Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v41i1.43361





# Breeding goals and economic values for Nellore cattle in a full-cycle production system

**Heverton Luis Moreira[1], Rodrigo Pelicioni Savegnago[2], Luara Afonso de Freitas[1], Raysildo Barbosa Lôbo[1,3], Luiz Antonio Framartino Bezerra[1] and Claudia Cristina Paro de Paz[1,2*]**

[1]Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto, Departamento de Genética, Avenida Bandeirantes, 3900, 14049-900, Ribeirão Preto, São Paulo, Brazil. [2]Instituto de Zootecnia, Centro Avançado de Pesquisa de Bovinos de Corte, Rodovia Carlos Tonani, Km94. Cx. Postal 63, 14174-000, Sertãozinho, São Paulo, Brazil. [3]Associação Nacional de Criadores e Pesquisadores, Rua João Godoy, 463, 14020-230, Ribeirão Preto, São Paulo, Brazil. *Author for correspondence. E-mail: claudiapaz@iz.sp.gov.br

**ABSTRACT.** The objective of this study was to develop a bio-economic model for the estimation of economic values of economically important traits in a full-cycle beef cattle production system. The bio-economic model calculated economic values by simulating the impact of changes in the profit of the system consisting of a 1% increase in each trait of the breeding objective, while the other traits were kept constant. The bio-economic model was effective in estimating the sources of revenues and expenses of the production system. The estimated economic values were, in the order of importance for the full-cycle system, R$ 3.69 for male slaughter weight, R$ 3.63 for male weaning weight, R$ 3.58 for weaning rate, R$ 3.40 for female slaughter weight, R$ 2.30 for female weaning weight, and R$ 0.13 for mature cow weight. The results showed that all traits evaluated in the full-cycle system had positive economic impact, indicating that selection would increase profitability maximizing the expected response for the traits of the breeding goal.

**Keywords**: bio-economic model; economic weights; genetic selection; productive traits.

Received on June 19, 2018.
Accepted on September 5, 2018.

## Introduction

The beef cattle industry plays an important role in the production of animal protein and it is desirable to optimize the production system to get greater genetic and monetary results. Thus, livestock production must improve its productive, genetic, nutritional, sanitary, environmental and marketing efficiency to make products more competitive in quality and productivity, increasing the economic efficiency.

Among the strategies to raise the productivity and quality of livestock products, the genetic selection of the animals for traits of economic importance should be a priority. Animal breeding programs have fundamental role in beef cattle production, increasing the productivity indices, fertility and carcass quality of selected animals (Rotta et al., 2009). In these programs, several traits of economic importance are included in the breeding objective, such as productive and reproductive traits and those related to carcass quality (Ito et al., 2012a; Ito et al., 2012b). However, these traits are weighted empirically, while the most indicated would be to perform these weightings on an economic basis to maximize the return for the production system.

According to Ponzoni and Newman (1989), the initiation of a livestock activity should be given by the real breeding objectives, which are related to profitability of the production system. If these objectives are consolidated on this economic basis, the alternative would be to propose a selection index with all traits of economic importance to maximize the response to selection. This method was proposed by Hazel (1943) for the genetic-economic selection of multiple traits, in which the response to selection is based on the increase in profit expected for each one unit of improvement in the traits of the breeding objective.

The objective of the present study was to evaluate traits of economic importance for Nellore cattle in a full-cycle production system in order to establish a selection index that maximizes the response to selection.

## Material and methods

The production system proposed in this study was a typical commercial Nellore herd reared in a semi-extensive system on *Brachiaria brizantha* cv. Marandu pasture and supplemented with protein-mineral salt during the dry season. The full-cycle production system consists of the replacement heifers, sale of empty heifers not reintegrated into the system (36 months), sale of steers (36 months of age), and culling of cows and bulls for slaughter. According to the climate conditions of the center region of Brazil, the dry season comprises the period from April to September and the rainy season the period from October to March. Natural breeding was performed from November to January, dividing the mating batches at a ratio of 30 females to one bull. Following the breeding plan, the births occurred from August to October, with weaning of the animals at seven months of age (March, April and May).

