

**Horse Agribusiness in Rio de Janeiro, Brazil: production diagnosis and productivity indexes of Mangalarga Marchador breeding systems**

**Agronegócio do cavalo no Estado do Rio de Janeiro, Brasil: diagnóstico da produção e proposição de índices de produtividade na produção de Mangalarga Marchador**

**Agronegocio equino en el estado de Rio de Janeiro, Brasil: diagnóstico de producción y propuesta de índices de productividad en la creación de Mangalarga Marchador**

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## Abstract

This study was carried out to evaluate the production indexes of the Mangalarga Marchador horse farms, in which horse's breeders were interviewed. The survey with 244 questions, where 262 variables were analyzed, of which 28 were used for the evaluation of productivity. The average number of births per farm/year throughout the Rio de Janeiro is 22.7 foals, which is equivalent to 42.5%, an average, of mares available for breeding. The birth rate is 94% throughout the Rio de Janeiro. More than 60% of stud farms have a mare's productivity index above 0.5, with the highest average for the Northwestern Fluminense mesoregion (0.70) and the lowest for the Central Fluminense mesoregion (0.52). The ratio between pregnant/donor recipients mares shows an average of 1.96 embryos conceived by donor, considering all farms in the State of Rio de Janeiro. The highest average was observed in the Northwestern mesoregion (2.20 embryos per donor) and the lowest in the Southern Fluminense mesoregion (1.72 embryos per donor). The artificial insemination using a stallion on the farm is greater than the use of natural mating, especially in the mesoregions where fertility rates in embryo transfer are higher. The productivity rate presented an average of 0.23 considering all farms in the State of Rio de Janeiro, and ranged from 0.20 to 0.26 in the Central and Northwestern Fluminense mesoregions, respectively. The Northwestern mesoregion presented the best average productivity index of the Mangalarga Marchador herd in the state of Rio de Janeiro.

**Keywords:** Gestation; Equine; Horse breeding; Productivity rate.

## Resumo

Este estudo objetivou avaliar os dados de produção e propor índices de produtividade dos criatórios da raça Mangalarga Marchador no Estado do Rio de Janeiro, cujos produtores foram entrevistados. O questionário continha 244 questões, onde foram analisadas 262 variáveis, sendo que 28 foram utilizadas para a avaliação da produtividade. A média de nascimentos por criatório / ano foi de 22,7 potros, o que equivale a 42,5%, em média, das fêmeas disponíveis para reprodução, sendo a taxa de natalidade de 94% em todo Estado. Mais de 60% dos criatórios possuem índice de produtividade das matrizes acima de 0,5, com a maior média para a mesorregião Noroeste Fluminense (0,70) e a menor para a mesorregião Centro Fluminense (0,52). A relação entre receptoras prenhes/doadoras em coleta demonstra uma média de 1,96 embriões por doadora, considerando para todo Estado. A maior média foi encontrada na mesorregião Noroeste (2,20 embriões por doadora) e a menor na mesorregião Sul Fluminense (1,72 embriões por doadora). Observou-se que a utilização de inseminação artificial com garanhão da propriedade é maior que a utilização de monta natural,

principalmente nas mesorregiões onde as taxas de fertilidade na transferência de embriões são maiores. A taxa de desfrute apresentou média de 0,23 em todo o Estado e variou entre 0,20 e 0,26 nas mesorregiões Centro Fluminense e Noroeste Fluminense, respectivamente. A mesorregião Noroeste Fluminense apresentou os melhores índices de produtividade média do plantel de equinos Mangalarga Marchador no Estado do Rio de Janeiro.

**Palavras-chave:** Cavalos; Equinocultura; Gestação; Taxa de desfrute.

### **Resumen**

El objetivo de este trabajo fue evaluar las tasas de producción de granja de la raza Mangalarga Marchador en el estado de Río de Janeiro. Se entrevistó a productores de caballos Mangalarga Marchador, con granjas instaladas en el Estado de Río de Janeiro. La encuesta contenía 244 preguntas, 28 de las cuales fueron utilizadas para la evaluación de la productividad. El número promedio de nacimientos en Río de Janeiro es de 22,7 potros, lo que equivale al 42,5% del número promedio de yeguas disponibles para la reproducción, y la tasa de natalidad es 94% en el estado. Más del 60% de los establecimientos tienen un índice de reproducción de las yeguas por encima de 0,5, con el promedio más alto para la mesorregión Noroeste Fluminense (0,70) y el más bajo para la mesorregión Centro Fluminense (0,52). La relación yeguas receptoras gestantes / receptoras muestra un promedio de 1,96 embriones concebidos por donante, considerando todas las granjas del Río de Janeiro. El promedio más alto se encontró en la región Noroeste (2,20 embriones por donante) y el más bajo en la mesorregión Sur Fluminense (1,72 embriones por donante). La inseminación artificial con un padrillo de la granja es mayor que el uso de la monta natural, especialmente en las mesorregiones donde las tasas de fertilidad con la transferencia de embriones son mayores. La tasa de productividad promedió 0.23 en todo el estado y varió entre 0,20 y 0,26 en las mesorregiones Centro Fluminense y Noroeste Fluminense, respectivamente. La mesorregión Noroeste Fluminense presentó los mejores índices de productividad promedio de la manada de caballos Mangalarga Marchador en el Estado de Río de Janeiro.

