SHORT COMMUNICATION

Influence of genetic merit on the price of Nellore bull semen in Brazil

Influencia del mérito genético en el precio del semen de toros Nellore en Brasil

Influência do mérito genético no preço do sêmen de touro Nellore no Brasil

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Abstract

Background: The genetic test for Expected Progeny Differences (EPDs) is one of the newest technologies to reduce uncertainty in calf production. It provides information about the genetic composition of a bull, which relates to its propensity to produce offspring with specific growth and quality characteristics. **Objective:** To evaluate the influence of EPDs reports on the variation of Nellore bull semen prices for artificial insemination in the Brazilian beef cattle industry. **Methods:** Ordinary Least Squares (OLS) regressions were estimated. The study utilized genetic data provided by GENEPLUS as well as market prices of semen and physical measurements of the bulls collected from the Alta Genetics Insemination Agency. **Results:** Genetic results, except for age at first calving, weaning weight, and weight at 120 days EPDs, have little influence on semen prices. For each additional day expected for the first calving of the progeny average price of semen decreases by 0.66%. For each additional kg expected in weaning weight, the semen price was 1.73% higher. Furthermore, for each additional kg expected in the progeny at 120 days, semen price increased by 2.46%. **Conclusion:** Joint analyses of genetic reports and physical characteristics of bulls may provide a better explanatory power.

Keywords: *age at first calving; artificial insemination; beef cattle; bovine; bulls; expected progeny differences; price formation; semen market; semen price; weaning weight.*

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Resumen

Antecedentes: La prueba genética de la diferencia esperada de progenie (EPDs) es una de las tecnologías más novedosas para para reducir la incertidumbre en la producción de terneros. Dicha prueba proporciona información sobre la composición genética de un toro, relacionando la propensión del toro a producir descendencia con rasgos particulares de crecimiento y calidad. **Objetivo:** Evaluar la influencia de los informes de EPD en la variación de los precios del semen de toros Nellore para reproducción por inseminación artificial en la industria ganadera brasileña. **Métodos:** Se estimaron regresiones de Mínimos Cuadrados Ordinarios (OLS). El trabajo utilizó los datos genéticos proporcionados por GENEPLUS y los precios de mercado del semen, así como las medidas físicas de los toros, recopiladas por la Agencia de Inseminación Alta Genetics. **Resultados:** Los resultados genéticos, con excepción de la edad al primer parto, peso al destete y peso a los 120 días EPDs, tuvieron poca influencia en los precios del semen. El precio del semen disminuyó en 0,66% por cada día adicional esperado para el primer parto de la descendencia. El precio del semen fue 1,73% mayor por cada kg adicional esperado en peso al destete. Además, el precio del semen aumentó un 2,46% por cada kg adicional esperado en la descendencia a los 120 días. **Conclusión:** El análisis conjunto de los informes genéticos y las características físicas de los toros puede proporcionar una mejor capacidad explicativa.

Palabras clave: *bovino; diferencias esperadas en la progenie; edad al primer parto; formación de precios; ganado vacuno; inseminación artificial; mercado de semen; peso al destete; precio del semen; toros.*

Resumo

Antecedentes: Uma das mais novas tecnologias disponíveis para produtores de bezerros desenvolvida com o intuito de reduzir a incerteza é o teste genético de diferença esperada na progênie (EPD). Os testes fornecem informações sobre a composição genética do touro, que se relaciona com a propensão do touro para produzir progênie com características particulares de crescimento e qualidade. **Objetivo:** Avaliar a influência dos relatórios de EPD na variação dos preços do sêmen de touros Nellore para reprodução por inseminação artificial na pecuária de corte brasileira. **Métodos:** Foram estimadas regressões de Mínimos Quadrados Ordinários (OLS). O trabalho utilizou os dados genéticos disponibilizados pela GENEPLUS e os preços de mercado dos sêmens e medidas físicas dos touros, coletadas da Agência de Inseminação Alta Genetics. **Resultados:** Os resultados genéticos, com exceção da idade ao primeiro parto, peso à desmama e peso aos 120 dias de EPD, têm pouca influência nos preços do sêmen. Para cada dia adicional esperado para o primeiro parto da progênie, o preço do sêmen diminui, em média, cerca de 0,66%. Para cada kg a mais esperado no peso à desmama, o preço do sêmen, em média, é 1,73% maior. Além disso, para cada kg a mais esperado na progênie aos 120 dias, o preço do sêmen aumenta, em média, 2,46%. **Conslusão:** Análises conjuntas de relatórios genéticos e características físicas dos touros podem entregar melhor poder de explicação.