Feed management was based on an extensive pasture system comprising an area of 2,000 ha. The higher stocking rate of 2.5 AU $ha^{-1}$ during the rainy season increased forage supply, while the stocking rate of 1.4 AU $ha^{-1}$ during the dry season decreased forage quality. All animals received supplementation, to avoid the effect of seasonality on animal performance, with protein-mineral salt specific for each category (on average 1 g $kg^{-1}$ of Body Weight) during the dry season and mineral salt (on average 0.18 g $kg^{-1}$ of Body Weight) during the rainy season, contributing to dry matter ingestion and potentiating weight gain.

The data of the production system and the performance parameters shown in Table 1 were the main information for initiating the bio-economic model whose objective was to stabilize the herd and to obtain the number of animals in each category. The information of the composition of the stabilized herd was used to calculate the sources of revenues and expenses per category according to the economic objective of the production system. The difference between the sources of revenues and expenses permitted to estimate the annual profit obtained for the traits of economic importance in the full-cycle system. Simulations of changes in the genetic gain obtained by the genetic improvement of the animals in the performance of a trait of economic interest permitted to calculate the profit after the improvement of the trait (marginal profit). The difference between profit and marginal profit together with the ratio of genetic gain are the economic values estimated for the traits included in the selection goal of the full-cycle system.

The sources of expenses and revenues (Table 2) were calculated for the animal categories of interest in the study. Expenses were derived from the costs of feeding and pasture that included expenses for formation, maintenance and annual depreciation, costs for annual protein-mineral salt supplements, and annual veterinary costs. The sources of revenues of the system were based on the sale of culled cows and bulls (weight of 450 and 700 kg, respectively), as well as of 36-month-old steers and heifers that were not reintegrated into the herd (weight of 510 and 450 kg, respectively). The revenues from animals destined for slaughter was described for two situations. In the first situation, the payment was based on the value paid per arroba (unit of weight) in each category. In the second situation, the payment was based on quality in which the use of improved bulls in the mattings can promote the growth of animals of better weight and carcass conformation.

**Table 1.** Performance parameters used in the final composition of the herd to obtain economic values for Nellore cattle.

| Performance parameters | Mean | |
|---|---|---|
| Annual rate of cow discard (%)[3] | 22 | |
| Annual bullfighting discard rate (%)[5] | 25 | |
| Cow conception rate (%)[1] | 78 | |
| Heifer conception rate 24 months (%)[4] | 85 | |
| Average birth rate % | 79 | |
| Number of females / bull[3] | 30 | |
| Mortality rate from 0 to 7 months (%)[1] | 4 | |
| Mortality rate above 12 months[1] | 1 | |
| Cow shelf life (years)[5] | 5 | |
| Mature cow weight - MCW (kg)[2] | 450 | |
| Average weight of bull breeder - (kg)[5] | 700 | |
| Traits | Male | Female |
| Average weaning weight (kg)[2] | 190 | 176 |
| Average weight at 365 days (kg)[2] | 252 | 228 |
| Average weight at 450 days (kg)[2] | 297 | 263 |
| Average weight at slaughter (36 months) (Kg)[2] | 510 | 450 |
| Carcass yield (%)[4] | 55 | 48 |

[1]Adapted from Euclides Filho (2008); [2]Lôbo et al. (2013); [3]Anuário da Pecuária Brasileira (ANUALPEC, 2013); [4]Jorge Júnior, Cardoso, and Albuquerque (2007); [5]Empresa Brasileira de Pesquisa Agropecuária (Embrapa, 2013).

**Table 2.** Source of income and expenses in the production system for Nellore cattle.

| Traits | Source | Value (R$) |
|---|---|---|
| Heifers 36 months empty [1] (arroba) | Income | 132.00 |
| Fat cow [1] arroba | Income | 128.00 |
| Discard bull [1] (arroba) | Income | 112.00 |
| Calf 36 months fat [1] (arroba) | Income | 142.00 |
| Expenditure on pasture training and reform [2] (R$ $ha^{-1}$) | Expenses | 964.00 |
| Depreciation of pasture (R$ $ha^{-1}$) | Expenses | 96.40 |
| Average expenditure on mineral salt [3] (R$ $kg^{-1}$) | Expenses | 1.38 |
| Average expenditure on protein salt [3] (R$ $kg^{-1}$) | Expenses | 1.17 |
| Average expenditure with veterinarian (R$ $head^{-1}$) | Expenses | 4.30 |

[1]Average price commercialized in SP, MT, MS e GO (ANUALPEC, 2013), [2]Price of training and reform (ANUALPEC, 2013), [3]Budget with delivery of Matsuda company.

