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Participation frequency and biometric characterization of Mangalarga horses that attended National Shows

[*Frequência de participação e caracterização biométrica de equinos Mangalarga participantes de Exposições Nacionais*]

"Scientific Article/Artigo Científico"

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Abstract
The aim of this study was to determine the frequency of participation of Mangalarga horses in morphofunctional trials, relating variables of sex and age group, and compare biometric characteristics of those animals among themselves and with the breed herd. Information on 4,133 Mangalarga horses that took part in national shows of the breed between 1984 and 2018 was used. To compare the proportion of stallions, females, and geldings that took part in national shows, the results were submitted to frequency distribution tests. To morphologically compare Mangalarga horses that attended national shows among themselves and with the breed herd (206,428 animals), the results of linear measurements were submitted to Mann-Whitney test and the means were compared by unpaired T-test. It was observed that most Mangalarga horses that took part in national shows competed only once. As for the age group of competitors, the proportion of females that competed only when young were similar to that of females that attended only as adults. Stallions competed more when young and geldings attended more as adults. Horses participating in shows had greater values for all three morphometric measurements (height to withers, shin perimeter and thoracic perimeter) than the breed herd. Moreover, in the last three decades, a reduction was observed in height at withers and cannon circumference of stallions and females attending the shows. It was concluded that most Mangalarga horses attended only one national show in their lives and that those animals have greater height at withers, cannon circumference, and thoracic circumference than the breed herd.

Keywords: competitions; equine; phenotypic selection; morphometry

Resumo
Objetivou-se determinar a frequência de participação de equinos Mangalarga em julgamentos morfofuncionais, relacionando às variáveis sexo e faixa etária, e comparar características biométricas desses animais entre si e com o rebanho da raça. Foram utilizadas informações de 4.133 equinos Mangalarga, participantes de exposições nacionais da raça entre 1984 e 2018. Para comparar a proporção de garanhões, fêmeas e machos castrados que participaram de exposições nacionais, os resultados foram submetidos a testes de distribuição de frequência. Para comparar morfologicamente os equinos Mangalarga participantes de exposições nacionais entre si e com o rebanho da raça (206.428 animais), os resultados de medidas lineares foram submetidos ao teste de Mann-Whitney e as médias comparadas pelo teste T não pareado. Observou-se que a maioria dos equinos Mangalarga participantes de exposições nacionais competiram somente uma vez. Em relação a faixa etária dos competidores, a proporção de fêmeas que competiram somente quando potras foi semelhante à das fêmeas que participaram apenas na fase adulta. Já os garanhões competiram mais quando potros. Os equinos participantes de exposições apresentaram maiores valores para as três medidas morfométricas que o rebanho da raça. Além disso, nas últimas três décadas observou-se redução na altura à cernelha e perímetro da canela dos garanhões e fêmeas participantes de exposições. Concluiu-se que a maioria dos equinos Mangalarga participam de apenas uma exposição nacional ao longo de sua vida e que esses animais possuem maior altura à cernelha, perímetro da canela e perímetro torácico que o rebanho da raça.

Palavras-chave: competições; cavalo; morfometria; seleção fenotípica.

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Introduction

In the process of formation of the Mangalarga breed, the search for animals able for sports practices, associated with the diagonal, comfortable gait, favored the expansion of the breed. However, breeders selected horses with such characteristics in an empirical manner, which led to the formation of a functionally superior herd, but that is morphologically heterogeneous (Almeida et al., 2021). In face of the need to standardize the animals of the breed, the Brazilian Association of Breeders of Mangalarga Horses (*Associação Brasileira de Criadores de Cavalos da Raça* – ABCCRM) was created in 1934, the same year the breed standard was instituted (ABCCRM, 2020). Currently, the ABCCRM has been orienting the breed selection to fit it into the concept of a saddle, work, and sports horse, maintaining the peculiar characteristics of the breed (Almeida et al., 2021).

