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Responses to selection for milk traits in dairy buffaloes

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ABSTRACT. The aim of the present study was to estimate the index and individual responses to selection for milk (MY), fat (FY) and protein (PY) yields for different breeding goals for two commercial buffalo milk production systems in São Paulo State characterized by: 1) all milk produced is sold to the industry (MILK) and 2) all milk produced is used in the mozzarella cheese-making process at the farm (MOZZARELLA). The current payment policy is based exclusively on milk volume. The mozzarella price refers to the wholesale selling price. Index responses to selection (IR) were calculated for three different breeding goals (BG): 1) MY exclusively (BG_1); 2) FY + PY (BG_2) and 3) MY + FY + PY (BG_3). IR for the MILK system were US$41.79 ($BG_1$), US$5.91 (BG_2) and US$38.22 ($BG_3$). For the MOZZARELLA system, IR were US$179.50 ($BG_1$), US$262.85 (BG_2) and US$402.41 ($BG_3$). The results suggest that for the present circumstances, selection for milk components is not advantageous when milk is produced for sale to the industry. However, when mozzarella making is added to the system, the selection for components and milk volume is the most economically beneficial.

Key words: Buffaloes, Production systems, Responses to selection, Milk, Mozzarella

INTRODUCTION

Borghese and Mazzi (2005) presented a comprehensive review on the Buffalo populations and production systems in the world. According to these authors, Brazil has the largest buffalo herd size in South America, followed by Venezuela, Argentina and Colombia. Buffaloes were imported into Brazil between 1940s and 1960s, where the ideal conditions such as thriving pastures, water, grazing space, and suitable temperatures were available. In the 1970s Brazilian buffalo breeders began to use these animals for dairy and meat production. Sixty-four percent of the Brazilian buffalo herd are found in the Northern region, while the Southern region has the second largest herd (13%). The Southeastern region, where buffalo milk production is quite relevant, has only 9% of the herd (ANUALPEC, 2005). Its importance results from the significant increase of market demands for quality cheese, made from buffalo milk, especially, mozzarella. Both the production and quality of mozzarella cheese depend greatly on milk composition. However, the absence of quality payment policies, in addition to the lack of breeding policies may have had a negative impact on milk composition traits of dairy buffalo herds.

The literature shows that the implementation of selection indexes was an important step in the evolution of the dairy industry in developed countries (Wilmink, 1988; Harris, 1998). In Brazil, Madalena (2000) compared two different situations of milk payment policies in different states of Brazil, Minas Gerais, in the Southeastern region (no payment for composition) and Paraná, in the Southern region (additional payment according to fat and protein content). Results showed that the selection for fat and protein would be economically advantageous in the situation of Paraná State. Groen (1990) and Pieters et al. (1997) discussed the importance of taking production circumstances into account when calculating economic values and expected responses to selection.

The aim of the present study was to estimate individual and index responses to selection for milk production traits (milk, fat and protein yields) for different breeding goals, in two buffalo milk production systems in São Paulo State.

MATERIAL AND METHODS

Using a bio-economic model, two buffalo commercial milk production systems were described in terms of performance, revenues and costs, based on the performance results reported by Faria (1997) for Murrah and crossbred animals in São Paulo State, Southern part of Brazil. The farm is located at 22º06'00''S and 30º06'30''W, at an altitude of 706 m. In both systems, lactating animals were kept under a grazing system with *Brachiaria decumbens*, receiving commercial concentrate for lactating cows (with 20% crude protein and 72.3% of TDN), in the proportion of 1 kg concentrate: 3 kg milk produced and mineral salt *ad libtum*. A mixture of sugar cane plus urea was also provided during the dry season (May-October). Cows were milked twice a day, with a milking machine and with the presence of calves for milk let down. Average milk production level of buffalo cows was 1,200 kg, in 270 days of lactation. Average age at first calving was 36 months and live weight were, respectively, 575, 615 and 650 kg for 1st, 2nd and 3rd or more lactation buffalo cows. Total annual milk production was calculated based on the calving distribution along the year, considering the monthly number of cows in milk, according to the lactation stage and calving order.

For the calculations of feed costs, energy requirements for maintenance, growth (heifers) and lactation (milk (MY), fat (FY) and protein yields (PY)) were estimated. These calculations were based on the results obtained for dairy buffaloes by Zicarelli (2001). Details on the bio-economic model were described by Seno (2005).

The two milk production systems considered were: 1) all milk sold to the industry (MILK); 2) all milk used in the mozzarella, a cheese-making process at the farm (MOZZARELLA).

The amount of mozzarella cheese produced was estimated based on the formula of Altiero et al. (1989).

The current payment policy is based exclusively on milk volume. The mozzarella price refers to the wholesale selling price. Milk and mozzarella prices were US$0.30/kg and US$5.90/kg, respectively. Exchange rate at the time of calculations: US$1.00:R$2.70.