The differential payment of the second situation (Table 3) was made within the Natural Nellore quality program which farmers had the opportunity to receive bonus payments from the slaughterhouse that can reach up to 4% of the value of the arroba of the animals. The profile necessary for the animals to receive the bonus in the steer category is a mean hot carcass weight of from 255 to 328 kg, with distribution of carcass fat ranging from 3 to 10 mm in a regular conformation score (rectilinear, sub convex, convex). Castrated males in the batch must have up to 6 permanent incisors, while uncastrated males must have all deciduous teeth. In the heifer category, females must have up to four permanent incisors and a mean hot carcass weight higher than 13 arrobas, with the same fat and carcass pattern as described for steers. The category of cows classified in the bonus batch requires a mean hot carcass weight higher than 15 arrobas (⩾ 225 kg), with the same finishing fat cover and carcass pattern as described for the other categories.

The methodology proposed by Groen et al. (1997) was used to derive economic values (EV) resulting from 1% increase in each trait of the breeding goal, while the other traits were kept constant. Economic values were derived using the equation

$$EV = [\delta(\text{Annual Revenue}) - \delta(\text{Annual Cost})],$$

in which δ (Annual Revenue) is the marginal change in revenues before and after genetic improvement, and δ (Annual Cost) is the marginal change in costs before and after genetic improvement. Sensitivity analysis was performed to determine if increases or decreases of 5, 25 and 50% in costs (forage, supplementation, and veterinary costs) and revenues (sales of the animals) would promote significant changes in economic values.

## Results and discussion

The performance parameters (Table 1) used for model fit were based on the production system of the center region of Brazil and on literature review because bio-economic models require certain information that is not evaluated in many production systems, a fact that can make the bio-economic model fit more difficult. According to Campos et al. (2014) the bio-economic model evaluated in different studies may not necessarily represent other complete-cycle production systems of beef cattle breed. However, these authors remind that it is possible to adapt the model to study other production situations that are similar. It was possible to estimate the feed cost centers according to forage, mineral and protein supplement requirements, as well as revenues from the sales of males and females at 36 months, sires, and culled cows based on the information about the composition and evolution of the herd in each animal category (Table 4).

**Table 3.** Bonus values for Nellore cattle.

| Lot classification index (%) | Nellore steer | Nellore heifer | Nellore cow |
|---|---|---|---|
| 0 – 49.9 | 0.0% | 0.0% | 0.0% |
| 50 – 69.9 | + 1.0% | + 2.0% | + 2.0% |
| 70 – 79.9 | + 1.5% | + 3.0% | + 3.0% |
| Above 80 | + 2.0% | + 4.0% | + 4.0% |

**Source:** http://www.nelore.org.br.

**Table 4**. Economic indicators of costs and revenues in the complete cycle system of beef cattle.

| Revenues / Costs | Values | % Of revenues / Costs |
|---|---|---|
| Total revenue with discard cows | R$ 418,164.78 | 20.52 |
| Total revenue with discard bulls | R$ 27,402.02 | 1.34 |
| Total revenue with heifers 36 months | R$ 471,378.83 | 23.13 |
| Total revenue with steers 36 months | R$ 1,120,795.76 | 55.00 |
| Total | R$ 2,037,741.40 | 100.00 |
| Fixed labor force | R$ 167,194.36 | 10.20 |
| Taxes | R$ 44,438.00 | 2.71 |
| Depreciation | R$ 16,028.85 | 0.98 |
| Total | R$ 227,661.21 | 13.89 |
| Pasture | R$ 1,042,432.17 | 63.60 |
| Protein mineral salt | R$ 229,022.77 | 13.97 |
| Mineral salt | R$ 72,592.51 | 4.43 |
| Veterinarian | R$ 21,993.49 | 1.34 |
| Other expenses | R$ 45,437.89 | 2.77 |
| Total | R$ 1,411,478.84 | 100.00 |
| Effective operational cost* | R$ 1,623,111.20 | ----- |
| Total operation cost ** | R$ 1,639,140.05 | ----- |

*Effective operational cost is composed of variable costs and part of the fixed cost, where depreciation is disregarded. ** Total operational cost is composed of the sum of the fixed cost and variables adding the depreciation.

