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Hedonic analysis of the price of mangalarga marchador horses sold at auctions

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ABSTRACT. The objective was to identify sets of relevant atributes for pricing Mangalarga Marchador horses at auctions and to estimate a hedonic pricing function. We analyzed 452 horses at 20 auctions. The studied variables were characteristics intrinsic to the animals and attributes that influence sale price, which were identified through generalized linear and logistic model analysis. For each additional prize and additional bid, the prices decreased by R$ 2110.00 and R$ 549.00 respectively. The individual's maternal grandsire positively or negatively affected prices, from R$ - 86.70 to R$ + 35.50. Non-pregnant females were penalized in price by R$ 110.00 compared to non-castrated males. A bay coat added R$ 215.00 to prices when compared to chestnut animals. Online auctions added R$ 20.10 to prices and virtual auctions penalized prices by R$ 617.00. The gray coat devalues a sale by 48% and Seller 3 decreasing by 18%. We conclude that auction type, number of prizes, share sold, animal category, coat, seller, number of bids, and maternal grandsire influenced the prices of Mangalarga Marchador horses, and that coat and seller that influenced the probability of the animal being sold.

Keywords: comercial; equine; pricing.

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Introduction

The horse market presents peculiarities that differentiate it from most livestock markets. It can be considered as one that is governed by monopolistic competition. In this kind of situation, there are a great number of enterprises producing a particular good or service, but each enterprise offers a differentiated product in terms of quality and standards (Santos et al., 2018). At the same time, these products are considered to be next substitutes, and each enterprise exerts a certain influence over the market price.

As reported by Cabral et al. (2020) the market and production costs were considered by breeders as the main obstacles for the growth of the industry in Brazil. Regarding the market, the main obstacle pointed out was the low liquidity of the animals and the lack of a guaranteed return on investment. They also criticized the great number of auctions and the easy terms of payment offered, which turn them into unfair competition.

Despite the relevance of the topic for the horse industry, the Brazilian scientific literature is scarce concerning the horse market and production costs. No paper was found regarding horse price determination in the country, while in the international literature there is some research, such as that of (Neibergs, 2001), (Lange, Johnson, Wilson, & Johnson, 2010), (Ng, Chong, Siu, & Everard, 2011), and (Mcgreevy, Oddie, Hawson, McLean, & Evans, 2015).

Most of the hedonic price research has involved race horses, show horses, and breeding cattle industries. For horses that will never earn any money, such as the ones used for work or recreation, the factors influencing prices are mostly unknown, since they do not rely on competitive performance parameters (Lange et al., 2010). Therefore, there is too little information available for horse buyers and sellers concerning the impact caused by the animals' characteristics on the prices achieved by them in auctions. The importance of each attribute of the horses and of the sale mechanism on Mangalarga Marchador breed prices is unknown, so the level of desire in the market for them is ignored (Lange et al., 2010).

Knowledge of the marginal values of each attribute could provide an important tool for breeders and sellers to understand the characteristics most valued by buyers, and to adapt their production to the most desired attributes. Thus, the aim of this study was to identify a set of relevant attributes for pricing Mangalarga Marchador horses in auctions and to estimate the function of a hedonic price to determine the marginal value of each attribute.

Material and methods

The research was conducted in four steps. First, we identified the auction calendar for Mangalarga Marchador horses disclosed by the Brazilian Association of Mangalarga Marchador Breeders (ABCCMM). In the second stage, we collected the information on the animals offered from the auction catalogues and organized it in a spreadsheet. The next step consisted of verifying the prices and number of bids achieved by each lot at the auctions, and in the fourth and last phase we analyzed the data through multiple and logistic regressions in order to identify the factors that influenced price variations and selling probability.

All the animals were registered with the ABCCMM (Brazilian Association of Mangalarga Marchador Horse Breeders), and their ages varied from 2 months to 20 years. Data were collected regarding the sales of 452 animals, offered in 16 online auctions, 3 live auctions, and 1 virtual auction, during September, 2017 and May, 2018. The information was obtained from auctions announced on the official ABCCMM website that took place via television programs (live auctions) or the internet (online and virtual auctions).