Palavras-chave: *bovino; bovinos de corte; diferenças esperadas na progênie; formação de preços; idade ao primeiro parto; inseminação artificial; mercado de sêmen; peso ao desmame; preço do sêmen; touros.*

Introduction

The Brazilian beef cattle industry has experienced significant advance with the introduction of novel technologies and production methods, resulting in heightened efficiency, productivity, and substantial overall progress (Barcellos *et al.,* 2011). Particularly noteworthy is the surge in the adoption of artificial insemination (AI) during the initial phase of the production cycle, commonly known as the breeding phase. According to the ASBIA Index 2020, a remarkable 75% of Brazilian municipalities have embraced this technique. Furthermore, there has been a noteworthy increase of approximately 24% in the importation of semen into the Brazilian market, coupled with a remarkable 42% growth in the export of genetic material for beef production between 2019 and 2020.

Considering the pivotal role of beef cattle farming, which constitutes a substantial component of the Brazilian economic framework and recognizing that semen choice for cattle reproduction plays a critical role in the sector efficiency, this study aimed to estimate the determinants of Nellore semen prices in Brazil. Specifically, this study seeks to calculate the premium associated with Expected Progeny Differences (EPDs) in relation to the pricing of Nellore bull semen doses.

This study contributes to our comprehension of price formation and semen market within the Brazilian beef cattle farming. Consequently, it aids in improving our understanding of the costs in the Brazilian livestock production chain, with a particular emphasis on exploring the pivotal dimension of the initial stage of livestock production, the breeding phase, which significantly influences the future efficiency of the sector as a whole. Indeed, it also allows identifying the genetic traits that are most highly prized by beef producers in Brazil.

Materials and Methods

The data used in this study were sourced from two key agencies: the Embrapa Program for Genetic Improvement of Beef Cattle (GENEPLUS) and the Alta Genetics Artificial Insemination Agency in Brazil, which distributes bovine semen for beef and dairy cattle and offers comprehensive information on available semen for various cattle breeds, including purebred Nellore. Within the extensive phenotypic and genotypic descriptions of semen donor bulls, genetic reports of Expected Progeny Differences (EPDs) from various specialized companies and associations are accessible. The data were extracted from the genetic analysis conducted by the GENEPLUS Genetic Improvement Program/Catalog as of January 2021 for the purposes of this study.

Selected variables

Semen data from 151 Nellore bulls available for commercialization by Alta Genetics agency were selected for analysis. The criterion for the initial sampling was the selection of semen from bulls with available prices and evaluated by the GENEPLUS program. Regarding the collected information, bull physical characteristics of interest were chosen, including scrotal circumference, rump height, rump width, rump length, rib depth, front height, chest girth, and body length. Additionally, data on Expected Progeny Differences (EPDs) of the animals were collected.

Estimation of EPD is based on information from the individual and/or its relatives and indicates the expected difference in the average production of the progeny of a specific animal compared to the average production of progenies of other animals of the same breed. To study the determinants of Nellore bull semen prices in Brazil with an emphasis on how genetic information expressed by EPDs influences semen price per dose, the following EPD variables were selected: maternal ability (birth weight and weight at 120 days), reproduction (yearling scrotal circumference, age at first calving, stayability, and weaning ratio), growth and development (weaning weight, yearling weight, and post-weaning weight gain), finishing and carcass traits (ribeye area, subcutaneous fat thickness, and marbling), as well as the genetic qualification index (GQI).