The most representative category in total revenue was the sale of males at 36 months, which corresponded to 55% of total revenue, followed by females at 36 months, which corresponded to 23.1% of total revenue. Feed costs (pasture, mineral salt and protein supplement) accounted for 82% of the total costs of the farm and were the most expressive costs in the determination of economic values. In contrast, according to Ponzoni and Newman (1989), no alterations occurred in fixed costs with changes simulated in the traits, assuming values of zero in the process of partial derivation. However, these costs were evaluated in this study to demonstrate that the farm presented an annual total profit of R$ 398 601.35 and a profitability of 19.6%. This indicator of profitability is important since it refers to the proportion of gross revenues, i.e. the profit after the difference of costs (Table 5), demonstrating that the farm studied exhibits productive and commercial efficiency and aggregates about 19.6% of profit on the products generated within the full-cycle production system for Nellore beef cattle.

The more important factor in the sale of 36-month-old males and females in revenue sources (55% and 23%, respectively - Table 4) was the highest amount of live weight, in agreement with results found in the literature for the same type of production system (Campos et al., 2014). Pasture costs accounted for 63% of the expenses of the system, a fact explaining this source of feeding to be the most exploited by the system. When the pasture lost its nutritional quality because of seasonality, protein supplementation became the alternative source so that the animals would not lose weight. These costs accounted for approximately 14% of the annual costs of the system.

The following traits influenced the sources of revenues and expenses in the full-cycle system for Nellore cattle reared in the center region of Brazil, both in the base situation and after simulation of a 1% increase in the genetic potential of the animals: mature cow weight (MCW), female slaughter weight (FSW), male slaughter weight (MSW), weaning rate (WR), male weaning weight (MWW), and female weaning weight (FWW) (Table 6).

The weaning rate (WR) is one of the most important traits in full complete cycles of production which represents the total of animals weaned in relation to the cows exposed for reproduction within a breeding system. This index reflected the overall data of the breeding activity. The male slaughter weight (MSW), female slaughter weight (FSW), male weaning weight (MWW), female weaning weight (FWW), and mature cow weight (MCW), called as productive traits are important in of beef cattle production because they promote greater efficiency in the meat production and increase the profit. Genetic evaluations of beef cattle in Brazil usually include growth traits, since they are easy to measure and they present estimates of heritability from medium to high magnitudes, indicating that selection based on those traits may result in genetic progress (Boligon, Mercadante, Baldi, Lôbo, & Albuquerque, 2009).

**Table 5.** Economic indicators of profitability of the complete cycle system of beef cattle.

| Economic indicators of property in study | |
|---|---|
| Gross margin | R$ 414 630.20 |
| Liquid margin | R$ 398 601.35 |
| Total profit | R$ 398 601.35 |
| Profitability | 19.56% |

**Table 6.** Lucrative performance in basic and simulated situations and estimates of economic values for studied traits for Nellore cattle.

| Traits | Final profit, R$ | Initial profit, R$ | Marginal profit, R$ | Genetic gain, kg | Economic values, R$ |
|---|---|---|---|---|---|
| MCW | 8 127.32 | 8 004.70 | 122.62 | 980.07 | 0.13 |
| MSW | 891 659.62 | 882 930.50 | 8 729.11 | 2 365.73 | 3.69 |
| FSW | 269 678.11 | 266 033.48 | 3 644.63 | 1 071.74 | 3.40 |
| WR | 1 166, 299.36 | 1 148 963.99 | 17 335.37 | 4 838.72 | 3.58 |
| MWW | 887 416.57 | 882 930.50 | 4 486.06 | 1 235.08 | 3.63 |
| FWW | 266 831.15 | 266 033.48 | 797.67 | 346.15 | 2.30 |

Mature cow weight (MCW); male slaughter weight (MSW); female slaughter weight (FSW); weaning rate (WR); male weaning weight (MWW); female weaning weight (FWW).