Judging animals aims to divulge the breed standard, via phenotypic and functional evaluation, so as to fixate the characteristics recommended by the breed pattern (Campidelli and Josahkian, 2012). In addition to the economic importance of those trials, by gathering the best specimens from the herds, such shows provide bases for breeders and technicians to select in breeding farms the most adequate breeding animals to produce the next generations (Santos et al., 2018).

It is expected that animals awarded in the evaluation tracks be superior to the average animal of the herd and, consequently, contribute to the genetic improvement of future generations (Silveira and Josahkian, 2012). One of the ways of verifying the genetic contribution of broodmares and sires in a herd is the evaluation of characteristics of medium to high heritability, such as morphometric measurements. Faria et al. (2004) observed in foals of the Quarter Horse, Mangalarga, and Arabian breeds that the highest estimates of heritability were, in decreasing order, body weight, thoracic circumference, height at withers, cannon circumference, and body length.

In this context, this study aimed to determine the frequency of participation of Mangalarga horses in morphofunctional trials between 1984 and 2018 while relating variables of sex and age group. The study also compared linear measurements, dactyl-thoracic index and the registration score of the animals taking part in morphofunctional trials among themselves and with the breed herd.

Material and Methods

It was used information from 4,133 Mangalarga horses that participated in national shows of the breed between 1984 and 2018, extracted from the database of the Brazilian Association of Mangalarga Horse Breeders (ABCCRM).

To determine the frequency of participation of the horses in national shows, the data regarding each of the 35 shows were incorporated into a single spreadsheet. After this, the names of the hoses were organized in alphabetical order, which allowed counting the number of times each name repeated. To compare the proportion of stallions, females, and geldings that took part in one to nine national shows, the results were submitted to frequency distribution tests (chi-squared). The index proposed for the chi-squared was (χ^2):

$$\chi^2 = \sum_{i=1}^{k} \frac{(fo_i - fe_i)^2}{fe_i} (1)$$

Where fo_i and fe_i represented the frequencies observed and expected for sex i, while k was the total of sexes (stallions, females, and geldings).

To compare the age groups at which stallions, females, and geldings attended national shows, the data concerning the shows were separated into three groups: horses that competed only when young, animals that participated only when adults, and individuals that competed in both age groups. Next, the number of stallions, females, and geldings was counted in each group. The results were then submitted to a frequency distribution test. The index proposed for each sex was chi-squared (Equation 1), in which k was the total of nine groups (three sexes multiplied by three age groups).

During the inspection for the definitive genealogic registration, ABCCRM technicians analyze the morphology, gait, and temperament of the animal, verifying the score of each of the items, always oriented by the guidelines of the current breed standard. Thus, each horse is compared with the breed standard and, after a sum of the points of each of the evaluation items, the individual is placed into the classifications “Regular” (60 to 69 points), “Good” (70 to 79 points), “Very good” (80 to 89 points), and “Excellent” (90 to 100 points).

To compare the classifications awarded in the inspection for genealogic registration to stallions, females, and geldings that attended national shows, the data referring to the shows were separated by classification into four groups: regular, good, very good, and excellent. Next, the number of stallions, females, and geldings was counted in each group. The results were then submitted to a frequency distribution test. The

index proposed for each sex was chi-squared (Equation 1), in which *k* was the total of 12 groups (three sexes multiplied by four classifications).

To morphologically characterize the horses attending national shows and compare them among themselves and with the Mangalarga herd, information on the morphometric measurements of height at withers, thoracic circumference, and cannon circumference were extracted from the database of the genealogic registration system of ABCCRM of 4,133 horses taking part in national shows and 206,428 Mangalarga horses representing the breed herd. Two of those linear measurements were used to calculate the dactyl-thoracic index, mentioned by Almeida et al. (2021):

dactyl-thoracic index = cannon circumference/thoracic circumference (non-dimensional).

The results of the linear measurements and dactyl-thoracic index did not exhibit normal distribution and were submitted to non-parametric statistical analyses. Thus, to compare the horses that attended shows with the breed herd, the morphometric data were submitted to Mann-Whitney test ($p \leq 0.05$) and the means were compared by unpaired T-test ($p \leq 0.05$) using the statistical software GraphPad Instat (version 3.06).

