. 1975. Model calculations concerning economic optimization of A.I. breeding with cattle. The economic value of genetic improvement in milk yield. Doctoral Thesis. Centre for Agricultural Publication and Documentation. 846 pp.

Brascamp, E.W. 1978. Methods on economic optimization of animal breeding plans. Report B-134. Research Institute for animal Husbandry "Schoonoord". Zeit.

Byrne, T.J.; Santos, B.F.S.; Amer, P.R.; Martin-Collado, D.; Pryce, J.E.; Axford, M. 2016. New breeding objectives and selection indexes for the Australian dairy industry. *J Dairy Sci,* 99: 8146-8168.

Campos, R.V.; Cobuci, J.A.; Kern, E.L.; Costa, C.N. and McManus, C.M. 2015. Genetic parameters for linear type traits and milk, fat, and protein production in holstein cows in Brazil. *Asian-Australas J Anim Sci,* 28:476-484.

Cardoso, V.L.; Nogueira, J.R.; Vercesi Filho, A.E.; El Faro, L. and Lima, N.C. 2004. Breeding goals and economic values for pasture based milk production systems in the Southeast region of Brazil. *Rev Bras Zootecn,* 33: 320-327.

Cardoso, V.L.; Lima, M.L.P.; Nogueira, J.R.; Carneiro, R.L.R.; Sesana, R.C.; Oliveira, E.J. and El Faro, L. 2014. Economic values for milk production and quality traits in south and southeast regions of Brazil. *Rev Bras Zootecn*, 43: 636-642.

Chen, J.; Wang, Y.; Zhang, Y.; Sun, D. and Zhang, Y. 2009. Estimation of economic values of production and functional traits in Chinese Holstein. *J Anim Vet Adv*, 8: 2125-2132.

Cobuci J.A. and Costa, C.N. 2012. Persistency of lactation using random regression models and different fixed regression modeling approaches. *Rev Bras Zootecn*, 41: 1996-2004.

Crane, T.A.; Roncoli, C. and Hoogenboom, G. 2011. Adaptation to climate change and climate variability: The importance of understanding agriculture as performance. *J Life Sci, 57*: 179-185.

Cunningham, E.P. and Tauebert, H. 2009. Measuring the effect of change in selection indices. *J Dairy Sci,* 92: 6192-6196.

Egger-Danner, C.; Cole, J.B.; Pryce, J.E.; Gengler, N.; Heringstad, B.; Bradley, A. and Stock, K.F. 2015. Invited review: overview of new traits and phenotyping strategies in dairy cattle with a focus on functional traits. *Animal,* 9: 191-207.

Esposito, G.; Irons, P.C.; Webb, E.C. and Chapwanya, A. 2014. Interactions between negative energy balance, metabolic diseases, uterine health and immune response in transition dairy cows. *Anim Reprod Sci*, 144: 60-71.

FAO (Food and Agriculture Organization). 2010. FAO Homepage. http://www.fao.org (16/06/2012).

Fuhrer, J.; Smith, P. and Gobiert, A. 2013. Implications of climate change scenarios for agriculture in alpine regions - A case study in the Swiss Rhone catchment. *Sci Total Environ*, 493: 1232-1241.

Gerdessen, J.C. and Pascucci, S. 2013. Data envelopment analysis of sustainability indicators of European agricultural systems at regional level. *Agr Syst*, 118: 78-90.

Giordano, J.O.; Kalantari, A.S.; Fricke, P.M.; Wiltbank, M.C. and Cabrera, V.E. 2012. A daily herd Markov-chain model to study the reproductive and economic impact of reproductive programs combining timed artificial insemination and estrus detection. *J Dairy Sci*, 95: 5442-5460.

Grandin, T. 2015. Improving animal welfare: a practical approach. CAB International of North America. 376 pp.

