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The effect of selected factors on the length of gestation period in Silesian mares*

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The aim of the study was to determine the average length of gestation and its variation in a population of Silesian mares bred during a period of 55 years (1945-2000) in national studs and private farms in southern Poland. Considered was the sex of foals, season, month and year of birth, environmental conditions (national or private breeding centres), breeding history of a mare (number of foals born) and influence of the preceding reproductive period.

Gestation period in Silesian mares lasted on average 338.66 days ±13.57 and ranged from 299 (the shortest) to 386 (the longest) days. Gestations lasting from 311 to 356 days were considered normal for the breed. Gestations resulting in a birth of a colt lasted one day longer (339.23±13.44 days compared to 338.19±13.60 days for fillies). Gestations from the autumn reproductive period (October–December), when photoperiods become shorter, were the shortest, whereas gestations from the late spring season (April-June), when photoperiods become longer, were the longest (329.82±10.25 and 341.14±13.87 days, respectively). Significant differences were also found in the length of gestations that ended in particular months: the shortest gestations ended in October (327.45 days ±12.24 days), while the longest in May (342.19±14.19 days). The analysis of the years of foaling, grouped in ten-year periods, showed that the shortest gestations occurred before 1960 (335.41±13.87 days), whereas the longest between 1961 and 1970 (339.64±15.15 days). A slow decrease was observed in the length of gestation in subsequent ten-year periods.

Mean gestation period in mares from national studs lasted 5 days longer than that in mares from private breeding centres (334.79±11.21 and 339.60±13.92 days, respectively). The number of foalings did not

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affect the length of gestation significantly; a small difference was found in the case of multiparous mares (more than eight foals born), whose gestation lasted one day longer compared to remaining mares (338.71±13.52 and 337.46±12.32 days, respectively). Gestations in mares whose preceding reproductive period ended with a miscarriage were the shortest, while gestations in mares that were barren in the previous season were the longest (336.36±13.11 and 340.05±13.71 days, respectively).

KEYWORDS: breeding / horse / pregnancy / Silesian horse

Numerous studies have addressed the source of the effect of both genetic and environmental factors on the length of gestation in mares. Contemporary reproduction techniques make it possible to determine the ovulation date and, consequently, to select the right moment for mating or insemination. Early prenatal tests, in turn, make it possible to determine the exact date of fertilization. The prediction of the length of gestation in particular mares would make possible a precise calculation of the date of delivery, which would help organising work in studs more efficient, take care of a mare and a foal properly, and plan the subsequent mating season, which is especially important in breeding centres that do not use artificial insemination [Davies Morel *et al*. 2002].

It is assumed that the average length of gestation period in mares ranges from 330 to 340 days [Bos and Van der Mey 1980], even though numerous authors give a much broader range of the length of normal gestation. Their studies aimed at determining the length of gestation in Thoroughbred mares, Hintz *et al*. [1979, 1992] with achieved results ranging from 305 to 382 days. According to Demirci [1988], the length of gestation in Arab Horse may range from 314 to 363 days. Valera *et al*. [2006] reported 311-358 days for Spanish Purebred Andalusian and 313-357 for Arab mares. Lofsted [1992] claims that one of the reasons why gestation lasts longer may be a delayed embryo development between the 20th and 40th day of gestation.

The length of gestation is affected both by genetic factors, including the utility type, breed and breeding line [Giger *et al*. 1997, Marteniuk *et al*. 1998, Valera *et al*. 2006], sex of a foal [Hintz *et al*. 1979], reproductive season, age of a mare, number of foals born [Perez *et al.* 2003, Satué *et al*. 2011] and by environmental factors (ambient temperature, humidity, light) or maintenance conditions [Hodge *et al*. 1982, Howell and Rollins 1951] .

Results of investigations depend to a large extent on the size of the population studied, variation of the studied factors and number of observations considered. There are relatively few studies carried out on big populations over many years and in varied (and changing) environmental conditions, as in the case of Silesian breed.

This study, which takes into account non-genetic factors influencing gestation length, is part of a complex description of Silesian mares' reproduction and will be supplemented with the analysis of the influence of genetic factors, including dam lines, share of foreign breeds in pedigrees and repeatability. Results of studies on reproduction traits in Silesian horse sire lines shows the differences between the lines, between mares and stallions within lines, and the combinations of lines of dams and sires [Walkowicz 2009].

The aim of this study was to determine the mean length of gestation in Silesian mares and the influence of selected factors on its variation. The investigation took into account the sex of the foals, season, month and year of foaling, age of a mare, number of foals born, breeding conditions and the result of a preceding reproductive period.

Material and methods

The study was based on information from the Silesian horse database [Walkowicz 1999] relating to the origin and breeding history of mares in the years 1945-2000 including 13,409 mares in 27,404 breeding seasons.