Interpretation of EPD - an example

Table 1 reports the estimated EPDs for the Nellore bull "REM USP," renowned as a prominent breed sire. Semen price of this animal is the highest in our sample R$ 200.00 (BLR - all economic values are given in Brazilian Reals) per dose, and it is more than 500% higher than the sample's average price (R$ 38.05).

The EPD results, such as those in Table 1, indicate the expected difference in the offspring of this bull compared to the offspring of other bulls of the same breed. Taking Weaning Weight (WW) as an example, according to its EPD, it is expected that the offspring of this bull (REM USP) will likely weigh 9.16 kg more than the offspring of other Nellore bulls when they reach weaning age. As for Yearling Scrotal Circumference (SCY), the EPD indicates that the offspring of this bull will average 1.71 cm more scrotal circumference than the offspring of other Nellore bulls. Additionally, Table 1 indicates that the bull progeny ranks in the top 1% for WW and in the top 10% for SCY among the best-evaluated bulls.

Empirical strategy

To achieve the objective, an Ordinary Least Squares (OLS) model was estimated. Additionally, in pursuit of better data fitting, the price per dose of semen was used as the dependent variable and the main physical measurements of the animals were used as explanatory variables. Equation 1 describes the functional form of the regression used:

$$ln(P_i)=\alpha+\beta X_i+\varepsilon_i \quad (1)$$

Where: $ln(P_i)$ is the natural logarithm of the price of Nellore semen, which is the dependent variable of the model. The intercept is represented by α. X_i is the vector of physical characteristics of the animals (scrotal circumference, rump height, rump width, rump length, rib depth, front height, chest girth, and body length). Finally, ε_i represents the random error term of the model.

A second OLS model was estimated to initiate the examination regarding the importance of using EPDs as a relevant characteristic in explaining semen prices. Equation (2) describes its functional form:

$$ln(P_i)=\alpha+\beta X_i+\gamma J_i+\varepsilon_i \quad (2)$$

According to this form, the model is the same as the one estimated in the first attempt of fitting; however, the Genetic Qualification Index (GQI) of the donor bull, represented in the above structure by J_i, was added as an explanatory variable. The aim was to test a better fit of the data to the regression when considering a measure from the genetic report, in this case the GQI, a kind of "concentrated measure."

Table 1. Estimated Expected Progeny Differences (EPD) for the Nellore bull "REM USP".

	EPD	Percentile (%)
Weight at 120 days	4.46	0.50
Weaning weight	9.16	1.00
Yearling weight	23.28	0.10
Yearling scrotal circunference	1.71	0.10
Age at first calving	-23.76	2.00
Stayability	41.48	0.10
Ribeye area	0.11	51.00
Subcutaneous fat T.	-1.37	95.00
Marbling	0.08	44.00
Genetic Qualification Index	33.77	0.10

Source: Alta Genetics agency and GENEPLUS.

EPD: Expected Progeny Differences for the bull "REM USP".

Additionally, a third model, represented by equation (3), was estimated to assess the level of explanatory power of semen prices. This assessment considered the utilization of selected EPD results (birth weight and weight at 120 days, yearling scrotal circumference, age at first calving, stayability, weaning ratio, weaning weight, yearling weight, post-weaning weight gain, ribeye area, subcutaneous fat thickness, and marbling) in conjunction with physical traits of the donor bull as explanatory variables.

$$ln(P_i)=\alpha+\beta X_i+fW\_i+\varepsilon_i \quad (3)$$

Represented by W_i, the selected EPDs aim to explain price variations of Nellore bull semen doses for the Brazilian beef cattle industry. The third estimated model seeks to understand to what extent an empirical analysis of visual and/or physical characteristics, along with genetic evaluations, is relevant in explaining the pricing of these doses.