**Palabras clave:** Caballos; Equinocultura; Gestação; Tasa de disfrute.

### **1. Introduction**

Agricultural activities conducted for profit must be audited for their economic and technical performance. However, there are few small and medium-sized rural properties that examine their economic activity for posterior economic analysis and are therefore not aware

of their production costs. Thus, the lack of reliable sources of information leads producers to make decisions based on their experience, tradition, potential in the region, the lack of other options and the availability of financial resources and labor. When profitability is low, the producer realizes, but has difficulty in quantifying and identifying the bottlenecks of the production process (Oliveira et al., 2001). This occurs in any agricultural enterprise, especially in those that have made a high capital investment, as is the case of the horse breeding. Nogueira (2004) argued that to be able to carry out management decisions the inherent field operating costs, the financial aspects and the productivity index must be considered. Scarpelli (2007) also considered that the type of resources available in each region is determinant to evaluate the expected potential productivity of an enterprise.

The Total factor productivity (TFP) measures the efficiency with which all inputs (land, labor, capital, and materials) are combined to produce total outputs (all crop and livestock commodities). It is a good indicator of technological change (Heisey et al., 2011). It can also be defined by the difference between the growth of output and the growth of all inputs. However, productivity measures the changes in the efficiency in which the inputs are transformed into products (Gebhardt et al., 2008).

Horse breeding currently plays an important role in the world economy as a source of employment and is a market in constant growth. There is an increase in the demand for animals of superior genetics and with good sporting performance. Consequently, there is an increased demand for assisted reproduction techniques since they optimize production and contribute to animal genetic improvement. Among these techniques, embryo transfer (ET) is the most widely used in the world and its development for horses has increased considerably in the last two decades (Montechiesi, 2015).

According to Lopes et al. (2013), after two decades of research and development of the embryo transfer technique in equine species, it is not uncommon to observe today, pregnancy rates in an embryo transfer program comparable to those obtained by the estrous cycle with the use of natural mating or artificial insemination. Pregnancy rates and loss of embryos can be dramatically affected in recipients' mares who are losing weight, even when in good body condition (Riera, 2009). A good selection will determine the quality of the recipients' mares, while an ideal management will provide the adequate environment to maximize the pregnancy rates and reduce embryo losses (Alonso, 2008). According to Lira et al. (2009), several factors can contribute to the early embryonic death, be they intrinsic, extrinsic, or embryonic. Among the extrinsic factors are tension, nutrition, season, palpation, manipulation of the gamete and overall health of the animal.

Artificial insemination in horses is a technology that is widely practiced worldwide, and the most used way in this species is through the cooling and transport of semen (Loomis, 2006). Artificial insemination has been vital for the improvement of horse breeding, through the dissemination of genetics and the improvement of reproductive indices. In addition to optimizing the use of semen, it also reduces the spread of sexually transmitted diseases and protects animals from possible accidents and traumas to which they could be subjected to at the time of natural mating. The use of Artificial insemination with cooled or frozen semen allows the use of a stallion by breeders from different regions of the country and even from abroad. The spread of genes from superior individuals promotes improved genetics and growth of the breed. Frozen semen allows the use of genes from already deceased stallions. Duarte et al. (2013) reported on the substantial use of frozen semen in the artificial insemination of mares of the Brazilian Sport Horse breed that had been submitted to embryo transfer at an equine reproduction center.

Unlike other species of economic interest, such as cattle, the equines are selected by characteristics such as conformation, results in competitions or due to their genealogy (Varner et al., 2008). Often the reproductive aspect is not considered or rarely breeders take productive and reproductive aspects into account. The equestrian industry is full of stud farms that have a poor or below-recommended fertility index for the species. In the Mangalarga Marchador breed, both stallions and mares, including donors, are selected almost exclusively for their qualities in gait, which is defined by their superior marching gait and, in a second evaluation, the morphological and behavior patterns (ABCCMM, 2019).