To assess the alterations over the last three decades on the measurements and dactyl-thoracic index of horses attending national shows, the data of the animals were separated by sex and periods (1990 to 1999, 2000 to 2009, and 2010 to 2018). Both to compare the measurements and biometric index of each sex over the decades and to compare those measurements among the sexes within the same decade, the morphometric data were submitted to Kruskal-Wallis test ($p \leq 0.05$) and the means were compared by Dunn's test ($p \leq 0.05$) using the statistical software GraphPad Instat (version 3.06).

Results

Between 1984 and 2018, most Mangalarga horses that took part in national shows competed only once (59.04%) (Table 1). An analysis of the proportion of animals that participated in two to nine shows showed a gradual reduction in the number of competitors, with only one animal (female) participating in nine shows.

Comparing the frequency of participation of stallions, females, and geldings in national shows revealed a greater percentage of stallions attending those events only once (62.92%) than females (57.86%) and geldings (44.17%). Moreover, no difference was seen among the sexes in the proportion of individuals that competed in two national shows (24.05% stallions, 23.66% females, and 18.40% geldings), while the percentage of females that attended three shows (11.35%) was higher than that of stallions (8.42%) and geldings (6.13%).

Table 1. Frequency of participation of stallions, females and geldings Mangalarga at national breed shows, carried out between 1984 and 2018.

	Number of national contests							
	1	2	3	4	5	6	7	9
Number of animals (%)	59,04	23,57	10,16	4,45	1,35	1,04	0,36	0,02
Sex	Number of national contests							
	1	2	3	4	5	6	7	9
Females	57,86[b]	23,66[a]	11,35[a]	4,76[a]	1,36[a]	1,05[a]	0,35[a]	0,04[a]
Stallions	62,92[a]	24,05[a]	8,42[b]	3,46[a]	1,30[a]	1,15[a]	0,36[a]	-
Geldings	44,17[b]	18,40[a]	6,13[b]	7,98[a]	1,84[a]	-	0,61[a]	-

Different letters in the columns indicate a difference between the sexes by the frequency distribution test ($p<0,05$).

The proportion of Mangalarga females that competed only when young (38.76%) was like that of females attending shows only when adults (38.53%), both proportions above the frequency of females that competed in both age groups (22.72%) (Table 2). Stallions competed more when young (46.25%) and geldings attended more shows as adults (82.17%). Considering only the horses that competed both when young and adults, the females had a higher percentage of participation (22.72%) than stallions (19.12%) and geldings (17.83%).

As for the classification obtained by the horses in the inspection for the definitive genealogic registration, 93.48% of females and 91.85% of stallions that participated in national shows were classified as excellent or very good (Table 3). In addition, the proportion of females classified as excellent (43.43%) was higher than that of stallions (35.56%). On the other hand, the proportion of geldings classified as excellent was only 8.6%, with most classified as good (27.96%) or very good (60.22%).

Table 2. Percentage (%) of horses Mangalarga, grouped by sex, who participated in national exhibitions only when foals, only when adult or in both age groups, between the years 1984 and 2018.

Sex	Age groups		
	Foals	**Adult**	**Both**
Females	38,76^{Ba}	38,53^{Ba}	22,72^{Ab}
Stallions	46,25^{Aa}	34,63^{Cb}	19,12^{Bc}
Geldings	-	82,17^{Aa}	17,83^{Bb}

Different capital letters in the columns indicate a difference between the sexes by the frequency distribution test (p<0,05).
Distinct lowercase letters in the lines indicate difference between age groups (foal, adult and both age groups) by the frequency distribution test (p<0,05).
(-) n the national exhibitions of the Mangalarga breed there are no categories for castrated foals.

Table 3. Comparison, in percentage (%), between the sexes of Mangalarga horses participating in national breed exhibitions and the classification given to these individuals at the time of evaluation for granting the definitive genealogical record.