The mares studied were maintained in two national studs located in south-western Poland and in private agricultural farms in southern Poland (50-51^{0}N and 17-22^0 E). In the grazing season, mares from national studs were grazed during the day and spent nights in stables. In the out-of-season months, the mares spent most of the day in stables and used yards for 2-3 hours a day. The maintenance conditions for mares in private farms varied with regard to both daily and seasonal grazing. Moreover, until the 1980s, most of the mares were used for field and farm works to a certain extent.

The mares were first used for reproduction at the age of three years. All the mares were mated by licensed stallions, using a natural mating system. In national breeding centres, the beginning of the estrus was determined through everyday teasing with a stallion, and the mating date was established based on a veterinary examination (palpation of the ovarian follicle to assess its level of development, and since the 1980s – ultrasonographically). Gestation diagnosis started between day 14 and 18 post-mating. In private farms, mares with external symptoms of estrus were teased with a stallion, and if there was no refusal – they were mated on the same day. The mating was repeated on the second / third day, depending on the length of estrus. The lack of estrus after 21 days confirmed gestation.

Statistical

The material analysed was divided based on the following criteria: sex of a foal, foaling season (early reproductive season – from January to March, late reproductive season – from April to June; inter-season period – from July to September; autumn reproductive season – from October to December), month of foaling and year of foaling (decades), type of ownership (national or private), breeding district (BD Wrocław, BD Katowice, BD Kielce and the remaining BDs); gestation number (from the first to the fourth, from the fifth to the eighth and from the ninth to the nineteenth) and the effect of the preceding breeding season: primiparous, mares that were barren in the previous season, mares that lost their pregnancy, mares that delivered a live foal in the preceding season.

Correlation was detected between the length of gestation and the age of a mare (years), its conformation traits (height at withers, chest circumference and cannon circumference), indices (massiveness index, expressed in a percentage ratio of chest

circumference to height at withers, and boniness index, expressed in a percentage ratio of cannon circumference to height at withers) and evaluation of the body conformation, expressed in scores.

The influence of particular factors was assessed using a single-factor variance analysis, and the significance of differences at $P<0.05$ was determined using the Tukey's test. All the analyses were performed using the SAS system.

Results and discussion

Mean gestation period in Silesian mares was 338.66 days, with SD of 13.57, and ranged from 299 to 386 days. When considering mean value ± SD, 73% of observations is situated between 325 and 352 days. Short (311-324 days) and long (353-366 days) gestations constituted respectively 10.92% and 9.55% of all observations. Abnormally short gestations (less than 311 days) and abnormally long gestations (more than 366 days) constituted 1.93% and 4.50% observations, respectively.

The effect of the sex of a foal

Gestations that resulted in a birth of a colt lasted on average 1 day longer than those that ended with a birth of a filly and the differences were significant at $P<0.001$ (Tab. 1). Similar results were achieved in other studies [Hevia *et al*. 1994, Davies-Morel *et al*. 2002, Perez *et al*. 2003, Valera *et al*. 2006, Cilek 2009, Dicken *et al*. 2012]. Although the differences cannot be explained scientifically, this tendency was observed in many breeds of various genetic and geographical origin, which may suggest a hormonal background.

Table 1. Mean gestation length (±SD) as related to sex of a foal

Foal sex	Number of observations	Gestation length (days)	SD
Filly	8260	338.19[a]	13.60
Colt	7676	339.23[a]	13.44
Total	15936	338.66	13.57

[a]Means marked with the same superscript letter differ significantly at $P\leq0.05$.

The effect of the month of foaling and reproduction season

The shortest gestations ended in October (327.45 days ±12.24 days), with the length of gestation increasing in subsequent months at a rate of 2 days per month (Tab. 2). The longest gestations ended in May (342.19±14.19 days) and in the subsequent months the length of gestation again decreased. The differences were significant ($P<0.05$) for months with numerous observations (from January to June) and were within statistical error for months with a low number of observations. When grouping the months according to

Table 2. Mean gestation length (±SD) as related to month of foaling

Month of foaling	Number of observations	Gestation length (days)	SD
I	1263	334.10[a]	11.15
II	2482	337.30[ab]	12.29
III	4103	338.13[ac]	13.65
IV	4601	340.68[abcd]	13.59
V	2183	342.19[abcde]	14.19
VI	481	340.70[abcf]	14.93
VII	169	335.79[dfg]	14.10
VIII	103	332.36[bcdef]	13.92
IX	60	333.42[cdef]	14.44
X	92	327.45[bcdef]	12.24
XI	176	327.[56abcdefg]	9.64
XII	314	331.79[bcdefg]	9.53
Total	16027	338.67	13.57

[abcdefg]Means marked with the same superscript letter differ significantly at P≤0.05.