Results

For initial evidence, correlations between the selected explanatory variables and the price of semen were calculated. Table 2 reports preliminary evidence regarding the correlation between the prices of Nellore bull semen doses and the selected EPD variables, as well as the physical characteristics of the breeding bull.

As per the correlation values among EPDs, it is worth highlighting the magnitude of age at first calving (AFC), which exhibits a negative correlation of approximately 20% with semen prices. Furthermore, the characteristics related to weight gain capacity also deserve attention, as EPDs for weaning weight, post-weaning weight gain, and yearling scrotal circumference showed positive correlations ranging from approximately 10 to 15% with semen dose prices. On the other hand, EPDs related to finishing and carcass traits, such as ribeye area (REA) and subcutaneous fat thickness (SFT), showed low-magnitude correlations.

Table 2. Correlation of EPD's and physical measurements of bulls with semen prices.

Physical measurements (cm)		**EPD's**	
Scrotal circumference	0.3508	EPD - Birth weight	-0.0173
Rump height	0.3004	EPD - Weaning ratio	0.0567
Rump width	0.3107	EPD - Post-weaning weight gain	0.1295
Rump length	0.3258	EPD - Weight at 120 days	0.0110
Rib depth	0.3259	EPD - Weaning weight	0.1756
Front height	0.3462	EPD - Yearling weight	0.0973
Chest girth	0.3890	EPD - Yearling scrotal circumference	0.1459
Body length	0.2835	EPD - Age at first calving (AFC)	-0.1976
		EPD - Ribeye Area (REA)	0.0068
		EPD - Subcutaneous Fat Thickness (SFT)	0.0024
		EPD - Stayability	0.0824
		EPD - Marbling	0.0034
		EPD - Genetic Qualification Index (GQI)	0.0871

Source: Authors' own elaboration based on data from Alta Genetics agency and GENEPLUS.
EPD: Expected Progeny Differences.

The physical characteristics specific to the breeding bull stand out due to the correlation results for chest girth and scrotal circumference. According to the results reported in Table 2, both variables exhibited a strong positive correlation with semen prices. The former showed a positive correlation of approximately 39%, while the latter of 36%. Additionally, the other variables in this group also demonstrated relevant correlations (above 30%) with semen prices.

However, to assess the impact of EPDs on semen prices, specifically to determine the premium of each trait on the price of Nellore bull semen doses for beef production, Ordinary Least Squares (OLS) regression models were estimated for three different specifications. In an effort to achieve the best data fit, a first specification was estimated using only the physical characteristics of the breeding bulls as explanatory variables. The results of the first estimation are described in Table 3.

Table 3 reports the main results of the estimation involving the dependent variable, natural logarithm of semen price, and the explanatory variables (physical characteristics of the breeding bulls). The estimated coefficients showed a low degree of magnitude, and -except for scrotal circumference (SC), chest circumference (CC), and body length (BL)- they did not demonstrate significance to explain the variations in semen prices. Taking the CC measurement as an example, the price per dose increased by 1.47% for every 1 cm increase (according to the preliminary evidence found). For SC and BL measurements, every 1 cm increase led to an average increase of semen price by 1.2 and 1.1%, respectively.

These results demonstrated that, in order to comprehend fluctuations in prices of Nellore bull semen for beef production, one must consider more than just the physical characteristics of the breeding bulls. In this regard, a second econometric estimation was conducted, similar to the first one, but adding the Genetic Quality Index (GQI) as an explanatory variable, which serves as a more general measure for EPD outcomes. The objective was to include in the estimation a first control variable directly related to the bull's genetic evaluation.

Table 3. Influence of physical measurements of bulls on semen price.