Studies that demonstrate productivity indexes in Mangalarga Marchador equine production systems, with the purpose to qualify or characterize the productive system were not found in the literature; however there were studies related to the reproductive area such as pregnancy rates in embryo transfer, early embryo deaths or embryo recovery rates. The present study aimed to evaluate the productivity indexes of the Mangalarga Marchador horse production system and the profile of the stud farms in the state of Rio de Janeiro.

## **2. Methodology**

This research was carried out in two stages: the first was a consultation with the Brazilian Association of Breeders Mangalarga Marchador (ABCCMM) in order to collect the number of associated breeders and the means to contact them; the second was a field survey, through the use of a questionnaire for structured interviews with the production segment of

the Mangalarga Marchador horse agribusiness complex in the state of Rio de Janeiro. The interviews were carried out with breeders, at equestrian centers, at riding schools, etc... to collect data that characterize the production system of the breed in the State. The research was approved by the Research Ethics Committee of the Federal Rural University of Rio de Janeiro (UFRRJ), under the number: 972/17.

The questionnaire was developed based on the questionnaires used by Lima et al (2006), Oliveira (2012) and Oliveira (2013), with quantitative and qualitative questions, developed through Google Drive® in which it was hosted and accessed through a link. The answers were collected through personal interviews or by sending the link electronically, so the respondent himself could reply to the survey and then return it. All the replies were saved in a MS-Excel® file as soon as they were received from the respondent or the interviewer.

The stud farms were selected through sampling, which was stratified by the six graphic mesoregions of the state of Rio de Janeiro. A total of 202 stud farms were included in the survey, and were distributed as follows: Northwestern Fluminense (22), Northern Fluminense (19), Central Fluminense (28), Coastal Lowlands (21), Metropolitan mesoregion of Rio de Janeiro (85) and the Southern Fluminense mesoregion (29). Stratified sampling was obtained by dividing the study population into exclusive groups (strata) and then the random samples were extracted from the individual strata. Stratification can improve sample accuracy because it outweighs the tendency of simple random sampling in the over or under representation of the sample spectrum (Thrusfield, 2004).

The sample size was defined considering the level of precision desired, at a 95% confidence interval (95% CI), for the estimation of some parameters of interest at different levels of geographical disaggregation and specific population groups (Souza-Junior et al., 2015). The data obtained from the Mangalarga Breeders Association were used to define the population groups. The level of precision desired for each indicator is based on the 95% confidence interval. Then, the standard error was calculated based on this. The sample size was determined based on the estimation of the population proportion, for a finite population, and the following equation was used:

$$n = \frac{N \times \hat{p} \times \hat{q} \times (Z_{\alpha/2})^2}{\hat{p} \times \hat{q} \times (Z_{\alpha/2})^2 + (N-1) E^2}$$

where:

n = sample size.

$Z_{\alpha/2}$  = critical value that corresponds to the desired degree of confidence.

$\hat{p}$  = population proportion of individuals belonging to the category of interest.

$\hat{q}$  = population proportion of individuals not belonging to the category of interest ( $q = 1-p$ ).

E = margin of error or maximum error of estimation. Identify the maximum difference between the sample proportion and the true population proportion (Souza-Junior et al., 2015).

In this study, a confidence level of 95% was used, where  $Z_{\alpha/2}$  corresponds to 1.96. The value of 0.5 was adopted for p and q, when these are unknown (Levine, 2000). In total, 244 questions were transformed into 262 variables, of which 28 were used to study the Mangalarga Marchador horse productivity in the state of Rio de Janeiro. Some indices were elaborated from the results to study the productivity of the stud farms in the Rio de Janeiro:

\_Productivity Index of the Mares: number of pregnant mares born / total number of mares;

\_Productivity Index of Donors mares: number of pregnant recipients / total number of donors;

\_Productivity Index of Females: number of births / mares + donors + recipients' mares;

\_Technological Index: number of pregnancies by AI gestations/total number of pregnancies.

\_Gestation rate: number of pregnant mares/total number of breeding mares;

\_Birth rate: number of births/number of pregnant mares;

\_Productivity rate: number of births/total number of animals;

\_Embryo Transfer (ET) Pregnancy Rate: number of pregnant recipients' mares/number of embryos transferred.

The data of the variables and indices were analyzed by descriptive statistics, using the Statistical Package for Social Science (SPSS), version 24.0.