Classification	Sex		
	Females	**Stallions**	**Geldings**
Regular	0,14^{Db}	-	3,23^{Ca}
Good	6,37^{Cb}	8,15^{Cb}	27,96^{Ba}
Very good	50,05^{Ab}	56,29^{Aa}	60,22^{Aa}
Great	43,43^{Ba}	35,56^{Bb}	8,60^{Cc}

Different capital letters in the columns indicate difference between the classifications by the frequency distribution test (p<0,05).
Distinct lowercase letters in the lines indicate a difference between the sexes, in each classification, by the frequency distribution test (p<0,05).

Regardless of sex, the horses that participated national shows had higher values than the breed herd for the three morphometric measures considered in this study (height at withers, cannon circumference, and thoracic perimeter) (Table 4). Furthermore, the scores the competing animals achieved in the evaluation for the definitive genealogic registration were also higher than the scores achieved by the animals that made up the average of the breed herd.

Over the last three decades, the height at withers decreased by 1.3 cm in stallions and 1.1 cm in females attending national shows (Table 5). In addition, regardless of the decade considered, stallions were taller than females and geldings.

Table 4. Linear measurements and registration scores of stallions, gilts and geldings that competed in national Mangalarga breed shows between 1984 and 2018 (n=4.133), and the individuals who represented the herd of the breed (n=206.428).

	Stallions	**Females**	**Geldings**
		Height to withers (m)	
Competing	1,594^{A}	1,580^{A}	1,577^{A}
Herd	1,566^{B}	1,536^{B}	1,552^{B}
		Shin perimeter (m)	
Competing	0,197^{A}	0,190^{A}	0,196^{A}
Herd	0,194^{B}	0,187^{B}	0,192^{B}
		Thoracic perimeter (m)	
Competing	1,830^{A}	1,857^{A}	1,797^{A}
Herd	1,779^{B}	1,801^{B}	1,753^{B}
		Punctuation	
Competing	89,84^{A}	90,41^{A}	85,14^{A}
Herd	85,12^{B}	83,62^{B}	79,79^{B}

Distinct capital letters in the columns indicate difference between competing horses and the herd of the breed by the unpaired T test (p<0,05).

A similar behavior was observed for the cannon circumference, with a reduction over time both in stallions and females, while values of geldings remained unchanged. From 1990 to 2018, the cannon circumference of females was continuously smaller than that of stallions and geldings.

The thoracic circumference of the animals remained unaltered between 1990 and 2018, irrespective of the sex. In addition, over the three decades, females had greater thoracic

circumference than stallions, which, in turn, had greater thoracic circumference than geldings.

Regarding the dactyl-thoracic index, between 1990 and 2018, stallions and geldings went from hypermetric to eumetric, while females remained hypometric.

Discussion

The participation of Mangalarga horses in only one national show may be related to the high financial costs required for the specific training and differentiated handling, besides the infrastructure and logistics needed for those animals to take part in trials.

The low frequency of participation of Mangalarga horses in different national shows, equally observed in a study on Mangalarga Marchador and Campolina breeds (Nascimento et al., 2019), may also be associated with the poor performance of many of those animals in the contests, partially because the high level of competitors makes the competitions very tight. Thus, breeders interrupt the career of poorly qualified horses early to concentrate their attention and efforts only in those that achieved better results.

Table 5. Linear measurements and dactyl-thoracic index of stallions, females and castrated males that competed in national shows of the Mangalarga breed, born in the 90s, 2000s and 2010s (n=4.133).