The data on animals and sales were collected through specific consultations of the association's website and auction catalogues, provided by the auctioneers before the auctions. The variables considered covered two categories: variables related to the animals and variables related to the sales process.

The characteristics intrinsic to the animals were: coat color, age, category (stallion, gelding, pregnant mare, non-pregnant mare, non-pregnant mare and foal pair, pregnant mare and foal pair), number of prizes earned by the animal, seller (seven categories), and genealogy with maternal (six categories) and paternal grandsires (six categories).

The characteristics related to the sales process consisted of: auction type (live, online, virtual), number of bids, and animal share offered.

Lot prices were obtained directly through direct follow up of the events or through reports provided by the auctioneers after the events. We considered that lots that were not sold, either due to an absence of bids or defense by the seller, did not obtain prices. We also investigated which attributes influenced the probability of the horses being sold or not.

We adopted two analysis strategies, one to identify the attributes that influenced the prices of sold animals, and another to verify which aspects increase or decrease the probability of the lot being sold. All analyses were conducted using the R statistical software.

To evaluate which characteristics influenced the selling price of the animals, we first tested the presuppositions of normality (Shapiro-Wilk and Kolmogorov-Smirnov tests) and variance homogeneity (Bartlett test). The significances of the intercept and of the variables were verified with the t-student test. Since a violation of these presuppositions occurred even after a Box-Cox transformation, we used a generalized linear model through a gamma regression, via an inverse link function.

The dependent variable was price, and the independent variables were the attributes intrinsic to the animal (number of prizes, sex, physiological situation, age, coat, maternal and paternal sires) and to the sales process (auction type, share offered, number of bids). This way we identified the variables that influenced prices and their marginal values.

We calculated the coefficient of determination (R^2) to assess the model's goodness of fit. To analyze the significance of the intercept and of the independent variables we used t statistics, and to verify the significance of the variables in relation to the price we used F statistics, via the partial F-test.

The variance inflation factor (VIF) was used to assess multicollinearity, and only variables with VIF<10 remained in the model (O'brien, 2007). Later we applied stepwise regression until the lowest possible AIC was achieved.

Finally, a new triage of continuous variables was performed through covariance analysis (ANCOVA), according to the partial F-test. Only variables with $p < 0.05$ remained in the model.

To verify which characteristics influenced the probability of the animal being sold, we used a logistic regression, in which the explanatory variables were the characteristics intrinsic to the animal (number of prizes, sex, physiological situation, age, coat, paternal grandsire, maternal grandsire, and seller) and to the sales process (auction type and share to be sold).

For the categorical variables, we carried out a chi-square test between the result and the various predictive variables, and all the variables with a value of $p < 0.20$ were incorporated into the model. For the continuous variables, we carried out the Mann-Whitney test and all the variables with a value of $p < 0.20$ were incorporated into the model.

We tested the chosen variables with regards to collinearity, including a multi-collinearity analysis to ensure an average variance inflation factor < 10 before being used in the models (O'brien, 2007).

We built the model by inserting all the variables chosen in the previous stages, and then we applied the stepwise method, in which the variables are removed until the lowest AIC statistic is obtained.

Result and discussion

The average price of the Mangalarga Marchador in the auctions analyzed was R$ 16,570.87, while the maximum price was R$ 150,000.00 and the minimum was R$ 3,000.00. 170 animals were awarded prizes in category competitions, 15 in national championships and 72 in regional ones. In gait competitions, 8 animals were awarded prizes in national championships, and approximately 60 were in regional ones. Only one animal was awarded a prize in a big national championship and 14 were in big regional ones.

The state that offered the most lots in accompanied auctions was Minas Gerais, with 166 animals, representing 36% of the total animals analyzed in the study. This is consistent with the fact that the state has, according to data from the Instituto Brasileiro de Geografia e Estatística (IBGE, 2016), the largest horse herd concentration in Brazil, with 762,000 individuals. Other notable states were São Paulo, with 85 lots, and Rio de Janeiro and Distrito Federal, with 34 sales each.