Classification of the traits according to economic importance considering the difference in profit before and after the simulation of improvement (marginal profit) showed that WR had the greatest economic impact on the full-cycle system followed, respectively, by MSW, MWW, FSW, FWW and MCW (Table 6). The same was observed by Urioste, Ponzoni, Aguirrezabala, Rovere, and Saavedra (1998), Jorge Júnior et al. (2007) and Brumatti, Ferraz, Eler, and Formigonni (2011) who reported that any positive increase in WR had favorable economic impacts for production systems for sale of animals at slaughter. However, Brumatti et al. (2011) verified greater impact from carcass and fertility traits than weight and weight gain traits. Campos et al. (2014) found that number of calves weaned showed the greatest impact on the profit of the production system in Aberdeen Angus cattle. This order of importance was also observed when it was simulated 1% increase on genetic gain for the studied traits, with WR had the greatest genetic gain in the full-cycle system. However, in contrast to marginal profit, MCW was the fifth most important trait in terms of genetic gain, thus surpassing FWW.

Considering the economic value expressed per herd, estimated by the methodology of Groen et al. (1997), the trait that promoted the greatest economic return for Nellore cattle in this study of a full-cycle production system was MSW (R$ 3.69 $kg^{-1}$), followed by MWW (R$ 3.63 $kg^{-1}$), WR (R$ 3.58 $kg^{-1}$), FSW (R$ 3.40 $kg^{-1}$), FWW (R$ 2.30 $kg^{-1}$), and MCW (R$ 0.13 $kg^{-1}$). In order of importance, traits measured in males had greatest economic return than in female, although WR was the trait with the greatest impact on the profitability of the system. When its economic return was evaluated in terms of gain due to genetic selection, this trait was the third more important economically for the studied system.

In the evaluation of the full-cycle system of this study, the economic value of MSW had the largest impact (R$ 3.69 $kg^{-1}$). This value was higher than those reported by Jorge Júnior et al. (2007) for Nellore cattle (R$ 1.17) and by Campos et al. (2014) for Angus cattle (R$ 1.43). Female slaughter weight at 36 months of age had a positive impact on this system, with higher economic value than those reported by the authors cited above, about R$ 3.40 for each one kg of weight gain by the herd due to selection. This superiority of the economic value found in the present study for both males and females might be explained by the fact that the sale prices of the animals, expressed as R$ $arroba^{-1}$ of cattle, remained high throughout 2014 when compared to the prices paid during the years of the studies cited above, as well as by the differences in slaughter weight and commercialization of the animals between the systems studied.

In contrast to the study of Fernández-Perea and Jiménez (2004) which obtained economic values in the order of 1.57 R$ $cow^{-1}$ $year^{-1}$, male and female weaning weight promoted positive economic returns. According to Fernández-Perea and Jiménez (2004), the system adopted which included supplementation of the animals from birth to weaning increased production costs. The full-cycle production system of Nellore cattle in Brazil was evaluated by Bittencourt, Lôbo, and Bezerra (2006), Jorge Júnior et al. (2007) and Brumatti et al. (2011), who reported economic values for weaning weight of 0.96, 0.34 and R$ 0.57, respectively. These values are much lower than those found in the present study for MWW (R$ 3.63) and FWW (R$ 2.30).

The economic return per 1% increase in MCW was R$ 0.13, similar to the R$ 0.09 reported by Jorge Júnior et al. (2007). The differences in these values are probably due to the dry matter costs of each production system or even to valuation of the cow at slaughter during the periods evaluated. Although the economic values were found to promote profit for the systems, Fernández-Perea and Jiménez (2004) obtained a value of R$ -8.45 per kg, i.e., the increase in MCW would decrease the profit of the production system.

The economic value for WR promoted economic return of R$ 3.58. Other studies showed that WR was the trait of major relative importance for the production systems, with highly expressive values compared to those cited above. Urioste et al. (1998) obtained R$ 130.35 per 1% increase in the trait in pasture-fed beef cattle. The number of weaned calves per cow had economic return of R$ 97.00 in the study of Bittencourt et al. (2006). Campos et al. (2014), who evaluated the same trait in Angus cattle, found economic value of R$ 6.67 for 1% gain due to genetic selection. Laske, Teixeira, Dionello, and Cardoso (2012) found relative importance of 89.5% economic for weaning rate for beef cattle smallholders in Rio Grande do Sul. According to these authors, the greater relative economic importance of this trait can be mainly assigned to the low reproductive levels of herds.

