

Effects of Age and Sex of The Foal on The Gestation Length of Thoroughbred Mares

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ABSTRACT

The purpose of this study was to determine the effects of age and sex of the foal on the gestation length of thoroughbred mares. The study covered six stallions (of average age of 10.25 years) and 34 mares (of average age of 10.51 years) with descent records (pedigree), English Thoroughbred horses raised and actively used for breeding at a study farm called *Ljubičevo*, located in Serbia. The following average morphological body measures were established: body weight (473.10 kg), withers height (159.55 cm), body length (160.54 cm), chest circumference (188.00 cm), and tibia circumference (19.21 cm) were found to be within the scope of standard measures for this breed and particular ages e.g. 9 to 15. The average gestation length, regardless of the sex of the foal, was 336.57 days. The gestation of mares carrying male foals was somewhat longer (337.70 days) than of mares carrying female foals (335.80 days). The difference (1.90 days) in gestation length was not statistically significant ($P>0.05$). A weak positive correlation ($r_p=0.321$) was observed between the age of the mare and the gestation length (regardless of foal sex). Additionally, a medium correlation ($r_p=0.444$) was observed between the mare's age and the gestation length in the case of male foals, and a very weak correlation ($r_p=0.210$) in the case of female foals.

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Yavruların Yaşı ve Cinsiyetinin Safkan Kısrakların Gebelik Uzunluğu Üzerine Etkileri

ÖZET

Bu çalışmanın amacı, kısraak yaşı ve tay cinsiyetinin safkan kısrakların gebelik süreleri üzerine etkilerini saptamaktır. Çalışma, Sırbistan'da bulunan Ljubičevo adlı bir damızlık çiftliğinde yetiştirilen ve aktif olarak kullanılan safkan atlar içerisinde pedigrı kayıtlı bulunan altı aygır (ortalama 10.25 yaş) ve 34 kısraak (ortalama 10.51 yaş) ile yürütülmüştür. Morfolojik beden ölçüleri canlı ağırlık (473.10 kg), omuz yüksekliği (159.55 cm), beden uzunluğu (160.54 cm), göğüs çevresi (188.00 cm) ve tibia çevresi (19.21 cm) olarak hesaplanmıştır. Ortalama gebelik süresi 336.57 gün olarak bulunmuş olup erkek tay taşıyan kısraakların gebelik süresi (337.70 gün), dişi tay taşıyan kısraaklara (335.80 gün) göre biraz daha uzun saptanmıştır. Kısraak yaşı ile gebelik süresi arasında zayıf pozitif korelasyon ($r_p = 0.321$) gözlenmiştir. Ayrıca erkek taylar söz konusu olduğunda, kısraak yaşı ile gebelik uzunluğu arasında orta bir korelasyon ($r_p = 0.444$); dişi taylar söz konusu olduğunda ise çok zayıf bir korelasyon ($r_p = 0.210$) gözlenmiştir.

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INTRODUCTION

Currently, the English Thoroughbred horse is raised

all over the world, with this breed long ago overcoming geographical barriers and borders between the countries. However, the information

available on the overall population of this breed remains insufficient. The English Thoroughbred horse has a long breeding history in Serbia and in the region. In Serbia, it is bred in small numbers on some farms and in horse clubs (FAOSTAT, 2018). In Serbia, their numbers are stagnant, while in countries within the region, breeding marks a growth. Trailović et al., (2007) point out that in this country (as well as globally) interest is primarily placed on horse racing, recreation and horse sports and consequently, breeding is focused on raising individual animals to serve these purposes. In urban environments in The Republic of Serbia, English Thoroughbred horses, trotters and half-blood breeds and types of horses are raised for this reason. *Ljubičevo* is a study farms in Serbia breeding Thoroughbred horses of different categories.