	1990-1999	2000-2009	2010-2018
		Linear measures	
		Height to withers (m)	
Stallions	1,602^{Aa}	1,592^{Ab}	1,589^{Ab}
Females	1,588^{Ba}	1,584^{Bb}	1,577^{Bc}
Geldings	1,580^{Ba}	1,581^{Ba}	1,551^{Ca}
		Shin perimeter (m)	
Stallions	0,199^{Aa}	0,197^{Ab}	0,198^{Aab}
Females	0,193^{Ba}	0,189^{Bc}	0,190^{Bb}
Geldings	0,197^{Aa}	0,196^{Aa}	0,194^{ABa}
		Thoracic perimeter (m)	
Stallions	1,826^{Ba}	1,831^{Ba}	1,837^{Ba}
Females	1,874^{Aa}	1,864^{Aa}	1,859^{Aa}
Geldings	1,580^{Ca}	1,581^{Ca}	1,551^{Ca}
		Dactyl-thoracic index	
Stallions	0,1088^{Aa}	0,1073^{Ab}	0,1073^{Ab}
Females	0,1027^{Ba}	0,1023^{Ba}	0,1021^{Ba}
Geldings	0,1087^{Aa}	0,1086^{Aa}	0,1107^{Aa}

Different capital letters in the columns indicate a difference between the sexes by Dunn's test ($p<0,05$).
Distinct lowercase letters in lines indicate difference between decades by Dunn's test ($p<0,05$).

The opposite is also true, i.e., hoses that in their first participation in a national show are awarded the main titles of the breed may retire from those events after a single attendance as they have already reached their maximum goals. Normally, early retirement after great success directs those individuals to reproduction. Such condition also contributes with a great percentage of Mangalarga horses that competed in only one national show of the breed.

Some of the horses that had a short competitive career, taking part in only one national show, are directed to reproduction earlier, especially females. This consequence may be advantageous to the breeding farm by contributing to the reduction in the interval of generations and increasing the genetic variability of the herd.

The greater participation of stallions in a single national show, when compared with females and geldings, signals a greater rotation of individuals that compete in those categories, which may also be a positive for breed selection and improvement programs. Since the genetic progress of horses takes longer due to sexual maturity reached at three years old, gestation of 11 months, birth of a single foal per gestation, and 15% embryonic death (Zamborlini and Pereira, 1996), the constant renovation of the stallions that breeders take to shows and likely use in reproduction ends up speeding up the genetic progress of the breed.

In addition, given that, over their reproductive lifetimes, stallions leave a higher number of offspring in the herd than females, a more rigorous evaluation of the stallion that participates in competitions and later enters reproduction is crucial for the success of selection and improvement programs adopted in breeding farms (Rosa et al., 2013).

Higher frequency of attendance of young animals (future stallions) in national shows, when compared with adult individuals, may be the result of a strategy by breeders to bring forward the selection of their animals, submitting a higher number of young horses to the evaluation in the shows. That would allow them to precociously rule out poorly qualified animals and focus more attention on those with greater competitive and reproductive potential.

The early dismissal of less promising young horses may even have favored the higher frequency of attendance of geldings in shows only as adults (82.17%). Thus, many young animals that failed to obtain satisfactory results in national shows may have been castrated and, as adults, returned to compete in the gelding categories.

If on the one hand the higher frequency of attendance of young horses, both male and female, in national shows favors the early selection of individuals, on the other hand, the natural and balanced development of those animals may be harmed. For a young horse to be ready to take part in trials, its management changes, often with excess confinement and energetic foods, added to intense and specific training for the competitions. Such changes negatively influence the physical development of young horses, thus increasing the incidence of locomotor and musculoskeletal issues such as osteochondrosis, angular and flexural deformities, and alterations in bones and tendons (Gallio et al., 2014). In addition, excess confinement, allied to greater supply of concentrate food and reduction in roughage, increases idle time, which predisposing the animals to sociobehavioral disorders (Gallio et al., 2014).

According to Lucena et al. (2015), the little use of contests and zootechnical indices in equine selection in Brazil often contributes to the castration of individuals that could contribute to the genetic improvement of a herd or breed. In this sense, the higher concentration of stallions attending only when young must be seen as a warning for the possible premature ruling out of animals since, even if the evaluations are made by well-trained referees, they are still subjective. However, it the evaluation of the genealogic registration is considered, that may not have been frequent in the Mangalarga breed, in which most geldings were not assessed as "excellent," since only 8.6% earned this classification.