Hasler, J.F. 2014. Forty years of embryo transfer in cattle: A review focusing on the jounal Theriogenology, the growth of the industry in North America, and personal reminisces. *Theriogenology*, 81: 152-169.

Hazel, L.N. and Lush, J.L. 1943. The efficiency of three methods of selection. *J Hered*, 33: 393-399.

Haresign, W. 2013. Recent Advances in Animal Nutrition - 1983: Studies in the Agricultural and Food Sciences. Butterworth-Heinemann.

Herlihy, M.M.; Crowe, M.A.; Berry, D.P.; Diskin, M.G. and Butler, S.T. 2013. Factors associated with fertility outcomes in cows treated with protocols to synchronize estrus and ovulation in seasonal-calving, pasture-based dairy production systems. *J Dairy Sci*, 96: 1485-1498.

Hill, W.G. 1974. Prediction and evaluation of response to selection with overlapping generations *Anim Prod*, 18: 117-139.

Inchaisria, C.; Jorritsma, R.; Vos, P.L.; van der Weijdena, G.C. and Hogeveen, H. 2010. Economic consequences of reproductive performance in dairy cattle. *Theriogenology*, 74: 835-846.

Koeck, A.; Miglior, F.; Kelton, D.F. and Schenkel, F.S. 2012. Alternative somatic cell count traits to improve mastitis resistance in Canadian Holsteins. *J Dairy Sci*, 95:432-439.

Komlósi, L.; Wolfová, M.; Wolf, J.; Farkas, B.; Szendrei, Z. and Béri, B. 2010. Economic weights of production and functional traits for Holstein-Friesian cattle in Hungary. *J Anim Breed Genet*, 127:143-153.

Kunda, B.; Pandey, G.S. and Muma, J.B. 2016. Somatic cell count and antibiotic residues in raw milk produced by smallholder dairy farmers in Lusaka province of Zambia. *Asian J Multidiscip Stud*, 4: 36-40.

Kosgey, I.S; Van Arendonk, J.A.M.and Baker, R.L. 2004. Economic values for traits in breeding objectives for sheep in the tropics: impact of tangible and intangible benefits. *Livest Prod Sci*, 88: 143-146.

Lean, I.J.; Westwood, C.T.; Golder, H.M. and Vermunt, J.J. 2013. Impact of nutrition on lameness and claw health in cattle. *Livest Sci*, 156: 71-78.

Lopes, F.B.; Borjas, A.R.; Silva, M.C.; Facó, O.; Lôbo, R.N.B.; Fioravanti, M.C.S. and McManus, C. 2012. Breeding goals and selection criteria for intensive and semi-intensive dairy goat system in Brazil. *Small Rumin Res*, 106: 110-117.

López-Gatius, F. 2012. Factors of a noninfectious nature affecting fertility after artificial insemination in lactating dairy cows. A review. *Theriogenology*, 77: 1029-1041.

McManus, C.; Pinto, B.F.; Martins, R.F.S.; Louvandini, H.; Paiva, S.R.; Braccini Neto, J. and Paim, T.P. 2011. Selection objectives and criteria for sheep in Central Brazil. *Rev Bras Zootecn*, 40: 2713-2720.

Murphy, S.C.; Martin, N.H.; Barbano, D.M. and Wiedmann, M. 2016. Influence of raw milk quality on processed dairy products: How do raw milk quality test results relate to product quality and yield? *J Dairy Sci*, 99: 10128-10149.

Petrini, J.; Iung, L.H.; Rodriguez, M.A.; Salvian, M.; Pértille, F.; Rovadoschi, G.A.; Cassoli, L.D.; Coutinho, L.L.; Machado, P.F.; Wiggans, G.R. and Mourão, G.B. 2016. Genetic parameters for milk fatty acids, milk yield and quality traits of a Holstein cattle population reared under tropical conditions *J Anim Breed Genet*, 133: 384-95.