In the Republic of Serbia, the exterior, reproductive and even racing characteristics of the Thoroughbred horses have been researched and verified on a very limited scale. In the middle of the 20th century, Hrasnica et al., (1964) report the following external parameters of the Thoroughbred horse: withers height – 159.2 cm (♀) and 160.3 cm (♂); body length – 161.0 cm (♀) and 162.2 cm (♂); rump height – 159.2 cm (♀) and 158.9 cm (♂); chest depth – 76.7 cm (♀) and 75.2 cm (♂); chest circumference – 185.4 cm (♀) and 182.4 cm (♂); tibia circumference – 19.0 cm (♀) and 20.3 cm (♂); body weight – 512.5 kg (♂). Mitrović and Grubić (2003) state that the Thoroughbred horses belongs to lighter horse type with a body weight ranging between 455 and 555 kg, withers height 155 and 175 cm, and gestation lasting between 328 and 340 days. In general, sport horses body weight ranges from 350 to 500 kilograms (Bilal and Meral, 2000).

According to individual authors, Kawareti et al. (2017), we took all traits from left side of the horses. Bene et al (2013) in their work gave body measurements of Thoroughbred broodmares according to different authors, measured with stick. However, body measurements and reproductive characteristics, primarily gestation length, depend not only on the genotype but also on a significant number of non-genetic factors. In this context, reported Hevia et al. (1994), Kurtz Filho et al. (1997). According to both earlier and contemporary literature, gestation is affected, among other factors, by the mare's age, mating/foaling season, breeding conditions and diet quality (Davies-Morel et al., 2002).

The effects of the mare's age and foetus (foal) sex on the length of gestation in different types of horses was studied by: Bucsy (1992), Kurtz Filho et al., (1997), Davies-Morel et al., (2002), Pérez et al., (2003), Valente et al., (2006), Valera et al., (2006), Đermanović (2010), Galvin and Corley (2010), Satué et al., (2011a,b), McCue and Ferris (2012), Aoki et al.,

(2013), Rezac et al., (2013), Bene et al., (2014), Ferreira et al., (2016).

There are certain contradictory results regarding effects of mare's age and foetus (foal) sex on the length of gestation reported by authors who have conducted research in this field. For this reason, the main aim of this study is the analysis of some morphological parameters (body measurements and body development indexes) of stallion and reproductive (fertility, gestation length and phenotype correlation) characteristics of the Thoroughbred horses (the finest breed for gallop races) mares raised at the *Ljubičevo* stud farm.

Bayram et al. (2005) stated that the effect of age on body length and chest width was significant ($P < 0.05$ and $P < 0.01$). Kaygisiz et al. (2011) determined that effects of both age and sex were significant on heart at withers, heart girth, cannon bone and body length measurements at different growth stages (birth, 6., 12., 18., 24., 36., 48. month). Additionally, aim of this study was to contribute to the advancement and development of the Thoroughbred horses breeding strategy and consequently to the equestrian sports (primarily gallop racing) in Serbia. By calculating the phenotype correlation, particular emphasis was placed on the effects of the mare's age and the sex of the foal on gestation length.

MATERIALS and METHODS

Research was conducted on the Serbian, state-owned *Ljubičevo* study farm (44°37'12" latitude N, 21°11'23" longitude E), with a horse breeding history that extends over a 160-year period. *Ljubičevo* is located in the vicinity of Požarevac, a town found in the Braničevski District. Braničevski District is located in the north-east of Serbia. When the air temperature was between -1 and 5 °C degrees in January; It is 15-27 °C degrees in June, 16-29 °C degrees in July, 3-12 °C degrees in November, and 0-6 °C degrees in December in *Ljubičevo*.

A few years subsequent to its establishment, the stud farm availed over 500 pure blooded Arabic and English horses (Mitrović and Grubić, 2003). The farm was devastated during World War II, leaving only 83 animals (60 Arabic and 23 English pure bloods). Today, *Ljubičevo* breeds Thoroughbreds exclusively. The individual horses with the best racing results which have been bred on this stud farm are *Ljubičevac* (father *Faktor*, mother – *Ljubičevka*) and *Tina*, both of which won the *Triple Crown* in 1974 and 1995, respectively.

Over the last decade, the total number of horses at *Ljubičevo* varied from 120 to 150 individual horses. Six stallions aged between 6.5 and 17.5 years are currently being used for reproductive purposes, and 34 mares aged between 5 and 17.5 years, are actively

selected for breeding, both the stallions and the mares have known origins. This was the selection of horses covered in the research during the period indicated.