### 3. Results

The mean number of stallions per stud farm of Mangalarga Marchador horses in the state of Rio de Janeiro is around 2.5 animals, both in the general average and in the mesoregions, without much variation (Table 1). There is also little variation for the average number of mares, which is approximately 18 mares per stud farm throughout the State and varies between 17.52 and 19.96 in the Coastal Lowlands and Central Fluminense mesoregions, respectively. The average number of donors varies from 5.59 to 9.27 between the Northern and Northwestern Fluminense regions, respectively. And the average number of recipients' mares varies from 17.65 to 37.64, also between the Northern and Northwestern Fluminense regions, respectively. Therefore, there is a mean range of 3 to 4 recipients' mares per donor between the same regions already mentioned, respectively.

**Table 1.** Average number of animals per category in the Mangalarga Marchador herds, throughout the state of Rio de Janeiro and in each mesoregion.

Category	Rio de Janeiro	Mesoregions					
		Coastal Lowlands	Central Fluminense	Metropolitan	Northwestern Fluminense	Northern Fluminense	Southern Fluminense
Stallions	2.50±2.03	2.67±2.16	2.64±1.61	2.41±1.75	2.45±2.63	2.13±1.06	2.70±2.51
Mares	18.57±14.34	17.52±12.46	19.96±13.71	18.58±15.70	17.68±13.02	19.82±13.99	17.83±15.04
Foals born	19.75±19.49	15.95±11.28	20.21±15.85	18.03±14.92	26.77±31.83	15.82±15.02	20.75±19.93
Colts 6 to 36 m	8.16±8.16	8.62±8.31	9.71±9.38	7.00±5.43	8.55±9.43	7.53±6.46	8.40±10.12
Fillies 6 to 36 m	14.03±12.64	15.10±16.21	14.75±10.86	12.62±10.41	15.36±15.18	15.00±11.96	13.25±13.12
Gelding horses	2.25±2.83	2.29±2.47	3.07±3.79	1.95±2.28	2.41±3.20	2.59±1.98	1.53±2.62
Donors mares	7.69±8.17	8.10±7.32	8.64±8.19	7.38±7.12	9.27±9.76	5.59±6.91	6.83±9.18
Recipients 'mares	27.23±34.82	27.86±34.70	32.93±30.68	23.41±26.95	37.64±46.98	17.65±26.33	23.88±39.76
Total animals	99.85±80.78	98.10±70.03	111.93±74.47	91.34±67.37	120.14±111.49	86.00±62.71	93.08±87.30

Source: Authors.



The average number of females for breeding, including mares, donors and recipients' mares, is 53.49 females per stud farm throughout the State, which corresponds to 53.57% of the total number of animals in the herd. The largest range of the mean number of breeding females, especially in the larger stud farms, occurs where there is a greater number of recipients' mares. Approximately 50% of stud farms throughout the State have 51 to 150 animals and 52% have between 0.1 and 100 ha of their own land (Table 2).

**Table 2.** Average number of mares for breeding, based on the size of the stud farm in number of animals and area.

	Category of Stud Farm	Average number mares for breeding
Total Number of Animals	1 to 10	2.82 ± 1.84
	11 to 50	14.21 ± 7.49
	51 to 150	48.01 ± 17.82
	>150	126.45 ± 45.16
Total Area (ha)	0	29.72 ± 15.85
	0.1 to 100	33.72 ± 29.22
	100.1 to 500	71.20 ± 36.66
	> 500	116.41 ± 69.32

Source: Authors.

The average number of births throughout the state is 22.73 foals per stud farm (Table 3). The lowest average is 16.06 births and the highest is 28.86 births, in the Northern and Northwestern Fluminense mesoregions, respectively. Considering the average number of breeding females throughout the State, the average number of births is equal to 42.49% of the average number of females available for breeding. These results correspond to the Female Productivity Index. Thus, on average 49% of the females in the State become pregnant and 46% gestate. These data reflect a birth rate of 94% throughout the State and varies from 85% in the Central Fluminense mesoregion to 98% in the Coastal Lowlands and Northwestern Fluminense regions.

The productivity index of Mangalarga Marchador proposed by the study are shown in the Table 4. Analyzing the mares separately, the state average is approximately 12 pregnant mares, 10 foaled mares and 4 maiden mares. This corresponds to 16.7% of embryonic loss during pregnancy and 22.2% of cover or insemination failure. When analyzing the productivity index of the mares, more than 60% of the stud farms have an index above 0.5.