Table 1 shows all the variables considered in the model and their variance inflation factors (VIFs), according to the multicollinearity diagnostic.

Table 1. Variables included in the regression model and their variance inflation factors (VIFs), according to the multicollinearity diagnostic.

Attributes of the animals			
Abbreviation	VIF	Abbreviation	VIF
Continuous variables			
PRIZES	7.42 e-10	AGE	7.59 e-09
Binary variables			
Category		Paternal grandsire	
STALLION	¥	PATGSIRE1	¥
GELDING	8.21 e-09	PATGSIRE2	1.02 e-08
NPREG	7.48 e-09	PATGSIRE3	4.68 e-08
PREGNANT	6.45 e-09	PATGSIRE4	8.27 e-09
NPREGFOAL	7.32 e-09	PATGSIRE5	7.63 e-09
PREGFOAL	1.06 e-08	PATGSIRE6	7.60 e-09
Coat color		Maternal grandsire	
CHESTNUT	¥	MATGSIRE1	¥
SORREL	4.95 e-09	MATGSIRE2	1.67 e-08
BAY	8.63 e-09	MATGSIRE3	2.39 e-08
PINTO	7.92 e-09	MATGSIRE4	4.98 e-08
BLACK	3.36 e-09	MATGSIRE5	1.42 e-08
GRAY	7.04 e-09	MATGSIRE6	1.95 e-08
GRULLO	3.26 e-09		
REDROAN	4.85 e-09		
Seller			
SELLER1	¥	SELLER5	9.88 e-08
SELLER2	4.85 e-09	SELLER6	3.42 e-07
SELLER3	7.06 e-08	SELLER7	1.84 e-08
SELLER4	1.67 e-07		

Attributes of the sale process			
Abbreviation	VIF	Abbreviation	VIF
Continuous variables		Binary variables	
NBIDS	2.59 e-09	Auction type	
SHARE	2.42 e-09	LIVE	¥
		ONLINE	6.54 e-09
		VIRTUAL	1.49 e-09

¥Values absent due to the use of the dummy variable as a reference.

The regression model determined as the reference animal an intact chestnut-coated male, sold at a live auction, by seller 1, of paternal grandsire 1, maternal grandsire 1, and therefore no VIF values were generated for these characteristics.

After carrying out the stepwise regression and applying the Akaike information criterion (AIC) for model optimization, we removed characteristics related to both the sale and to the animals. Then we carried out the partial F-test, in which the age characteristic did not present significance (P=0.5277), and was thus also removed from the model. Table 2 presents the variables that remained in the final model and their P-values. Thus, the multiple regression model generated was as described in Equation (1).

Table 2. Inherent values that remained in the final model after the stepwise regression and the application of the AIC, their variance inflation factors (VIFs), and P-values, according to the partial F-test.

Attributes of the animals					
Abbreviation	VIF	P-value	Abbreviation	VIF	P-value
Continuous variables					
PRIZES	5.58 e-10	3.42 e-09			
Binary variables					
Category			Paternal grandsire		
STALLION	¥	¥	PATGSIRE1	¥	¥
NPREG	4.47 e-09	0.00237			
Coat color			Maternal grandsire		
CHESTNUT	¥	¥	MATGSIRE1	¥	¥
BAY	2.51 e-09	0.08613	MATGSIRE2	7.40 e-10	0.0026
			MATGSIRE3	1.12 e-08	0.0899
Seller					
SELLER1	¥	¥			
SELLER3	3.72 e-09	9.05 e-08			
SELLER4	9.63 e-09	6.50 e-07			
SELLER5	5.56 e-09	0.0042			

Attributes of the sale process					
Abbreviation	VIF	P-value	Abbreviation	VIF	P-value
Continuous variables			Binary variables		
NBIDS	2.59 e-09	9.38 e-07	Auction type		
SHARE	2.42 e-09	6.36 e-06	LIVE	¥	¥
			ONLINE	6.54 e-09	< 2 e-16
			VIRTUAL	1.49 e-09	0.6015

¥Values absent due to the use of the dummy variable as a reference.