Table 3. Mean gestation length (±SD) as related to reproductive season

Reproduction season	Number of observations	Gestation length (days)	SD
I-III	7848	337.22[A]	12.93
IV-VI	7265	341.14[A]	13.87
VII-IX	332	334.29[A]	14.14
X-XII	582	329.82[A]	10.25
Total	16027	338.67	13.57

[A]Means marked with the same superscript letter differ significantly at P≤0.01.

the reproductive period (Tab. 3), significant differences between all the groups were found (P<0.01). Gestations from the autumn reproduction period (October-December), when photoperiods become shorter, were the shortest (329.82±10.25 and 341.14±13.87 days, respectively), while gestations from the late spring season (April-June), when photoperiods become longer, were the longest. The most considerable variations within a group were found in mares that gave birth in months out of the reproductive season, although their gestations were relatively short (334.29 ±14.14 days). Davies-Morel *et al.* [2002] achieved similar results. Ropiha *et al*. [1969], Marteniuk *et al*. [1998], Perez *et al*. [2003], Cilek [2008], Galisteo and Perez-Marin [2010], Satue *et al*. [2011] obtained different results, showing that gestations at the end of the reproductive season were the shortest. It is believed that mares may accelerate delivery as photoperiods become longer and as the reproduction season comes to an end. Numerous authors [Hodge *et al*.

1982, Marteniuk *et al*. 1998, Perez *et al*. 2003] stressed the relation between the length of gestation and the changes in the length of a photoperiod, with the shortest gestations occurring during the summer and winter equinox. It is, thus, assumed that the results obtained in this study were influenced by environmental factors, including the system of maintenance (access to pastures and paddocks) and use for work, which, even if indirectly, are related to the access to the sunlight.

The effect of the year of foaling

To analyse the effect of the year of foaling on the length of pregnancy, observations were grouped into 10-year periods (Tab. 4). Such an approach gives more conclusive results when determining the effect of maintenance conditions than does one-year periods. It was shown that gestations in the early post II-nd world's war years were the shortest (335.41±13.87 days), whereas gestations in the two subsequent decades were longer (339.64±15.15 and 339.19±13.73 days, respectively). In the last twenty years, the length of gestation periods once again decreased. The influence of a year of foaling on the length of gestation was shown by Perez *et* al. [2003] and Cilek [2008], who stressed the significance of weather conditions (gestations were longer in hot, dry years) and feeding conditions, which were related to the climate [Valera *et al*. 2006, Satue *et al*. 2011]. A significant role in long-term observations is played by agricultural practice and the related manner of maintenance system. Using the mares for work puts a strain on the organism of a foaling animal, but it allows it to spend the whole day in fresh air and ensures a natural day-night cycle, which is not the case with horses that are not used for work and spend most of the day in stables.

Table 4. Mean gestation length (±SD) as related to year of foaling

Years of foaling	Number of observations	Gestation length (days)	SD
up to 1960	1042	335.41^{abcd}	13.87
1961-70	3448	339.64^{ae}	15.15
1971-80	3355	339.19^{bf}	13.73
1981-90	3591	338.86^{cg}	13.15
1991-00	4591	338.13^{defg}	12.26
Total	16027	338.67	13.57

^{abcdefg}Means marked with the same superscript letter differ significantly at P≤0.05.

The effect of a breeder

Gestation periods in mares from national studs were the shortest, while those in mares owned by private breeders from the Wrocław BD were the longest (334.79±11.21 and 340.13±14.06 days, respectively) (Tab. 5). As the national studs were located in the Wrocław BD, the influence of climatic conditions may be ruled out. Gestations in mares from the remaining BDs, which had a similar geographical and climatic

Table 5. Mean gestation length (±SD) as related to breeder

Breeder	Number of observations	Gestation length (days)	SD
National Studs	3134	334.79^{ABC}	11.21
Wrocław district	7198	340.13^{ADE}	14.06
Katowice district	4911	338.99^{BD}	13.81
Kielce district	606	339.18^{C}	13.48
Other districts	178	337.05^{E}	11.66
Total	16027	338.67	13.57

^{ABCDE}Means marked with the same superscript letter differ significantly at P≤0.01.

location, were significantly longer (P<0.01). Therefore, it may be assumed that maintenance conditions, including feeding and reproduction, were the most decisive factors [Howell and Rollins 1951, Walkowicz and Jodkowska 2003, Valera *et al*. 2006, Cilek 2008, Satue *et al*. 2011]. Importance of body condition on reproduction reported Winter *et al*. [2007]. Mares from national studs were maintained in line with higher breeding standards; they had an all-year access to pastures or paddocks, were fed in accordance to the nutrition science and were not used for work. Reproduction took place under a veterinary supervision, including the determination of the ovulation date, optimum mating date and early gestation diagnosis, which made it possible to determine the moment of fertilisation more precisely compared to mares from private farms, where it was estimated based on the date of the last mating.