Mature cow weight, which in the base system was the last trait to increase the marginal profit, became the most profitable trait (41 to 58%) in the system when it started to receive 2 to 4% more in the price of the arroba of beef cattle. In contrast, WR, which promoted the highest marginal profit in the base situation, was in the third position of profitability when it received bonuses with batches above 60% of slaughtered animals.

The economic values of the traits studied had positive returns in terms of profit of the system for all percentage indices (50-59, 60-79, and > 80%) of composition of the batches of animals destined for slaughter (Table 7) when it was considered the payment system of the Natural Nellore Program. These results were expected since the changes only occurred in the revenues of slaughtered animals, while the production costs remained constant. Thus, the order of importance for the three bonus percentages was the same as that of the base payment situation, i.e., MSW, MWW, WR, FSW, FWW, and MCW.

Following the order of importance in the situation with bonus payment compared to the base situation, the economic values were 7% higher for FWW, 5% for FSW, 4% for WR, 3% for MWW, and 2% for MSW. These higher economic values of female traits can be explained by the higher bonus payments (+4% above the value per arroba of cattle) when compared to males (+2%), while the production costs remained constant.

**Table 7.** Economic performance in basic and simulated situation and estimation of economic values under the natural Nellore program payment system.

| Traits | Final profit, R$ | Initial profit, R$ | Marginal profit, R$ | Genetic gain, kg | Economic values, R$ |
|---|---|---|---|---|---|
| Economic value for the natural Nellore system (50 – 59% of the lot) | | | | | |
| MCW | 16 574.25 | 16 368.00 | 206.25 | 980.07 | 0.2 |
| MSW | 902 967.22 | 894 138.46 | 8 828.76 | 2 365.73 | 3.73 |
| FSW | 279 203.62 | 275 461.06 | 3 742.57 | 1 071.74 | 3.49 |
| WR | 1 187 256.25 | 1 169 599.52 | 17 656.73 | 4 838.72 | 3 65 |
| MWW | 898 682.99 | 894 138.46 | 4 544.52 | 1 235.08 | 3.68 |
| FWW | 276 289.19 | 275 461.06 | 828.13 | 346.15 | 2.39 |
| Economic value for the natural Nellore system (60 – 79% of the lot) | | | | | |
| MCW | 20 797.71 | 20 549.65 | 248.07 | 980.07 | 0.25 |
| MSW | 908 621.03 | 899 742.44 | 8 878.59 | 2 365.73 | 3.75 |
| FSW | 283 966.38 | 280 174.85 | 3 791.53 | 1 071.74 | 3.54 |
| WR | 1 197 734.69 | 1 179 917.29 | 17 817.41 | 4 838.72 | 3.68 |
| MWW | 904 316.19 | 889 742.44 | 4 573.75 | 1 235.08 | 3.70 |
| FWW | 281 018.21 | 280 174.85 | 843.36 | 346.15 | 2.44 |
| Economic value for the natural Nellore system (above 80% of the lot) | | | | | |
| MCW | 25 021.18 | 24 731.29 | 289.88 | 980.07 | 0.30 |
| MSW | 914 274.83 | 905 346.42 | 8 928.41 | 2 365.73 | 3.77 |
| FSW | 288 729.14 | 284 888.63 | 3 840.50 | 1 071.74 | 3.58 |
| WR | 1 208 213.14 | 1 190 235.05 | 17 978.08 | 4 838.72 | 3.72 |
| MWW | 909 949.40 | 905 346.42 | 4 602.98 | 1 235.08 | 3 73 |
| FWW | 285 747.23 | 284 888.63 | 858.59 | 346.15 | 2.48 |

Mature cow weight (MCW); male slaughter weight (MSW); female slaughter weight (FSW); weaning rate (WR); male weaning weight (MWW); female weaning weight (FWW).

The bonus payments per quota for high-quality animals caused expressive changes in the economic values of some traits when compared to the payment system without bonuses. Further studies of payment methods per carcass quality in Brazil, production costs of high-yielding animals and inclusion of visual scores in a selection index are necessary. Brumatti et al. (2011) reported higher importance of reproductive traits as the stability and fertility than the growth traits. These authors reported the importance of the inclusion of reproductive traits in selection indexes to increase the productive and economic efficient.