The fact Mangalarga females and stallions have reached higher registration scores than geldings indicate the selection by breeders, allied to the evaluation criteria used by registration technicians, using a scoring chart, reached the expected goal by eliminating from reproduction exactly individuals with lower scores (Almeida et al., 2021). Those results reinforce the importance of the genealogic registration system for the selection of phenotypically superior animals, eliminating undesirable characteristics from the herd.

Higher registration scores obtained by competing horses, compared with the breed herd, indicate proximity between the selection criteria adopted by breeders and the evaluation criteria used by registration technicians. Furthermore, although horses participating in national shows had higher means for the linear measurements and registration score, those values are numerically close to those of the breed herd, indicating that the morphological qualities valued on the evaluation tracks are also sought after for the remaining animals in breeding farms.

Regarding the three linear measurements assessed, the highest values observed in the competing horses compared with the breed herd may be associated with better nutritional and sanitary management provided to the former. Thus, the special attention provided to horses that participate in national shows enabled greater gene expression of the phenotype of the animal, translated into greater body development (Santiago et al., 2013). Such results corroborate those by Almeida et al. (2021), who assessed the Mangalarga breed herd and reported values of the linear measurements studied always lower than those of horses that took part in national shows.

In relation to the measurements and morphometric indices of the horses that attended national shows in the three decades under study, the values of height at withers of both Mangalarga stallions and females drew closer between 2000 and 2018. For the ABCCRM, the minimum height at withers required for definitive registration is 1.50 m for males and 1.45 m for females (ABCCRM, 2017), so males would be expected to be taller than females. However, over time, the use of taller stallions made the height of the entire herd increase since height at withers has high heritability (Almeida et al., 2021). That made females also taller, closer to the stature of males. The fact geldings always have lower height at withers than Mangalarga females and stallions may be one of the reasons why those animals were ruled out from reproduction (Lucena et al., 2015).

The dactyl-thoracic index is used to verify whether the bone capacity of the animal is proportional to its body weight by expressing the

relationship between the cannon and thoracic circumferences of a horse. According to Loughridge et al. (2017) and Wulster (2018), lower bone density added to intense and repetitive exercises increase the risk of bone fatigue and fractures. Thus, the smaller the cannon circumference of a horse, the greater the physical risks for this individual and its descendants since this trait has high heritability (0.68) (Meira et al., 2013). The thoracic circumference is related to cardiorespiratory and digestive capacities of the animal (Costa et al., 2016), besides also being associated with gestational conditions in females (Lucena et al., 2016).

Over the three decades assessed, the cannon circumference of females was continuously smaller than that of stallions and geldings, which contributed toward those females being classified as hypometric, i.e., lacking proportion between their body weight and bone-tendon structure, which makes them more vulnerable to orthopedic lesions given the fragility of their bones and tendons (Almeida et al., 2021). It is worth noting that hypometria may not be associated with smaller cannon circumference, but with excess weight of the horse, which leads to an increase in thoracic circumference and, consequently, a lack of proportion between the two measures.

Although stallions have exhibited a reduction in thoracic circumference over the decades assessed, they were still classified as eumetric. That means their bone structure is proportional to their body volume, a condition that is prescribed to saddle horses and recommended by the breed standard of the Mangalarga breed. In the last decade assessed (2010-2018), geldings reached the classification dictated by the breed standard, going from hypermetric to eumetric. Hypermetria indicates the horses have heavier bone structure than body volume, which may be undesirable to some sports activities as it makes the movements of the animal less agile.

Conclusions

Most Mangalarga horses attended only one national show in their lives. Horses that took part in national shows have greater height at withers, cannon circumference, and thoracic circumference than the breed herd and, over time, the selection applied made the stature of competing stallions and females decrease.

Conflict of interest

The authors declare that there is no conflict of interest.

Ethics and biosafety committee

The study used only the database of the Brazilian Association of Mangalarga Breeders, not requiring a license from the ethic committee in the use of animals.

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