$$y = \beta_0 + \beta_1 * ONLINE + \beta_2 * VIRTUAL + \beta_3 * PRIZES + \beta_4 * SHARE + \beta_5 * NPREG + \beta_6 * BAY + \beta_7 * SELLER3 + \beta_8 * SELLER4 + \beta_9 * SELLER5 * \beta_{10} * NBIDS + \beta_{11} * MATGSIRE2 + \beta_{12} * MATGSIRE3 \quad (1)$$

The variables considered in this study accounted for 67.47% of the variation in the sales price of the animals. In other studies reviewed, the R^2 varied between 0.26 and 0.74 (Buzby & Jessup, 1994), (Lansford Jr, Freeman, Topliff, & Walker, 1998), (Neibergs, 2001), (Lange et al., 2010), (Oddie, Hawson, McLean, & McGreevy, 2014), (Mcgreevy et al., 2015), demonstrating a good model fit.

Morphology is evaluated based on scores in animals that already participated in specific tests, in which one animal is compared with another, but it is also established individually for animals that already have a definitive registration, and must thus be more than three years of age. In this study, many of the animals are foals with a lower age than required to obtain definitive registration. Moreover, this is also a subjective characteristic, as it depends on the evaluation of an inspector or judge to establish scores for the animals analyzed, and there may be discrepancies between different evaluators. In horses, some factors can contribute to a wide dispersion of paternity and maternity data. According to Hafez and Hafez (2004) the species presents a long pregnancy period, of 11 months, and pregnancies with more than one fetus are rarely viable.

Thus, only older mares have the opportunity to be mothers of various individuals. One way of overcoming these characteristics would be the use of reproductive biotechnologies, which aim to maximize the reproductive use of mares and higher quality sires. However, the development of such techniques is also restricted in the species. The freezing of semen and the superovulation of mares, for example, procedures used for the dissemination of technologies such as artificial insemination and embryo transfer, are not as efficient for horses as they are for other species, such as cows. This technical aspect as well as the resulting high cost of assisted reproduction in horses means the use of such biotechnologies is not present in most cases of breeding.

For this reason, it was not possible to include in the model the genealogical information about mothers and grandmothers, as these did not present sufficient repetition of offspring to enable the analysis.

Table 3 presents the estimates of the parameters of the multiple regression model, which indicate the marginal value of each attribute studied.

Table 3. Estimates of the parameters of the multiple regression model and their standard deviations.

Attribute	Estimate	Attribute	Estimate
Continuous variables			
Intercept	35.30	NBIDS	-549.00
PRIZES	-2,110.00	SHARE	33.20
Binary variables			
Auction type			
ONLINE	20.10	VIRTUAL	-617.00
Category		Coat color	
NPREG	-101.00	BAY	215.00
Seller		Maternal grandsire	
SELLER3	-23.80	MATGSIRE2	-86.70
SELLER4	22.10	MATGSIRE3	35.5
SELLER5	-44.20		

Thus, the model determined to explain the variation in the prices of the horses of the Mangalarga Marchador breed at the accompanied auctions is described by Equation (2).

$$y = 35..30 + 20.10 * LIVE - 617.00 * VIRTUAL - 2.110.00 * PRIZES + 33.20 * SHARE - 101.00 * NPREG + 215.00 * BAY - 23.80 * SELLER3 + 22.10 * SELLER4 - 44.20 * SELLER5 - 549.00 * NBIDS - 86.70 * MATGSIRE2 + 35.5 * MATGSIRE3 \quad (2)$$

The number of prizes won by the animals in competitions negatively affected their sales value, reducing the value of the animal by R$ 2,110.00 for each prize obtained. Also present in the literature is the information that the prize of an animal can even be reflected in the price of its offspring (Robbins & Kennedy, 2001) (Taylor, Dhuyvetter, Kastens, Douthit, & Marsh, 2006). Moreover, consistent performance in competitions also makes breeding farms more respected, which is reflected in the sales prices of their products independent of the parentage of the animals sold (Lange et al., 2010).