Piccardi, M.; Funes, A.C.; Balzarini, M. and Bó, G.A. 2013. Some factors affecting the number of days open in Argentinean dairy herds. *Theriogenology*, 79: 760-765.

Ponzoni, R.W. and Newman, S. 1989. Developing breeding objectives for Australian beef cattle production. *Anim Prod*, 49: 35-47.

Prata, M.A.; Faro, L.E.; Moreira, H.L.; Verneque, R.S.; Vercesi Filho, A.E.; Peixoto, M.G.C.D. and Cardoso, V.L. 2015. Genetic parameters for milk production traits and breeding goals for Gir dairy cattle in Brazil. *Genet Mol Res*, 14: 12585-12594.

Pritchard, T.; Coffey, M.; Mrode, R. and Wall, E. 2013. Genetic parameters for production, health, fertility and longevity traits in dairy cows. *Animal*, 7: 34-46.

Roelofs, J.; López-Gatius, F.; Hunter, R.H.; Van Eerdenburg, F.J. and Hanzen, C.H. 2010. When is a cow in estrus? Clinical and practical aspects. *Theriogenology*, 74: 327-344.

Roibas, D. and Alvarez, A. 2010. Impact of genetic progress on the profits of dairy farmers. *J Dairy Sci*, 93: 4366-4373.

Seno, L.O.; Cardoso, V.L.; El Faro, L.; Sesana, R.C.; Aspilcueta-Borquis, R.R.; Camargo, G.M.F. and Tonhati, H. 2010. Genetic parameters for milk yield, age at first calving and interval between first and second calving in milk Murrah buffaloes. *Livest Res Rural Dev,* 22. http://www.lrrd.org/lrrd22/2/seno22038.htm (20/06/2015).

Shook, G.E. 2006. Major advances in determining appropriate selection goals. *J Dairy Sci,* 89: 1349-1361.

Thatcher, W.; Santos, J.E. and Staples, C.R. 2011. Dietary manipulations to improve embryonic survival in cattle. *Theriogenology*, 76: 1619-1631.

Thomasen, J.R.; Egger-Danner, C.; Willian, A.; Guldbrandtsen, B.; Lund, M.S. and Sorensen. A.C. 2014. Genomic selection strategies in a small dairy cattle population evaluated for genetic gain and profit. *J Dairy Sci*, 97: 458-470.

Togashi, K. and Lin, C.Y. 2009. Economic weights for genetic improvement of lactation persistency and milk yield. *J Dairy Sci*, 92: 2915-2921.

Urioste, J.L.; Franzén, J.; Windig, J.J. and Strandberg, E. 2012. Genetic relationships among mastitis and alternative somatic cell count traits in the lactations of Swedish Holsteins. *J Dairy Sci*, 95: 3428-3434.

Vance, E.R.; Ferris, C.P.; Elliott, C.T.; McGettrick, S.A. and Kilpatrick, D.J. 2012. Food intake, milk production, and tissue changes of Holstein-Friesian and Jersey × Holstein-Friesian dairy cows within a medium-input grazing system and a high-input total confinement system. *J Dairy Sci*, 95: 1527-1544.

Van Der Werf, J. 1999. Software MTINDEX – Multiple Trait Selection Index 20Trait Version. The University of New England. Armidale. Australia.

Usman, T.; Qureshi, M.S.; Yu, Y. and Wang, Y. 2013. Influence of various environmental factors on dairy productionand adaptability of Holstein cattle maintained under tropical and subtropical conditions. *Adv Environ Biol*, 7: 366-372.

Wolfová, M. and Pribyl, J. 2007. Impact of milk pricing system on the economic response to selection on milk components. *J Anim Breed Genet*. 124: 192-200.

Wolfová, M.; Wolf, J.; Kvapilík, J. and Kica, J. 2007. Selection for profit in cattle: I. economic weights for purebred dairy in the Czech Republic. *J Dairy Sci*, 90: 2442-2455.