Economic values (Table 1) were calculated for MY, FY and PY (Seno, 2005), taking into account the differences of the two production systems. For the calculation of economic values, revenues and costs refer exclusively to the milk production process. Therefore, costs related to the raising of replacement heifers were ignored. The prices of production components and products were obtained from economical reports. Costs associated to mozzarella cheese production were, packing (variable cost), labor, storage, depreciation, and maintenance of equipment (fixed costs). This information was provided by a dairy buffalo farmer who produces mozzarella cheese at the farm.

Table 1. Economic values (EV), expressed in US$ for milk (MY), fat (FY) and protein (PY) yields for MILK and MOZZARELLA systems.

System	EV_{MY}	EV_{FY}	EV_{PY}
MILK	0.26	-0.27	-0.30
MOZZARELLA	1.12	6.90	20.14

Source: Seno (2005).

Expected responses were calculated for three different breeding goals (BG):

1) MY exclusively (BG_1)
2) FY + PY (BG_2)
3) MY + FY + PY (BG_3)

Index responses to selection were calculated based on the selection index theory (Hazel, 1943), according to Brascamp et al. (1995). Solutions for weighting factors (b) were calculated as $\mathbf{b} = \text{var}(\mathbf{X})^{-1} \text{cov}(\mathbf{X},\mathbf{A})$. **X** is a vector with the information sources, var(**X**) is a matrix with (co)variances between these sources and cov(**X**,**A**) is a vector of covariances between each information source and the true genotype. The index equations are then $\mathbf{Pb} = \mathbf{Gv}$ or $\mathbf{b} = \mathbf{P}^{-1}\mathbf{Gv}$. **P** is used to describe the matrix with variances and covariances between the information sources in **X**. It is a variance-covariance matrix between the means of phenotypic observations. **G** is the matrix with covariances between **X** and **A**. Finally, **v** is a vector with economic values of traits in the breeding goal. After calculating the b values, the index (σ^2_I) and breeding goal (σ^2_H) variances were obtained from: σ^2_I = **b'Pb** and σ^2_H = **v'Cv**, where **C** = matrix of (co)variances for traits in the breeding goal. Index responses were then obtained from R = i * σ_I = i *r_{IH} * σ_H, where i is the selection intensity, σ_I is the standard deviation of the index, r_{IH} is the correlation between the index and the breeding goal and σ_H is the standard deviation of the breeding goal. The correlation between the index and the breeding goal (r_{IH}) was given by σ_I/σ_H.

The availability of performance information was assumed for on the three traits in all breeding goals. Individual responses to selection were also calculated for the studied traits. Genetic and phenotypic parameters of traits used in response calculations are presented in Table 2 (Duarte, 2002). Only the sire-dam selection path was considered, with an average progeny size of 25 daughters per sire. Selection intensity was equal to one.

Table 2. Standard deviations (**σ_P**), heritabilities (bold), genetic (above diagonal), and phenotypic correlation coefficients (below diagonal) for milk (MY), fat (FY) and protein (PY) yields.

	σ_P	MY	FY	PY
MY	452.84	**0.21**	0.66	0.63
FY	31.12	0.73	**0.24**	0.88
PP	20.16	0.68	0.93	**0.31**

Source: Duarte (2002).

Relative selection efficiencies (RSE) were expressed as a percentage of the expected responses to selection obtained for BG_1, as follows:

$RSE_2 = (BG_2/BG_1)*100$, and
$RSE_3 = (BG_3/BG_1)*100$.

RESULTS AND DISCUSSION

The weighting factors for MY, FY and PY, standard deviations of indexes and of breeding goals, correlations between selection indexes and breeding goals, according to the breeding goal, are presented in Table 3, for the two systems.

In general, the weighting factors of traits showed magnitude and signals that were in agreement with the breeding goals and economic values of traits in the breeding goals. The selection indexes, calculated for the two studied production systems and different breeding goals are presented in Table 4. X_M, X_F and X_P refer to the average performance of sires' daughters for MY, FY and PY, expressed as deviations from the average performance of all females. X_F and X_P were standardized for the b value obtained for MY.

The index and individual responses to selection, calculated for each breeding goal in the two systems (MILK and MOZZARELLA), are presented in Table 5.

Regarding the MILK system, the greatest economic response to the index was observed for BG_1 (US$41.79), where the only trait in the breeding goal was MY, while the lowest

Table 3. Weighting factors (b) for milk (MY), fat (FY) and protein (PY) yields, standard deviations of indexes (σ_I) and of breeding goals (σ_H), correlations between selection indexes and breeding goals (r_{IH}), according to the breeding goal (BG), for the two systems.