The behavior of the estimate for the number of prizes won is probably due to the particular characteristics of the dataset studied. In this study, the animals that obtained the highest prices had few prizes, and they were young animals, which had few opportunities to participate in events to win prizes. The animals with the highest number of prizes were older individuals, with an average age of 11 years, which are less attractive to buyers due to their reduced useful life expectancy both for reproduction and for work and recreation.

In any case, knowledge of the marginal value attributed to the animals' prizes is important in the sense of planning spending on trials and competitions, and in which situations it is valid to think of competing with the exclusive aim of raising the value of the individual in question. Participation in equestrian competitions, in any modality, involves costs of enrollment, housing the animals and handlers during the competition, training, and transporting the animals, among others. Competitions with the Mangalarga Marchador breed, such as gait and conformation competitions, do not offer money prizes to the winners, but rather a winner's certificate, which attests to the animal's aptitude for that purpose. Along this line of reasoning, an individual's campaign of competitions may not be an investment that can be paid for with the sale of the animal alone.

The SHARE variable positively affected the sales value. A positive marginal value of R$ 33.20 was attributed to each extra share percentage offered. It is possible to explain this factor by the fact that the higher the share, the closer to 100% the sale of the animal is, and consequently, the more portions are sold, the higher the value will be of that animal.

With regards to genealogy, the parentage of the animal sold may positively or negatively influence the price. In this study, the pedigree variables that obtained significance in the model were maternal grandsires MATGSIRE2 and MATGSIRE3. The former had a negative result of R$ -86.70 with relation to the sale, and the latter positively affected the sale by R$ 35.50, in relation to the reference animal whose maternal grandsire

was MATGSIRE1. In the animals sold, the maternal grandsire variable was significant, and this occurs as there is an increase in valuation in relation to better known animals or those with greater performance in offspring and results, in relation to coat, morphology, gait, and other aspects.

The type of auction influenced the price of the animals. Live auctions, used as a reference, reach their audience through televised transmission on a previously scheduled date and time, as well as their being greater competition as there is a chance to buy the animal, as it is only possible to make a bid at the time when the lot is being transmitted. There is also the possibility of making a pre-purchase, in which a particular lot is chosen and paid for by the buyer before the transmission of the auction, based on negotiations.

In comparison to live auctions, online auctions positively affected the prices of the animals by R$ 20.10. This may be due to the fact that this system reaches a greater audience, as the lots are available on a website that accepts bids over a longer period, and when it closes, the possibility to buy and sell ends. The virtual type negatively affected the sales value by R$ -617.00, demonstrating that this auction has a considerably smaller audience as it concerns a website on which the lots are available for the participants to make their bids over a longer period, but with subsequent transmission on the website itself, which depends on an audience that accompanies the transmission in real time. However, it does not concern a televised transmission, and moreover, the sales begin based on the values already achieved in the pre-bid, where the animals were already previously available. This factor may also be explained by the marketing auction audience. According to Machado Filho and Zylbersztajn (1999), the sales system known as an auction depends on an organization that involves transaction costs, which consist of: informational costs, trading costs, and monitoring costs. Therefore, to run this event, there is a higher cost than for a direct sale.

According to Machado Filho and Zylbersztajn (1999), for there to be market competitiveness numerous buyers and sellers are needed, who should be attracted to the same place. For this, adequate disclosure is necessary, through specialist magazines, association newsletters, newspapers, and the media, which results in higher costs. Besides the costs of disclosure, general organization of the event, and displacement of the animals, the location for holding the event also gives rise to a high cost, and if the auction is live, a television channel must be acquired to carry out the auction. Consequently, the decision between the animals that will be sold at auctions and the type of auction must be directly related with their cost, as these factors influence the individual's value.

Regarding the seller, this variable both positively and negatively affected the sales value, depending on the seller. The SELLER3 and SELLER5 variables had a negative effect by R$ -23.80 and R$ -44.20, respectively. SELLER4 had a positive effect by R$ 22.10. This variation demonstrates that some of the sellers are more recognized, especially based on the name of the stud farm, and other are not, which can give the buyer greater confidence both in relation to the genealogy and to the results that a certain stud farm has.