Dependent variable (cm)	**nl_price**
Scrotal circumference	0.0122*
	(0.0055)
Rump height	0.0059
	(0.0154)
Rump width	0.0003
	(0.0112)
Rump length	0.0023
	(0.0099)
Rib depth	0.0070
	(0.0114)
Front height	0.0044
	(0.0159)
Chest girth	0.0147***
	(0.0048)
Body length	0.0112*
	(0.0065)
Constant	0.8562
	(0.9379)
Observations	151
R - Squared	0.244
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Source: Authors' own elaboration based on data from Alta Genetics agency and GENEPLUS.

nl_price: variable natural logarithm of semen price.

Table 4 presents the main results of the estimation. Once again, the estimated coefficients for the bull's physical measurements showed little magnitude, and furthermore, the body length measurement lost its level of significance. However, the GQI proved to be significant in explaining variations in semen prices. The evidence indicates that for each marginal increase in the index, semen price varied approximately 0.6%.

Table 4. Influence of physical measurements and Genetic Qualification Index (GQI) of bulls on the price of semen.

Dependent variable (cm)	nl_price
Scrotal circumference	0.0122*
	(0.0055)
Rump height	0.0059
	(0.0154)
Rump width	0.0003
	(0.0112)
Rump length	0.0023
	(0.0099)
Rib depth	0.0070
	(0.0114)
Front height	0.0044
	(0.0159)
Chest girth	0.0147***
	(0.0048)
Body length	0.0112*
	(0.0065)
Constant	0.8562
	(0.9379)
Observations	151
R - Squared	0.244
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Source: Authors' own elaboration based on data from Alta Genetics agency and GENEPLUS.

nl_price: variable natural logarithm of semen price.

The significance of GQI in explaining the variation of semen prices indicates that EPDs may influence the prices, despite having a coefficient of low magnitude. Thus, a third model was estimated. In this model, for the explanation of semen dose prices, both the physical measurements and the EPD's of the breeding bulls were used as explanatory variables. Table 5 reports the main results of this estimation.

The estimated coefficients of the EPDs did not show high magnitude either. However, the EPDs for weight at 120 days, post-weaning weight, and age at first calving were significant in explaining semen price variations. The price decreased 0.66% for each additional day expected for the first calving of the progeny. The price was 1.73% higher for each additional kg expected in weaning weight. Furthermore, semen price increased 2.46% for each additional kg expected in the progeny at 120 days. As for the physical attributes, the greater emphasis is, again, on the measurement of chest circumference: semen price increased 1.5% for each additional centimeter.

Discussion

The evidence found in the present study indicates that, albeit with low magnitude, only the EPDs of yearling scrotal circumference, age at first calving, and weight at 120 days were significant in explaining variations in the prices of semen doses. The evidence indicates that producers are focused on enhancing profitability by advancing the genetic quality of their herds, targeting traits linked to early maturity and reproductive efficiency.

It's important to emphasize the negative coefficient associated with the birth weight EPD. While this might seem counterintuitive at first glance, it aligns with existing literature and EPD value recommendations. As documented by Buzzo and Martinez (2014), a lower birth weight in calves is a crucial factor in predicting calving ease, and it has a direct impact on reducing the likelihood of dystocia.

Among the observed physical traits, thoracic and scrotal circumferences have emerged as significant factors. Furthermore, it is important to note that when utilizing both physical attributes and EPDs in the model, the slight decrease of the coefficients for bull size measurements underscores the significance of considering genetic reports for a better understanding of the factors influencing semen dose prices.

In summary genetic reports have little influence on the variation of semen prices in the Nellore beef cattle market in Brazil. However, combining genetic evaluations with bull main physical measurements improves the prediction of semen prices. It is reasonable to assume that a bull with very large body structure but below-average EPDs would have median semen price.

The same applies to a bull with excellent EPD values without visibly large body structure.

These results corroborate the findings of Irsik *et al.* (2008), which pointed in the same direction, indicating that EPD data does not exert strong influence on bull prices. Additionally, as highlighted by Vestal *et al.* (2013), producers still need time to familiarize themselves and build confidence in the available genetic reports.