The measurements including the stallions withers height, trunk length, chest circumference, tibia circumference, and body weight were recorded. Absolute and relative variation measures and major stallion body development indices were calculated for indicated parameters, including format index – (trunk length/withers height) x 100, trunk compactness index (chest circumference / trunk length) x 100, massiveness index (chest circumference /withers height) x 100, body weight index (body weight/withers height) x 100 and gauntness index (tibia circumference/withers height) x 100.

For breeding mares, absolute and relative variation measures for the mare's age and gestation length were calculated, the difference significance between mares in relation to the sex of the foal, was determined. Additionally, the number of foals per mare - from first fertilisation (birthed) to the last foal birthed during the period studied was recorded. Based on the mare's age and the sex of the foal, the correlation strength between the age and the gestation length was established by calculating phenotype correlation (r_p) coefficients.

Basic data analysis was applied with Stat Soft. Inc. (2003) Statistica (data analysis software system), version 6, by implementing standard variational-

statistics methods (descriptive statistics). For most of the observed indicators, the arithmetic mean (\bar{x}), arithmetic mean error ($S_{\bar{x}}$), standard deviation (SD) and variation coefficient (VC) were calculated. Furthermore, phenotype correlation coefficients (r_{xy}) between the observed characteristics were calculated according to the appropriate formula, primarily between the age of the mare and gestation length (regardless of foal sex).

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}}$$

Phenotype correlation coefficients strength was discussed on the basis of the Roemer-Orphal classification referred to by Tavčar (1946).

RESULTS and DISCUSSION

The total number of registered horses on *Ljubičevo* study farm was 125 horses, 6 of which (4.80%) were breeding stallions, 53 (42.40%) breeding mares, 12 (9.60%) competing horses and 54 (43.20%) foals. On special occasions, breeding stallions were mated with mares whose owners were private individual horse breeders. The average age of breeding stallions was approximately 10 years of age, and their mean values and the variability of external indicators are given in Table 1.

Table 1. Mean values and the variability of some morphological measurements and indices of the body measurements of stallions

Çizelge 1. Aygırların vücut ölçümlerinin ortalama değerleri ile bazı morfolojik ölçümlerin değişkenliği ve endeksleri

Age, Body Weight and Some Morphological Measurements (<i>Yaş, Canlı Ağırlık ve Bazı Morfolojik Ölçümler</i>)				
Indicators (<i>Göstergeler</i>)	\bar{X}	$S_{\bar{x}}$	SD	VC
Age (years) (<i>Yaş, yıllar</i>)	10.25	1.24	3.04	29.66
Body weight (kg) (<i>Canlı ağırlık, kg</i>)	473.10	10.84	26.55	5.61
Withers height (cm) (<i>Omuz yüksekliği, cm</i>)	159.55	0.73	1.80	1.13
Trunk length (cm) (<i>Gövde uzunluğu, cm</i>)	160.54	0.79	1.93	1.20
Chest circumference (cm) (<i>Gögüs çevresi, cm</i>)	188.00	1.35	3.30	1.75
Tibia circumference (cm) (<i>Tibia çevresi, cm</i>)	19.21	0.06	0.15	0.78
Body Development Indices (<i>Vücut Gelişim Göstergeleri</i>)				
Indicators (<i>Göstergeler</i>)	\bar{X}	$S_{\bar{x}}$	SD	VC
Format (frame) index (<i>Beden indeksi</i>)	100.62	0.08	0.19	0.19
Trunk compactness index (<i>Gövde kompaktlık indeksi</i>)	117.10	1.10	2.69	2.30
Massiveness index (<i>Büyükklük indeksi</i>)	117.83	1.12	2.74	2.32
Body mass index (<i>Vücut kitle indeksi</i>)	296.52	7.62	18.67	6.30
Gauntness index (<i>Gauntnes indeksi</i>)	12.04	0.09	0.22	1.83

\bar{X} -arithmetic mean; $S_{\bar{x}}$ -arithmetic mean error; SD-standard deviation; VC-variation coefficient

Table 1 shows an average stallion body weight of 473.10 kg and a relatively low (5.61%) variation coefficient, in contrast to the coefficient variation of 29.66% in the case of stallion age, which is understandable, considering that the youngest stallion was 6.5 years of age, while the oldest was

17.5 years old. Withers height was 159.55 cm, trunk length 160.54 cm, chest circumference 188.00 cm, and tibia circumference were 19.21 cm. Despite the discrepancy in the stallions age, their some morphological measurements were rather similar, which is demonstrated by the variation coefficients.