The lowest average is in the Northwestern Fluminense mesoregion (0.70) and highest average is in the Central Fluminense mesoregion (0.52).

The analysis of the reproduction system with embryo transfer showed that the State average is 6.13 donors per farm. However, the Northern Fluminense mesoregion differs from the others, presenting not only a low average number of donors, but also pregnant recipients' mares, barren recipients' mares and transferred embryos, as well as the use of artificial insemination as a reproduction technique. These results clearly reflect the lower productivity rates, in this mesoregion, of donors (0.58) and the use of technology in reproduction (0.45), because 58.8% of the stud farms do not transfer embryos and 43.8% do not use them or any form of artificial insemination in reproduction.

The ratio between pregnant recipients' mares/donor shows an average of 1.96 embryos conceived per donor, considering the whole State. The highest average was found in the Northwestern mesoregion (2.20 embryos per donor) and the lowest in the Southern Fluminense mesoregion (1.72 embryos per donor). These averages reflect the number of pregnancies per donor, but do not yet consider the embryonic losses during the gestational period. Considering these losses gives the productivity index of the donors, which is very low throughout the State. In some regions, less than one donor-born embryo is reported. The productivity rate presented an average of 0.23 for the whole State and ranged from 0.20 to 0.26 in the Central Fluminense and Northwestern Fluminense mesoregions, respectively.

Considering the profile of the stud farms, the donor productivity, female productivity, gestation rate, embryo transfer gestation rate and productivity rate, are lower when the main aim of the breeding is direct trade, that is, the purchase and sale of animals (Table 5).

**Table 3.** Average productivity of each category of Mangalarga Marchador herds, in every State of Rio de Janeiro and in each mesoregion.

Variable	Options	Rio de Janeiro	Mesoregions					
			Coastal Lowlands	Central Fluminense	Metropolitan	Northwestern Fluminense	Northern Fluminense	Southern Fluminense
Mean								
number of births/year		22.73±19.98	22.00±18.32	21.62±16.35	23.19±18.72	28.86±26.78	16.06±16.70	22.16±19.47
Mean number of deaths/year		1.84±1.87	2.45±2.17	2.27±2.30	1.86±1.91	1.52±1.22	1.18±1.30	1.68±1.71
Mean number of mares	Pregnant	12.47±11.25	11.15±6.98	13.69±11.37	12.67±11.38	12.14±9.25	11.12±13.14	12.92±13.45
	Foaled	10.26±10.53	8.25±6.31	10.62±9.41	10.28±11.17	11.24±9.19	10.82±12.62	9.82±12.37
	Barren	4.33±6.15	5.85±8.45	4.54±7.70	4.45±5.83	3.38±3.40	2.35±3.34	5.21±6.21
Embryo Transfer Reproduction	Donors	6.13±7.72	6.50±6.72	6.50±7.56	6.09±6.70	7.86±10.03	2.47±4.07	6.37±8.70
	Pregnant Recipients mares	12.07±16.82	14.00±19.06	12.69±14.62	11.52±14.94	17.33±23.37	4.53±9.36	11.00±14.75
	Barren Recipients mares	9.72±14.39	9.25±13.64	8.04±10.63	9.13±12.78	17.10±21.11	3.82±8.22	9.61±13.51
	Transferred embryos	12.84±19.59	15.55±22.44	10.23±15.42	11.74±16.05	20.43±29.73	5.71±10.38	13.13±16.79
Pregnancies	Pregnant by natural mating	7.98±9.60	5.80±5.14	7.88±9.43	8.65±9.71	6.33±5.77	8.47±10.96	9.71±31.01
	Pregnant by AI stallion	9.21±15.13	12.50±20.61	9.15±16.04	7.94±9.20	16.24±22.04	2.94±5.83	6.58±10.51
	Pregnant by AI-cooled semen	4.91±6.66	5.40±6.05	5.77±7.61	3.89±4.89	6.67±9.47	4.59±6.92	3.89±4.21
	Pregnant by AI-frozen semen	0.81±3.27	0.80±1.58	0.77±2.94	1.37±5.21	0.81±1.99	-	0.45±1.78

Source: Authors.