System	BG*	(b)			σ_I	σ_H	r_{IH}
		MY	FY	PY			
MILK	1	0.83	-2.41	-3.62	41.79	54.58	0.7657
	2	0.01	-0.64	-1.62	5.91	7.36	0.8033
	3	0.84	-3.05	-2.00	38.22	49.97	0.7649
MOZZARELLA	1	3.56	-10.37	15.56	179.50	234.42	0.76571
	2	-0.38	7.49	99.22	262.85	322.70	0.81454
	3	3.17	-2.88	114.80	402.41	508.40	0.79153

*BG: 1 = MY; 2 = FY + PY; 3 = MY + FY + PY.

Table 4. Selection indexes standardized for the b value obtained for MY, for the two production systems (MILK and MOZZARELLA) and different breeding goals (BG).

Production system/BG	Index	b value (MY)
MILK		
BG_1	$1.00 (X_M) - 2.90 (X_F) - 4.36 (X_P)$	0.83
BG_2	$1.00 (X_M) - 64.00 (X_F) - 162.00 (X_P)$	0.01
BG_3	$1.00 (X_M) - 3.63 (X_F) - 2.38 (X_P)$	0.84
MOZZARELLA		
BG_1	$1.00 (X_M) - 2.91 (X_F) + 4.37 (X_P)$	3.56
BG_2	$1.00 (X_M) - 19.71 (X_F) - 261.11 (X_P)$	-0.38
BG_3	$1.00 (X_M) - 0.91 (X_F) + 36.21 (X_P)$	3.17

Table 5. Individual[#] and expected index responses to selection for MILK and MOZZARELLA systems.

Systems	BG*	Individual response (g)			Index response (US$)
		MY	FY	PY	
MILK	1	158.90	-	-	41.79
	2	-	-11.65	-8.95	5.91
	3	157.80	6.48	4.94	38.22
MOZZARELLA	1	158.90	-	-	179.50
	2	-	11.19	9.21	262.85
	3	137.60	10.69	8.70	402.41

[#]For milk (MY), fat (FY) and protein (PY) yields.
*Breeding goal (BG): 1 = MY; 2 = FY + PY; 3 = MY + FY + PY.

index response was observed for BG_2 (US$5.91), with negative responses for FY and PY in this case. This was expected, taking into account the current milk payment policy with no differential payment for components. The expected index response for BG_3 (US$38.22) was close to that obtained for BG_1. The relative efficiencies of selection were 14% (BG_2) and 91% (BG_3), respectively, indicating that the selection exclusively on MY (BG_1) would be the most efficient in this case. These results suggest that under the current payment policy, it is not desirable to improve fat and protein yield, given that the revenues are based exclusively on milk sale.

The expected index responses in the MOZZARELLA system were US$179.50 ($BG_1$), US$262.85 (BG_2) and US$402.41 ($BG_3$). The individual responses to selection for FY and PY were positive and similar for BG_2 and BG_3, although the index response for BG_3 was approximately 53% higher than BG_2. The relative efficiency of selection for BG_2 and BG_3, was 146 and 224%, respectively, indicating that selection based exclusively on MY as usually done would not be the most efficient.

In spite of the economic importance of milk components in the production of mozzarella cheese, the results showed that the greatest response was observed when the breeding goal also included the milk yield. It was also observed that the lowest response was obtained when selection was based exclusively on MY. The results also suggest that the additional payment for fat and protein could benefit not only milk producers, but also the industry.

Comparing the individual responses to selection for FY and PY obtained for the MILK and MOZZARELLA systems, if selection were based on these two traits (BG_2), it is observed that in the first case, negative responses were obtained, because of negative economic values. In the second case, the incorporation of the mozzarella-making process on the farm level resulted in positive economic values, and consequently in positive individual responses for these traits. Looking now at the individual responses obtained for BG_3, it is observed that the individual response to selection for MY obtained for the MILK system was superior to the response obtained for the MOZZARELLA system, while the individual responses for FY and PY were around 65 and 76%, respectively, superior for the latter.

The differences in both index and individual responses for milk production traits between the two production systems (MILK and MOZZARELLA) show the importance of implementing appropriate selection indexes for buffalo dairy herds taking into account the local production and market circumstances, with special reference to regions where the mozzarella cheese represents the main product of the buffalo dairy activity.

CONCLUSIONS

The results obtained in the present study suggest that for the present payment policy, selection for milk components is not advantageous when milk is produced for sale to the industry. However, when the manufacturing of mozzarella cheese is adopted and an add-value policy is incorporated to the production system, selection for components and milk volume is the most economically beneficial.

The differences in both index and individual responses for milk production traits between the two production systems (MILK and MOZZARELLA) suggest that it is necessary to take into account the local production and market circumstances, when designing breeding programs for buffalo milk production systems in Brazil.

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