During the period of this research, 34 out of 53 mares underwent normal fertilisation and gestation processes, giving birth to healthy foals. During the breeding period and to the date of the completion of this study, 34 observed mares of varying age birthed a

total of 138 foals of both sexes (4.06 foals per mare). Table 2 below provides the average age structures and gestation lengths for the 34 observed breeding mares in relation to sex of the foals.

Table 2. Mean values and variability of mare's age (years) and gestation length (days) and difference significance in relation to foal sex

Çizelge 2. Tay cinsiyetine bağlı olarak kısırak yaşı (yıllar) ve gebelik günlerine (gün) ait ortalama değerler ve farklılıklar

Indicators (<i>Göstergeler</i>)	N	\bar{X}	$S\bar{x}$	SD	VC	
Age of mare with ♀ foal (<i>Dişi taylı kısırak yaşı</i>)	20	10.23	0.71	3.16	30.89	
Age of mare with ♂ foal (<i>Erkek taylı kısırak yaşı</i>)	14	10.93	0.95	3.57	32.66	
Age of mare with ♀+♂ foals (<i>Hem erkek hem dişi taylı kısırak yaşı</i>)	34	10.51	0.57	3.34	31.78	
Gestation of mares with ♀ foal (<i>Dişi taylı kısırakların gebeliği</i>)	20	335.80	1.78	7.95	2.37	
Gestation of mares with ♂ foal (<i>Erkek taylı kısırakların gebeliği</i>)	14	337.70	2.27	8.50	2.52	
Gestation of mares with ♀+♂ foals (<i>Hem erkek hem dişi taylı kısırakların gebeliği</i>)	34	336.57	1.39	8.10	2.41	
Difference Significance Indicators (<i>Göstergeler</i>)		\bar{X}_\varnothing	\bar{X}_σ	d	$t_{exp.}$	$t_{tab.}$
Mare's age (<i>Kısırak yaşı</i>)		10.23	10.93	0.70 ^{ns}	0.603	2.042
Gestation length (<i>Gebelik süresi</i>)		335.80	337.70	1.90 ^{ns}	0.667	2.042

n-number of foals; \bar{X} -arithmetic mean; $S\bar{x}$ -arithmetic mean error; SD-standard deviation; VC-variance coefficient; d-difference

Data given in Table 2 demonstrate that the average age of mares and stallions was similar, independent of the sex of the foal, i.e. 10.51 years (♂ foals = 10.93; ♀ foals = 10.23). Deviations from the average age (C.V.=31.78%) were also similar. Gestation length in mares carrying male foals was on average 1.90 (337.70 – 335.80 days respectively) days longer than in mares carrying female foals. The average gestation length in all mares, regardless of the sex of the foal was 336.57 days. The observed difference in gestation length (1.90 days) was not statistically significant

(P>0.05). The variability related to the gestation length was insignificant as the variation coefficient value was 2.41%.

The phenotype correlation coefficients between the age of mares and gestation length were calculated, with an aim to determine the effects of age on the gestation length of mares with male and female foetuses, i.e. male and female foals. Calculations of coefficients, strength and significance between these characteristics are given in Table 3.