**Table 4.** Productivity indexes of Mangalarga Marchador horses throughout the state of Rio de Janeiro and in each mesoregion (continued)

Indices (n=848)	Values	Rio de Janeiro (%)	Mesoregions (%)					
			Coastal Lowlands	Central Fluminense	Metropolitan	Northwestern Fluminense	Northern Fluminense	Southern Fluminense
Productivity index of mares	0	9.7	-	11.5	12.1	4.8	12.5	13.2
	0.01 – 0.30	9.4	20.0	15.4	9.1	9.5	-	2.6
	0.31 – 0.50	13.1	5.0	15.4	16.7	4.8	12.5	18.4
	0.51 – 1.00	67.8	75.0	57.7	62.1	81.0	75.0	65.8
Mean/standard deviation		0.59±0.29	0.63 ±0.26	0.52±0.31	0.54±0.30	0.70±0.27	0.64±0.30	0.55±0.27
Productivity index of donors	0	32.5	25.0	26.9	34.8	19.0	58.8	34.2
	0.01 – 1.00	22.8	35.0	26.9	27.3	14.3	11.8	18.4
	1.01 – 2.00	32.3	15.0	38.5	27.3	42.9	23.5	42.1
	2.01 – 4.00	12.4	25.0	7.7	10.6	23.8	5.9	5.3
Mean/standard deviation		1.03±0.96	1.14±1.16	0.99±0.86	0.90±0.89	1.57±0.99	0.58±0.77	1.00±0.87
Productivity index of females	0	4.8	-	7.7	4.5	-	11.8	5.3
	0.01 – 0.30	14.0	15.0	23.1	15.2	9.5	-	15.8
	0.31 – 0.50	44.8	50.0	50.0	43.9	47.6	41.2	36.8
	0.51 – 1.00	36.5	35.0	19.2	36.4	42.9	47.1	42.1
Mean/standard deviation		0.46±0.21	0.45±0.14	0.40±0.21	0.46±0.20	0.51±0.18	0.51±0.25	0.46±0.23
Technological index	0	24.1	11.1	24.0	25.4	14.3	43.8	27.0
	0.01 – 0.30	9.0	11.1	12.0	12.7	-	-	13.5
	0.31 – 0.50	20.9	22.2	28.0	11.1	19.0	31.3	24.3
	0.51 – 1.00	46.0	55.6	36.0	50.8	66.7	25.0	35.1
Mean/standard deviation		0.53±0.50	0.67±0.48	0.48±0.38	0.57±0.64	0.61±0.31	0.45±0.56	0.43±0.39

Indexes (n=848)	Values	Rio de Janeiro (%)	Mesoregions (%)					
			Coastal Lowlands	Central Fluminense	Metropolitan	Northwestern Fluminense	Northern Fluminense	Southern Fluminense
Gestation rate	0	4.8	-	7.7	4.5	-	11.8	5.4
	0.01 – 0.30	14.2	15.0	23.1	13.6	14.3	5.9	10.8
	0.31 – 0.50	36.2	50.0	30.8	36.4	28.6	35.3	40.5
	0.51 – 1.00	44.8	35.0	38.5	45.5	57.1	47.1	43.2
Mean/standard deviation		0.49±0.23	0.47±0.14	0.45±0.25	0.48±0.22	0.56±0.20	0.50±0.27	0.51±0.29
Birth rate	0	5.9	-	9.1	5.9	-	13.3	6.7
	0.31 – 0.50	5.3	-	9.1	5.9	-	-	13.3
	0.51 – 1.00	88.8	100.0	81.8	88.2	100.0	86.7	80.0
Mean/standard deviation		0.94±0.42	0.98±0.27	0.85±0.38	0.98±0.53	0.94±0.26	0.95±0.50	0.91±0.41
Productivity rate	0	4.8	-	7.7	4.5	-	11.8	5.3
	0.01 – 0.30	77.8	85.0	80.8	77.3	76.2	64.7	81.6
	0.31 – 0.50	17.0	15.0	11.5	18.2	23.8	23.5	10.5
	0.51 – 1.00	0.4	-	-	-	-	-	2.6
Mean/standard deviation		0.23±0.09	0.22±0.06	0.20±0.08	0.23±0.08	0.26±0.09	0.23±0.09	0.23±0.11
Embryo Transfer gestation rate	0	30.8	27.8	28.0	28.8	14.3	52.9	40.5
	0.01 – 0.30	1.0	5.6	-	1.5	-	-	-
	0.31 – 0.50	7.9	5.6	8.0	10.6	9.5	11.8	-
	0.51 – 1.00	60.3	61.1	64.0	59.1	76.2	35.3	59.5
Mean/standard deviation		0.53±0.50	0.68±0.58	0.67±0.75	0.54±0.39	0.66±0.32	0.32±0.37	0.48±0.42

Source: Authors.

**Table 5.** Average productivity indexes of Mangalarga Marchador horses in the state of Rio de Janeiro and in the mesoregions, within the profile of each stud farm.