In this study, the number of bids was an attribute of the sales process that negatively influenced the price of the horses in the auctions, where a R$ 549.00 loss of value was observed in the sales price of the animals for each additional bid. This occurred because in the accompanied auctions the most highly valued animals were not sharply contested. It warrants mentioning that the five animals with the highest bids were offered in the same auction, and there may be a direct relationship with the audience and disclosure of the event. Moreover, four animals that achieved the highest number of prizes in this study obtained only one or two bids.

This result appears to be particular to the dataset analyzed, as it is expected that competing bids in auctions raise the sales value of the animals offered, and that in sell-offs with weak competition the prices are lower (United States Department of Agriculture [USDA], 1954). For this reason, one of the fundamental aspects in the organization of auctions is their disclosure, in order to attract the greatest number of possible buyers to the sell-off. Such disclosure, according to Machado Filho and Zylbersztajn (1999), occurs through the media, newspapers, the internet, breed association newsletters, and adverts in specialist magazines. These disclosure strategies appear to be the ones that provide the public with more comprehensive knowledge, thus increasing the demand for the animals offered, and therefore their price.

Empty females presented a negative marginal value of R$ 101.00 in relation to the non-castrated males, adopted as a reference by the model. Two interpretations of this could be the buyers' profile and the animals' profile. Empty females are usually more highly valued for work or recreation purposes, as they can be used without the risk of problems such as abortions, while pregnant mares are primarily used for reproduction and preferred by a public that is interested in breeding horses. (Lange et al., 2010) verified higher marginal values for castrated males, lower ones for mares, and intermediate ones for sires in auctions of work and recreation horses. Thus, it is possible that most of the buyers were interested in animals for these purposes, instead of

mothers and sires. Moreover, animals with superior genetics are not normally sold at auctions and are preferably sold directly at the properties, or their genetics are made available only for the sale of mating and embryos. The other explanation is that in an empty female lot only one animal is offered, and an embryo or an upright foal is not included, which could raise its value.

In this study, the empty mares offered did not have renowned grandsires, as well as 90% of them being young ones that may not yet have started their reproductive life. Thus, despite the age variable not presenting significance in the model, it may help to explain the devaluation of the empty females.

Coat color is generally not a factor that is considered in hedonic analyses of race horse prices (Buzby & Jessup, 1994), (Neibergs, 2001), (Ng et al., 2013), in which sporting performance is usually a determinant. However, for animals meant for recreation this aspect becomes important, as verified by Lange et al. (2010). These authors identified positive marginal values of US$ 1,000.00 and US$ 400.00 for horses with a gray palomino coat in relation to animals with a chestnut coat. Maia, Silva, Maracaja, Marques, and Oliveira (2013) detected an increase in the Brazilian population of horses of the Quarto de Milha breed with a gray coat after the year 2000, and attribute this change to the increase in value of that coloration among buyers, highlighting that this taste is a manifestation of personal preference. The chestnut coat is the most frequent one in the breed (around 44% of the animals), but it has lost space to gray palomino colorations (7.8% of the animals), with the bay color remaining stable (at around 23%). The pinto coat is not accepted for registration purposes in the Quarto de Milha breed.

In this study, the bay coat was the most highly valued, obtaining values R$ 215.00 higher than the chestnut coat, which was used as a reference. The other coats did not present any effect in the model. No other studies were found regarding the preference for coats in the Mangalarga Marchador breed.

According to Briquet (1959), coat color is genetically determined through the interaction of various genetic loci and can be altered by factors such as sex, age, nutrition, season of the year, and climate. The genetic determination of coats in horses is harder to achieve compared with other species due to the cost of maintenance, age when the first offspring is born, duration of pregnancy, long generational intervals, and expensive installations. Moreover, the mode of inheritance and the large number of genetic loci involved have not yet been well elucidated by basic genetics (Edwards, 2001) nor defined by molecular genetics.

Nonetheless, coat color is a characteristic that is partly liable to manipulation by breeders, through mating choices. For example, for an animal to be born gray, one of its parents necessarily needs to be gray, and two chestnut animals necessarily produce chestnut foals. Therefore, knowing the marginal values of the different coat colors is important for providing decision-making support to breeders, especially regarding selection objectives.