Braga (2021) and Abreu (2017) investigated the factors influencing the pricing of Nellore bulls in beef cattle auctions in Brazil. Their findings indicate that GQI offers minimal insight into price determination. Moreover, Abreu (2017) suggests that a significant portion of price fluctuations might be unrelated to product assessment metrics. This underscores a vast opportunity for deeper exploration and research on the subject.

Table 5. Influence of physical measurements and EPD's of bulls on the price of semen.

Dependent variable (ln_price)			
Physical measurements (cm)		**EPD's**	
Scrotal circumference	0.0023	EPD - Birth weight	-0.0051
	(0.0146)		(0.0779)
Rump height	0.0055	EPD - Weaning ratio	0.0097
	(0.0147)		(0.0355)
Rump width	0.0044	EDP - Post-Weaning Weight Gain (PWG)	0.0151
	(0.0116)		(0.0099)
Rump length	0.0029	EPD - Weight at 120 days	0.0246*
	(0.0105)		(0.0137)
Rib depth	0.0212	EPD - Weaning weight	0.0173*
	(0.0407)		(0.0097)
Front height	0.0059	EPD - Yearling weight	0.0001
	(0.0166)		(0.0109)
Chest girth	0.0154***	EPD - Yearling scrotal circumference	0.0578
	(0.0052)		(0.0481)
Body length	-0.0061	EPD - Age at First Calving (IPP)	-0.0066**
	(0.0061)		(0.0029)
		EPD - Ribeye Area (REA)	0.0342
			(0.0321)
		EPD - Subcutaneous Fat Thickness (SFT)	0.0078
Constant	0.1790		(0.0207)
	(1.3305)	EPD - Stayability	0.0055
			(0.0127)
Observations	151	EPD - Marbling	0.0052
R - Squared	0.393		(0.0263)
Robust standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Source: Authors' own elaboration based on data from Alta Genetics agency and GENEPLUS.
EPD: Expected Progeny Differences.

Finally, the data reported here indicate that genetic reports of EPDs influence semen prices variations of Nellore beef cattle in Brazil. Additionally, observed size measurements -indicators of the animal body structure- have demonstrated significance, particularly regarding scrotal circumference and chest size.

Other unconsidered aspects, such as exhibition premiums and the breeder's reputation, may generate strong attractiveness for producers in choosing their breeding bull. To support this conjecture, Table 6 reports the EPD results of the Nellore bull named "Alarme", whose semen price is R$ 80.00 (approximately 75% above the average).

Table 6. EPDs of bull "Alarme".

	EPD	Percentile (%)
Weight at 120 days	-7.68	0,99
Weaning Weight	5.88	0,06
Yearling Weight	8.83	0,11
Yearling Scrotal Circumference	-0.33	0,79
Age at First Calving	7.08	0,8
Stayability	23.5	0,98
Weaning Ratio	-2.7	0,99
Ribeye Area	-0.11	0,59
Subcutaneous Fat Thickness	-0.65	0,8
Marbling	-0.76	0,83
GQI	-1.39	0,64
Semen price - R$80.00		

Source: Alta Genetics agency and GENEPLUS.
EPD: Expected Progeny Differences.

As shown in Table 6, bull "Alarme" EPD results are not among the best in most categories. However, according to discretionary comments from Alta Genetics Agency, he was the champion of Expozebu in 2012 and passes on breed beauty to his offspring. Exhibition awards and breeder reputation also appear to play a role in this equation, as exemplified by bull "Alarme". However, evaluating this matter was beyond the scope of the present study. In summary, the results of this bull demonstrate that the examination of EPD's is not the sole determining factor for the commercial price of bovine semen.

Declarations

Funding

This study was self-funded by the author.

Conflicts of interest

The author declares he has no conflicts of interest with regard to the work presented in this report.

Author contributions

OD is the sole author; he collected the data, estimated the regressions, performed the statistical analyzes and wrote the manuscript.

Use of artificial intelligence (AI)

The author did not use any artificial intelligence tool during the preparation of the manuscript.

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