Indices	Profile of Stud farm					
	Sport (n=269)	Commercialization of Production (n=311)	Direct Sale (n=53)	Recreational (n=126)	Working (n=18)	Training Center (n=12)
Productivity of Mares	0.59 ±0.30	0.59 ±0.27	0.58 ±0.32	0.58 ±0.30	0.54 ±0.23	0.54 ±0.38
Productivity of Donors	1.03 ±1.04	1.04 ±0.96	0.80 ±0.74	1.11 ±0.82	1.51 ±0.91	0.52 ±0.62
Productivity of Females	0.47 ±0.20	0.46 ±0.59	0.38 ±0.23	0.47 ±0.17	0.48 ±0.91	0.51 ±0.28
Pregnancy rate	0.48 ±0.22	0.51 ±0.24	0.38 ±0.23	0.50 ±0.16	0.42 ±0.17	0.67 ±0.26
Embryo Transfer pregnancy rate	0.50 ±0.44	0.56 ±0.43	0.47 ±0.31	0.79 ±0.74	0.68 ±0.37	0.26 ±0.31
Birth rate	0.96 ±0.44	0.89 ±0.46	0.97 ±0.37	0.96 ±0.29	0.98 ±0.35	0.79 ±0.30
Productivity rate	0.23 ±0.09	0.23 ±0.09	0.20 ±0.90	0.23 ±0.64	0.22 ±0.14	0.21 ±0.59
Technological index	0.49 ±0.46	0.52 ±0.57	0.56 ±0.27	0.68 ±0.48	0.43 ±0.43	0.50 ±0.39

Source: Authors.

#### 4. Discussion

The Northern Fluminense region has a low average number of births per stud farm and has the highest female productivity index (0.51), the same as the Northwestern Fluminense region which has the highest birth rate. The gestation rate of the breeding females presents averages a little higher, since it does not consider the losses during gestation. In relation to the pregnancy and birth rates, higher results were obtained by Sereno et al. (1996) who observed, at the mating season of 1991/1992, rates of 100% gestation and 100% birth rate in a Pantaneiro horse herd in a natural mating system, using a male/female ratio of 1:10. Ferraz e Vicente (2006) observed after 60 days a 60.4% pregnancy rate and early embryonic death of 10.7% in Thoroughbred mares between 1995 and 2002, submitted to AI.

These mares were maintained on Coast Cross pastures (*Cynodon dactylon* (L.) Pers. cv Coast cross 1), and received commercial feed supplements, oats, alfalfa, and mineralized salt, twice a day. Oliveira et al. (2013) observed a pregnancy rate of 70% in Crioula mares

inseminated with fresh semen and 40% for those inseminated with frozen semen. Taveiros (2011) observed embryo loss rates of 10.7% in mares submitted to AI and 11.8% in mares submitted to embryo transfer.

Donors are mostly kept on a semi-intensive or intensive system, while the recipients' mares are kept, in large majority, on an extensive system. As pastures are of low nutritional value, since 43.69% of the pasture area in the state of Rio de Janeiro is formed by *Brachiaria* grass, nutritional management may be contributing effectively to the low productivity indexes in the production of embryos of mares of the Mangalarga Marchador breed. In the Northern Fluminense region, where the lowest donor and gestation rates are observed, 100% of the recipients' mares are raised in the field, where 54.40% of the pastures are formed by *Brachiaria* grass. In the Northwestern Fluminense region, for example, where productivity and fertility rates are higher, 31.09% of pastures are *Brachiaria* grass, 22.33% Tifton and 18.99% Mombaça grass. According to Cintra (2014), nutritional imbalance is one of the main causes of infertility of breeding mares. Furthermore, one of the greatest risks of embryo transfer is the feeding of the recipient mares, which, because it is an animal of lower zootechnical value, often receives feed that does not reach its daily minimum needs so that it can gestate normally. Therefore, providing the right amount of protein, energy, vitamins, and minerals is fundamental.

Recipient mares also play a key role in the success of the embryo transfer program. These mares must be in good health, and because they represent the most numerous categories within the production system, it is generally impossible for these recipient mares to have ideal management conditions in the central part of the properties. Therefore, it is recommended that the recipients' mares are housed in facilities far from the busy areas of the properties (Lopes et al., 2013). Fleury et al. (2001) observed a pregnancy index of 78.7% of the embryos of Mangalarga mares transferred to recipients' mares. This index is for the fixation of the transferred embryo, which was considered in this study as the pregnancy rate of embryo transfer. Jacob et al. (2002) observed, in Mangalarga Marchador mares, gestation rates of 70.3% (270/384) at 14 days and 64.3% (247/384) at 60 days, with early embryo loss of 6% at 60 days after donor ovulation. Jacob et al. (2010) reported 60% gestation at 60 days (274/454) in Mangalarga Marchador mares. Santos et al. (2008) observed 63.6% gestation at 60 days of 382 embryos transferred.