Table 3. Phenotype correlation coefficients (r_p) between a mare's age (MA) and gestation length (GL) in relation to foal sex

Çizelge 3. Tay cinsiyetiyle ilişkili olarak kısırak yaşı ve gebelik uzunluğu arasındaki fenotipik korelasyon katsayısı

Indicators	n	r_{xy}	$t_{exp.}$	$t_{tab.}$	Correlation
MA x GL (♀) (<i>Kısırak yaşı * Gebelik süresi, Dişi</i>)	20	0.210 ^{ns}	0.911	2.101	Very weak
MA x GL (♂) (<i>Kısırak yaşı * Gebelik süresi, Erkek</i>)	14	0.444 ^{ns}	1.716	2.19	Medium
MA x GL (♀+♂) (<i>Kısırak yaşı * Gebelik süresi, Erkek ve dişi</i>)	34	0.321 ^{ns}	1.917	2.042	Weak

According to the data given in Table 3, a very weak ($r_p=0.210$), medium ($r_p=0.444$) and weak ($r_p=0.321$) correlation was observed between the age of the mare and the gestation length in relation to the sex of the foal. The established phenotype correlation coefficients were not significant (P>0.05).

Bayram et al., (2005), stated that in terms of phenotypic correlation coefficients, the correlation between body length and chest width and height of rump and chest width was insignificant. The researchers also found significant correlation between

chest depth and shank circumference at P<0.05; the correlations between all other values were stated to be significant at the level of P<0.01. Kaygisiz et al., (2011) found that the phenotypic correlations between the features examined were generally significant (P<0.01), while the correlations between the birth weight and the investigated features were not. Duru et al., (2017) found that direct maternal genetic correlations for cidago height, chest circumference and shank circumference were -0.15, -0.99 and -0.42, and genetic correlations between features ranged between 0.68 and 0.71.

The following presentation briefly discusses some morphological measurements of Thoroughbred stallions. The effects of a mare's age and the sex of the foal on gestation length are discussed in details and compared to results obtained by certain authors who studied the effects of the mentioned nongenetic factors on the gestation length of Thoroughbred mares.

During the research period, six stallions were used in the fertilisation of mares. Their body measurements and certain some morphological measurements are given in Table 1. These measurements were taken for the purpose of comparing Thoroughbred stallion standards during the fertilization condition. Data obtained was in accordance with the standards of the breed, which are confirmed by the calculations of the body development indexes of studied stallions. Regarding our comparisons of some morphological measurements of English Thoroughbreds, similar results are reported by Mitrović and Grubić (2003) and Đermanović et al., (2010), *i.e.*, they have concluded that Thoroughbreds belong to the category of lighter horses with a sport body structure, which is confirmed by body development indexes.

When the effects of a mare's age on gestation length is in question, authors who have treated this issue have come up with contradictory results. Ferreira *et al.*, (2016) report that there is no effect of the mare's age on gestation length. Similar results were reported by Galvin and Corley (2010), Aoki et al., (2013), McCue and Ferris (2012). However, Bene et al., (2014) conclude that the gestation length of mares whose ages range from 3 (328.7 days) to 17 years of age and more (334.9 days), show a growing length trend, *i.e.* gestation length is insignificantly prolonged in line with the mare's age. Similar conclusions have been drawn by Valera et al., (2006).

Satué et al., (2011b) report a shorter gestation period in younger mares in comparison to older ones. These authors report that mares aged between 8 and 12 years have a shorter gestation length than those aged between 13 and 17 (330.8 days and 336.1 days, respectively).

By calculating the phenotype correlation Valera et al., (2006) observed a weak correlation ($r_p = 0.383$ – for both breeds studied) between two consequent gestations. They determined $r_p = 0.394$ for the Spanish Purebred and $r_p = 0.380$ for the Arabian, *i.e.* that gestation length increases with the mare's age until a certain age limit is reached. These authors report significant effects of the mare's age, sex of the foal, mating (fertilisation) month and genotype (breed) on gestation lengths in mares. The mating (fertilisation) month had a significant effect on gestation length, while the stallion's age and origin did not affect gestation length. Apart from Valera et al., (2006), Đermanović et al., (2010) report a weak

correlation ($r_p=0.320$), between the mare's age and gestation length, regardless of foetus (foal) sex, and the coefficient was not statistically significant ($P>0.05$).

Most of the cited authors report that the age of the mare (mother) has a certain amount of influence over the gestation lengths of different horse breeds, *i.e.* that the gestation length shortens from the time of first fertilization (pregnancy) until a certain age, when it starts to increase again. Similar conclusions were drawn in our study based on the gestation lengths observed and the phenotype correlation coefficients determined between the mare's age and gestation length.