According to Marques, Magnabosco, Lopes, and Silva (2013), the inclusion of traits to be exploited in animal breeding programs provides information that could guide actions designed to efficiently increase the quality and volume of the meat produced. In Brazil, loin eye area and backfat thickness have been evaluated genetically and the results based on correlated responses showed that animals with a greater growth potential tend to deposit more muscle in the carcass, promoting an increase in carcass yield and consequently in the value of the final product (Yokoo et al., 2010; Zuin et al., 2012). There is a need for implementation and expansion of bonus payment programs since the economic return will occur throughout the production chain.

The inclusion of visual scores (conformation, precocity, musculature and scrotal circumference) in a selection index is very important (Campos et al., 2014). According to Lima et al. (2013) the selection exclusively on weight can affect the harmonic structure of animals resulting in unequal distribution of meat on the carcass and due to the inclusion of visual scores associated with weight can be more adequate.

## Conclusion

The economic values found in this study showed that the traits studied can be used as breeding goals, generating economic returns for their production systems. Therefore, new traits should be evaluated regarding their genetic and economic potential to facilitate the definition of breeding goals and selection criteria for Nellore cattle, permitting the study of the composition of economic selection indices that maximize the economic response for beef cattle production systems in Brazil.

## Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance code 001. We thank the Postgraduate Program of Faculdade de Medicina de Ribeirão Preto – USP (Departamento de Genética), Conselho Nacional de Desenvolvimento de Pesquisa (CNPq) for financial support (Grant 472753/2010-0) and for the fellowship granted (Grant 140517/2011-1) and São Paulo Research Foundation (FAPESP) for fellowship granted (Grant 2013/20091-0 and 2016/10583-1).

## References

Anuário da Pecuária Brasileira [ANUALPEC]. (2013). *Anuário da Pecuária Brasileira* (Vol. 1, 20th ed.). São Paulo, SP: Instituto FNP.

Bittencourt, T. C. C., Lôbo, R. B., & Bezerra, L. A. F. (2006). Economic values for breeding goal traits for brazilian beef cattle production. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 58*(2), 196-204. doi: 10.1590/S0102-09352006000200008.

Boligon, A. A., Mercadante, M. E. Z., Baldi, F., Lôbo, R. B., & Albuquerque, L. G. (2009). Multi-trait and random regression mature weight heritability and breeding value estimates in Nelore cattle. *South African Journal of Animal Science, 39*(1), 145-148. doi: 10.4314/sajas.v39i1.61167.

Brumatti, R. C., Ferraz, J. B. S., Eler, J. P., & Formigonni, I. B. (2011). Development of selection index in beef cattle under the focus of a bio-economic model. *Archivos de Zootecnia, 60*(230), 205-213. doi: 10.4321/S0004-05922011000200005.

Campos, G. S., Braccini Neto, J., Oaigen, R. P., Cardoso, F. F., Cobuci, J. A., Kern, E. L., ... McManus, C. M. (2014). Bioeconomic model and selection indices in Aberdeen Angus cattle. *Journal of Animal Breeding and Genetics, 131*(4), 305-312. doi: 10.1111/jbg.12069.

Empresa Brasileira de Pesquisa Agropecuária [Embrapa]. (2013) Gado de corte. Recovered from: http://www.embrapa.br/a_embrapa/unidades-de-pesquisa-e-de-servicos/unidades-de-pesquisa -de-produtos/cnpgc/.

Euclides Filho, K. (2008). A pecuária de corte no cerrado brasileiro. In: F. G. Faleiro, & A. L. F. Neto, *Savanas: desafios e estratégias para o equilíbrio entre sociedade, agronegócio e recursos naturais.* Planaltina, DF: Embrapa Cerrados.

Fernández-Perea, M. T., & Jiménez, R. A. (2004). Economic weights for a selection index in Avileña purebred beef cattle. *Livestock Production Science, 89*(2–3), 223-233. doi: 10.1016/j.livprodsci.2004.01.004.

Groen, A. B. F., Steine, T., Colleau, J.-J., Pedersen, J., Pribyl, J., & Reinsch, N. (1997). Economic values in dairy cattle breeding, with special reference to functional traits. Report of an EAAP-working group. *Livestock Science, 49*(1), 1-21. doi: 10.1016/S0301-6226(97)00041-9.