The average number of 27.23 recipients' mares throughout the State and the average of 9.72 barren recipients' mares per farm shows that a little over 1/3 of the total number of recipients' mares are barren at the end of the breeding season, and this reflects on the costs of

feeding, labor and sanitary management. The breeders prefer to keep these mares in the herd, mainly because they will already be adapted to the environment and handling for the next season. The use of artificial insemination with stallion of the farm is greater than the use of natural mating, mainly in the mesoregions where the fertility rates in ET are higher, which are the mesoregions of the Coastal Lowlands and Northwestern Fluminense.

About the use of breeding techniques, Oliveira (2012) observed that 51% of the producers in the Southern part of Brazil and 42.5% in Argentina maintained natural mating. However, 12.9% and 2.5% used artificial insemination with fresh semen and 6.5% and 20% used fresh and frozen semen in the South of Brazil and Argentina, respectively. According to the author, the high frequency of properties that use only natural mating can be explained by the restriction of the use of breeding bio-techniques by the associations of pure Thoroughbred and Crioulo breeds predominant in the South of Brazil and Argentina. Duarte et al. (2013) found embryo recovery rates of 62%, 62.2% and 51.6% with the use of fresh, refrigerated and frozen semen, respectively, in Brazilian Sport mares and concluded that artificial insemination processed with frozen semen, generated fewer embryos than with fresh and refrigerated semen, suggesting the need for more research into freezing sperm cells, in order to reach the pregnancy index levels when semen was used fresh or cooled. When the data are analyzed within the profile of each stud farm, ie sport, commercialization of production, direct trade, recreation, working or training center, lower indices and lower rates were observed at stud farms where direct trade is the main objective. In these cases, reproduction is a priority as the focus is buying and selling, and the less time the animal stays at the stud farm, the more profitable it will be. Animals that remain longer in the herd are used for reproduction, but productivity rates fall due to, perhaps, the little investment in biotechnology.

## **5. Conclusions**

The average number of females in breeding, including mares, donors and recipients is 53.5 mares throughout the State of Rio de Janeiro, corresponding to 53.57% of the total of animals in the herd. The average number of births is 22.7 foals, which is equivalent to 42.5% of the average number of mares available for breeding in the Rio de Janeiro. The birth rate is 94% in all regions and varies from 85% in the mesoregion Center Fluminense to 98% in the mesoregions of Coastal Plains and Northwest Fluminense.

The average number of donors ranged from 5.6 to 9.3 between the North and Northwest Fluminense regions, respectively. The average number of recipient's mares ranged



from 17.7 to 37.6 heads, also between the North and Northwest Fluminense regions, respectively, varying from 3 to 4 recipients per donor, among these regions. There was a mean of 2.5 stallions and approximately 18 mares per herd throughout the State of Rio de Janeiro.

More than 60% of the farms have a mare productivity index above 0.5, highest in the Northwest Fluminense (0.70) and lower in the Center Fluminense (0.52) mesoregion. In the analysis of the embryo transfer reproduction system, an average of 6.2 donors per herds was observed, but in the Northern Fluminense mesoregion 58.8% of the herds do not use transfer embryos technique and 43.8% do not use any form of artificial insemination in the reproduction.

The ratio of pregnant/donor recipients mares shows an average of 1.96 embryos conceived per donor, considering all regions. The highest average was observed in the Northwest mesoregion (2.20 embryos per donor) and the lowest in the South Fluminense mesoregion (1.72 embryos per donor). It is observed that the use of artificial insemination with stallion of the property is greater than the use of natural mating, mainly in the mesoregions where the fertility rates in the embryo transfer are higher, which are the mesoregions of the Coastal Plains and Northwest Fluminense.

The productivity rate presented an average of 0.23 in all regions and ranged from 0.20 to 0.26 in the Center and Northwest Fluminense regions, respectively. Donor productivity indexes, mare productivity, pregnancy rate, embryo transfer pregnancy rate, and productivity rate are lower when the main objective of breeding is direct trade. The Northwest Fluminense mesoregion presented the best average productivity index of the Mangalarga Marchador farms in the state of Rio de Janeiro.

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