The effect of the number of foalings

The studies did not show any significant differences between the length of the first and the remaining seven gestations (Tab. 6). The mean length of the first four gestations was 338.78±13.67 days and the length of the remaining four gestations was 338.49±13.36. The first gestation lasted 338.58±13.97 days. Starting from the ninth gestation, there was a significant decrease in the length of gestation by a mean of one day per gestation (P<0.05). The results achieved by other authors are different. Studies by Arora *et al*. [1983] did not show any link between the length of subsequent

Table 6. Mean gestation length (±SD) as related to number of foalings

Number of foalings	Number of observations	Gestation length (days)	SD
1-4	12367	338.78^{a}	13.67
5-8	2989	338.49^{b}	13.36
9>	671	337.46^{ab}	12.32
Total	16027	338.67	13.57

^{ab}Means marked with the same superscript letter differ significantly at P≤0.05.

gestations. Pool-Anderson *et al*. [1994] and Cacic *et al.* [2002] achieved different results. They found that gestations in primiparous mares were significantly shorter. Studies by Satue *et al*. [2011] showed that a difference in length of gestations between primiparous and multiparous mares was 14 days (331.4 and 345.9 days, respectively). Walkowicz and Jodkowska [2003] reported that there were more short gestations (301-320 days) in younger mares (2-4 years of age) than in older ones (13.4% and 11.0 %, respectively).

The effect of preceding season

The differences in the length of gestation were compared taking into account the last breeding season and distinguishing between primiparous mares, mares that were barren, mares that lost pregnancies (miscarriages and resorptions) and mares that delivered healthy foals (Tab. 7). It was found that gestations in mares that miscarried in the preceding season were the shortest, while the gestations in mares that were barren in the preceding season were the longest (336.36 and 340.05 days, respectively); the average length of gestation in mares that delivered a healthy foal in the previous season did not differ significantly from the length of gestation in primiparous mares. Similar results reported Arora *et al.* [1983] and Langlois and Blouin [2012].

Table 7. Mean gestation length (±SD) as related to preceding season

Previous season	Number of observations	Gestation length (days)	SD
Nothing (primiparous)	3799	338.58[a]	13.97
Infertility	2556	340.05[abc]	13.71
Miscarriage	206	336.36[bc]	13.11
Live foal	9354	338.42[b]	13.34
Total	15915	338.68	13.57

[abc]Means marked with the same superscript letter differ significantly at P≤0.05.

The effect of age and biometric indices

Small but highly significant correlations (P<0.01) between the age of a mare and the length of gestation were found (Tab. 8). Demirci [1988], Walkowicz and Jodkowska

Table 8. Correlations between gestation length and biometric indices (P<0.01)

Parameter	Correlation coefficient
Age	0.05
Height at withers	-0.03
Chest circumference	
Cannon circumference	0.02
Massiveness index	
Boniness index	
Sum of scores	-0.12

[2003], Valera *et al*. [2006], Elliot *et al.* [2009], Langlois and Blouin [2012] achieved similar results. In turn, Davies-Morel *et al*. [2002], and Perez *et al*. [2003] did not find any influence of the age of a mare on the length of gestation. Moreover, a negative correlation was found between the length of gestation and the height at withers and the assessment of the exterior of a mare, expressed as the sum of evaluation scores. It is worth attention that the exterior, for which the correlation coefficient was the highest, is the only factor based on subjective assessments of the judges.

Summing up, the average length of gestation in Silesian mares was 338.66±13.96 days, and gestations lasting from 311 to 365 days were considered to be normal (more than 90 % of all observations). Abnormally short (less than 311 days) and abnormally long gestations (more than 366 days) constituted less than 5.5% of all observations and were within statistical error.

The length of gestation is influenced by a number of factors, including the sex of a foal, season, month and year of foaling, the sequence of gestation of a mare and the result of a previous breeding season. The variation based on the season (month/season), age of a mare, length of a period when a mare was used for reproduction, and sex of a foal did not differ from results for different breeds cited in the literature. The almost five-day difference in the length of gestation period between national studs and private breeders is noteworthy. The value seems to be too high to result from the difference in maintenance conditions between them (especially as the geographical conditions in all the Silesian mares breeding centres are similar). Probably, in the national studs, under veterinary supervision, moment of fertilization was defined more precisely, compared with mares from private farms, where it was estimated, based on the date of the last mating, but it seems to be necessary to analyse the factor in more detail.

The above results indicate a significant influence of environmental conditions on the length of gestation. However, in order to get a full image, it is necessary to supplement them with the analysis of the influence of genetic factors.

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