Hazel, L. N. (1943). The genetic basis for constructing selection indexes. *Genetics, 28*(6), 476-490.

Ito, R. H., Prado, I. N., Rotta, P. P., Oliveira, M. G., Prado, R. M., & Moletta, J. L. (2012a). Carcass characteristics, chemical composition and fatty acid profile of *Longissimus* muscle of young bulls from four genetic groups finished in feedlot. *Revista Brasileira de Zootecnia, 41*(2), 384-391.

Ito, R. H., Valero, M. V., Prado, R. M., Rivaroli, D. C., Perotto, D., & Prado, I. N. (2012b). Meat quality from four genetic groups of bulls slaughtered at 14 months old. *Acta Scientiarum. Animal Sciences, 34*(4), 425-432. doi: 10.4025/actascianimsci.v34i4.14728.

Jorge Júnior, J., Cardoso, V. L., & Albuquerque, L. G. (2007). Breeding goals and economic values for beef cattle production systems in Brazil. *Revista Brasileira de Zootecnia, 36*(5), 1549-1558. doi: 10.1590/S1516-35982007000700013.

Laske, C. H., Teixeira, B. B. M., Dionello, N. J. L., & Cardoso, F. F. (2012). Breeding objectives and economic values for traits of low input family-based beef cattle production system in the State of Rio Grande do Sul. *Revista Brasileira de Zootecnia, 41*(2), 298-305. doi: 10.1590/S1516-35982012000200010.

Lima, P. R. M., Paiva, S. R., Cobuci, J. A., Neto, J. B., Machado, C. H. C., & McManus, C. (2013). Genetic parameters for type classification of Nelore cattle on central performance tests at pasture in Brazil. *Tropical Animal Health and Production, 45*(7), 1627-1634. doi: 10.1007/s11250-013-0408-1.

Lôbo, B., Bezerra, L.A.F., Oliveira, H.N., Freitas, M.A.R., Penna, V.M., Vozzi, P.A., ... & Oliveira, H.N. (2013). Avaliação Genética de Touros das Raças Nelore, Guzerá, Brahman e Tabapuã. Ribeirão Preto, SP: ANCP.

Marques, E. G., Magnabosco, C. U., Lopes, F. B., & Silva, M. C. (2013). estimate the genetic parameters of growth characteristics, carcass and scrotal perimeter in Nellore evaluated in weight gain performance tests in feedlot. *Bioscience Journal, 29*(1), 159-167.

Ponzoni, R. W., & Newman, S. (1989). Developing breeding objectives for Australian beef cattle production. *Animal Science, 49*(1), 35-47. doi: 10.1017/S0003356100004232.

Rotta, P. P., Prado, R. M., Prado, I. N., Valero, M. V., Visentainer, J. V., & Silva, R. R. (2009). The effects of genetic groups, nutrition, finishing systems and gender of Brazilian cattle on carcass characteristics and beef composition and appearance: a review. *Asian-Australasian Journal of Animal Sciences, 22*(12), 1718-1734.

Urioste, J. I., Ponzoni, R. W., Aguirrezabala, M., Rovere, G., & Saavedra, D. (1998). Breeding objectives for pasture-fed Uruguayan beef cattle. *Journal of Animal Breeding and Genetics, 115*(1-6), 357-373. doi: 10.1111/j.1439-0388.1998.tb00357.x.

Yokoo, M. J., Lobo, R. B., Araujo, F. R. C., Bezerra, L. A. F., Sainz, R. D., & Albuquerque, L. G. (2010). Genetic associations between carcass traits measured by real-time ultrasound and scrotal circumference and growth traits in Nelore cattle. *Journal of Animal Science, 88*(1), 52-58. doi: 10.2527/jas.2008-1028.

Zuin, R. G., Buzanskas, M. E., Caetano, S. L., Venturini, G. C., Guidolin, D. G. F., Grossi, D. A., ... Munari, D. P. (2012). Genetic analysis on growth and carcass traits in Nelore cattle. *Meat Science, 91*(3), 352-357. doi: 10.1016/j.meatsci.2012.02.018.