Of the total quantity of 452 animals evaluated, 95 did not receive bids and were consequently not sold or did not obtain a price. To investigate which attributes influenced the chance of the animal being sold or not, we carried out a logistic regression with qualitative variables and chi-square tests with the continuous variables. The number of bids characteristic was not included in the model, precisely due to the fact that various animals did not present any bid (Table 4).

Table 4. Continuous variables analyzed[¥], and their U values (Mann-Whitney test) and P-values.

Continuous variables	U	P-value[Φ]	
PRIZES	11528	0,0023	*
SHARE	15018	0,0043	*
AGE	9654	7.055 e-05	*

[¥] The NBIDS variable was not included, as the unsold animals do not present bids.

No continuous variable was excluded by the Mann-Whitney test, and all were included in the model. Table 5 shows the binary variables analyzed and their χ^2 values, degrees of freedom, and P-values after the chi-square test.

Table 5. Binary variables analyzed and their χ^2 values, degrees of freedom, and P-values after the chi-square test.

Binary variables	χ^2	Degrees of freedom	P-value[Φ]	
Auction type	30.832	2	2.018 e-07	*
Category	5.506	5	0.3573	
Coat color	14.982	7	0.0362	*
Seller	121.85	6	< 2.200 e-16	*
Paternal grandsire	31.307	5	8.148 e-06	*
Maternal grandsire	13.495	5	0.0192	*

[Φ]Variables with $p < 0.20$ were incorporated into the model.

The sex variable was excluded from the model. Then the non-eliminated characteristics were included in the regression model and selected regarding the multicollinearity diagnostic, in order to guarantee variance inflation factors (VIFs) lower than 10. Table 6 contains the variables kept in the regression model and their VIF values, after the exclusion of the variables by the VIF criterion, we carried out a stepwise regression and new selection using the AIC.

Table 6. Variables kept in the regression model and their variance inflation factors (VIFs), after the multicollinearity diagnostic

Abbreviation	VIF	Abbreviation	VIF
Coat color		Seller	
SORREL	5.68	SELLER2	6.04
GRAY	5.99	SELLER3	4.65
GRULLO	4.84	SELLER5	6.96
Maternal grandsire			
MATGSIRE4	7.36		
MATGSIRE5	4.36		

The variables that remained in the final model, the estimates of the parameters of the logistic regression model, their standard deviations, and P-values, are found in Table 7.

Table 7. Variables that remained in the final model after the stepwise regression, estimates of the parameters of the logistic regression model, their standard deviations, and P-values.

	Odds ratio	Estimate	Standard deviation	P-value
Intercept	5.38	1.68	0.1625	< 2 e-16
GRAY	0.48	-0.74	0.2793	0.0083
SELLER3	0.18	-1.73	0.4309	5.71 e-05

With relation to the probability of selling or not selling, it is possible to measure this information based on the result of the risk. Values above 1 increase the chance of the animal being sold, and those below 1 reduce the possibility of it being sold. A gray coat reduced the probability of a sale by 48%. Seller 3 reduced the possibility of selling the animal by 18%.

The model determined to explain the chance of the horses of the Mangalarga Marchador breed being sold or not at accompanied auctions is described by Equation (3).

$$y = 1.68 - 0.74 * GRAY - 1.73 * SELLER3 \quad (3)$$

In the conditions of this study, the attributes that influenced the prices of the horses of the Mangalarga Marchador breed at auctions were the auction type, number of prizes, share sold, animal category, coat, seller, number of bids, and maternal grandsire. The factors that influenced the chance of the animals being sold or not were coat and seller.

Conclusion

Based on the hedonic function estimated by the model and the marginal values of each characteristic it is possible to provide support to breeders and other sellers to plan their breeding strategies and supply of animals, in order to obtain the most rewarding values from them. Coat color, category, prize, and seller influence auction type. As well as, number of prizes, share sold, animal category, coat, seller, number of bids, and maternal grandsire influenced the prices of Mangalarga Marchador horse. More studies are needed in this area, due to the scarcity of information and of data in the literature.

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