Aoki et al., (2013) point out that many authors studied the effects of foetus (foal) sex on gestation length in mares and reached similar conclusions. These authors observed that the gestation length in mares with male foals was longer than that of mares with female foals. It is generally acknowledged that in many domestic animals, including horses, gestation length is longer in the case of a male foetus. This phenomenon has not yet been sufficiently studied nor explained.

According to our research, the gestation length in mares carrying male foals was on average longer by 1.90 days than in mares carrying female foals (337.70 and 335.80 days, respectively), while the average gestation length of all mares, regardless of the sex of the foal was 336.57 days. A difference of 1.90 days in terms of gestation length was not statistically significant ($P>0.05$). These results are, to a certain extent, in accordance with those obtained by previous researchers, although their authors report significantly longer gestation periods for mares carrying male foals in comparison to those carrying female foals. Results considerably closer to ours are reported by Valente et al., (2006), Valera et al., (2006), Satué et al., (2011a,b), Aoki et al., (2013).

Valera et al., (2006) reported that the average gestation length of Spanish Purebred mares with male foals was 337.91 days, and 335.54 days for mares with female foals (difference of 2.37 days). In the case of Arabian horse mares, the reported gestation length was 341.05 days and 339.64 days, respectively (a difference of 1.41 days). In contrast to most other authors, Ferreira et al., (2016) have not established statistical significance ($P>0.05$) between the gestation length in mares with female foals and mares with male foals (341.96 days and 344.32 days, respectively).

Unlike previous authors, Bene et al., (2014) reported that mares with female foals had significantly longer ($P<0.05$) gestation lengths (335.6 and 333.5 days, respectively). Pérez et al., (2003) report longer gestation periods in mares with male foals, which is

in line with our results. Similar conclusions were reached by Davies-Morel et al., (2002), Cilek (2009), McCue and Ferris (2012), Rezac et al., (2013), who also reported significantly longer gestation in mares of different breeds carrying male foals than in those with female foals. Compared to our results, Davies-Morel et al., (2002) and Đermanović et al., (2010), report significantly and insignificantly longer gestation of mares with male and female foals. According to Davies-Morel et al., (2002) the gestation length in mares with female foals was 342.4 days (6.6 days longer than in our research), while in those with male foals, gestation length was 346.2 days (8.5 days longer than observed in our study).

An insignificantly longer gestation period (one day, approximately) is reported by Đermanović et al., (2010) in mares with female foals (336.90 days – 335.80 days), and (338.92 days – 337.70 days) in mares with male foals.

According to the literature, the gestation period in mares carrying male foals is general longer than the gestation period in mares with female foals. This phenomenon has yet to be scientifically explained. It is assumed that the female embryo and foetal development takes a shorter amount of time than the male, which results in a shorter gestation period. (Jainudeen and Hafez, 2000). In humans, this fact in relation to pregnancy is related to the differences in androgen production and its effects, as well as with effects related to sex differentiation chromosomes (Pergament et al., 1994). This physiological phenomenon in horses, i.e. mare gestation periods in relation to different sexes, has not yet been established.

CONCLUSION

According to research conducted on the Ljubičevo stud farm (Serbia), aiming to determine major some morphological measurements and reproductive characteristics of English Thoroughbreds, we may conclude that the body measurements of the individual stallion examined, were in concord with the standards of this breed and that the mare's age and the sex of the foal have an impact on gestation length. The gestation period of mares carrying male foals was somewhat longer (337.70 days), than of mares carrying female foals (335.80 days). The difference (1.90 days) in gestation length was not statistically significant ($P > 0.05$). A weak positive correlation ($r_p = 0.321$) was observed between the age of the mare and gestation length (regardless of foal sex). Additionally, a medium correlation ($r_p = 0.444$) was observed between the mare's age and gestation length in the case of male foals, and a very weak correlation ($r_p = 0.210$) in the case of female foals. Phenotype correlation coefficients were not statistically confirmed ($P > 0.05$). Generally, we can

say that with some oscillations the gestation length grows with the mother's (mare's) age, as well as that the male sex of the foal encourages the prolongation of the gestation period.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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