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Determinants of gestation length in Thoroughbred mares on German stud farms

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ABSTRACT

The aim of the present study was to analyze the effects of stallion and mare, their ages, and maternal lineage on the gestation length (GL) in Thoroughbreds. In addition, additive genetic effects of the dam, stallion and fetus were analyzed. Data were taken from 1993 through 2009, and included 16,226 pregnancies from 5959 Th oroughbred mares mated with 290 different stallions. All analyses were performed using linear mixed models. The GL ranged from 306 to 390 days, with a mean length of 347.0 ± 14.4 days. Mating of mares with stallions aged 17 years and older resulted in a significantly longer GL compared to younger stallions. Furthermore, the GL significantly increased with the increasing age of the mares, and the GL was longer with male foals. The month and year of breeding, as well as the mare´s breeding history (parity and reproductive status) also affected GL. The mare and stallion themselves explained 18% and 4% of the variance in GL. Coefficients of inbreeding of mares and foals had no significant effect on GL. The heritability for the GL was 0.17 for the dam and 0.006 for the fetus, whereas an additive genetic paternal effect was not estimable. The relative proportions among the additive genetic and permanent environmental contributions of the dam were 76.5% and 23.5%. A maternal lineage effect was not obvious.

1. Introduction

Predicting the time of parturition is of great economic importance for livestock breeding, in terms of managing expected dates of parturition and ensuring greater offspring survival. Generally, in horses, viable foals were reportedly born after gestation lengths (GL) ranging from 310 to 380 days (Rossdale et al., 1984; Immegart, 1997), 315 to 388 days (Davies Morel et al., 2002) or 309 to 390 days (Christmann et al., 2017). One study reports GLs ranging between 309 and 398 days in Thoroughbred mares (van Rijssen et al., 2010).

Factors that affect this large variation were assessed for a number of different horse breeds (Davies Morel et al., 2002, Thoroughbred; Pérez et al., 2003, Carthusian; Valera et al., 2006, Andalusian and Arabian; van Rijssen et al., 2010, Thoroughbred; Satué et al., 2011a, Carthusian; Langlois and Blouin, 2012, French Breeds; Reilas et al., 2014, Finnhorse and Standardbred; Aoki et al. 2013,

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Heavy Draft; Walkowicz et al. 2014, Silesian; Kuhl et al., 2015, Warmblood; Christmann et al., 2017, Hanoverian).

In summary, influences on the horse GL may be divided into i) environmental, ii) fetal and iii) maternal factors or iv)of other origin (as reviewed by Satué et al. 2011b). It is generally accepted that the month of breeding (Marteniuk et al. 1998; Pérez et al. 2003; Valera et al. 2006; van Rijssen et al., 2010; Satué et al., 2011a; Langlois and Blouin, 2012; Reilas et al., 2014; Walkowicz et al., 2014; Kuhl et al., 2015; Christmann et al., 2017) or the month of parturition (Davies Morel et al., 2002) have a significant role for GL. Factors affecting the GL are also the fetal sex, with gestation lengths being longer for male than female foals (Davies Morel et al., 2002; Pérez et al., 2003; Valera et al., 2006; van Rijssen et al., 2010; Satué et al., 2011a; Langlois and Blouin, 2012; Reilas et al., 2014; Aoki et al., 2013; Korabi et al., 2014; Walkowicz et al., 2014; Kuhl et al., 2015; Christmann et al., 2017).

Conflicting data are, however, reported for the influence of the stallion (Marteniuk et al., 1998; Davies Morel et al., 2002; Satué et al. 2011a; Christmann et al., 2017), age of mare (Langlois and Blouin, 2012; Valera et al., 2006; Reilas et al., 2014; Kuhl et al., 2015; Christmann et al., 2017), effect of reproductive status of mares, e.g. maiden or barren (van Rijssen et al., 2010; Satué et al., 2011a; Langlois and Blouin, 2012; Reilas et al., 2014; Walkowicz et al., 2014), parity (Valera et al.,2006; Satué et al., 2011a; Reilas et al., 2014; Kuhl et al., 2015) and year of gestation (Langlois and Blouin, 2012; Valera et al., 2006; Kuhl et al., 2015; Christmann et al., 2017).

Considering the influence of the stallion and age of the stallion, no significant effect on GL has been previously reported (Davies Morel et al., 2002; Christmann et al., 2017). Previous studies reported a heritability of moderate size for GL (Valera et al. 2006; Langlois and Blouin, 2012; Christmann et al., 2017). Differentiating between the additive genetic effects between the mare and the fetus revealed a heritability of 0.08 to 0.12 (Langlois and Blouin, 2012) and 0.07 (Christmann et al., 2017) for the direct effect and 0.08 to 0.12 (Langlois and Blouin, 2012) and 0.27 (Christmann et al., 2017) for the maternal effect.

A significant effect of maternal lineage on GL has been reported by Kuhl et al. 2015. Accurate prediction of parturition date has been suggested to be valuable for improving stud management (Davies Morel et al., 2002; Valera et al., 2006).

The aim of the present study was to assess the effect of the stallion age and the stallion itself as well as maternal effects (mare´s age, parity, reproductive status, coefficient of inbreeding and the mare itself, maternal lineage), fetal effect (sex of foal and coefficient of inbreeding of the foal), environmental effects (month and year of breeding) as well as additive genetic effects of the dam (mare), stallion and fetus (animal) on GL based using a large number of records collected in multiple Thoroughbred studs of Germany. In contrast to previous studies, stallions and mares were grouped by age and the mare and the stallion was included as permanent random effect. To ensure effects could be estimated, the factors parity and mare's reproductive status were combined into one effect allowing for assessment of the different combinations in a model. All fixed and random effects were evaluated simultaneously using a linear mixed model to ensure a proper weighting of the sources of variance. The genetic analysis was performed using additive animal and maternal or paternal effects as well as the permanent environmental effects of the dam and stallion. Fixed effects were included according to the mixed model analyses without genetic effects.

2. Material and methods

2.1. Data origin

All stud farms follow a mandatory code of practice issued by the Thoroughbred Horse Racing and Breeding Directory for Germany, Cologne (https://www.german-racing.com/gr-wAssets/docs/verbandsdokumente/Rules-of-Breeding-2017.pdf). Furthermore, daily veterinary services were offered on each individual stud farm. Mandatory daily mating records were compiled by all stud farms.

Data with mating records from breeding seasons 1993 to 2009 and pedigree records for all mares and stallions of the study were obtained from the German Thoroughbred Horse Racing and Breeding Directory e.V. Cologne, Germany. Records included the identification number of the stallion and mare, the stud farm where the mare was mated, the last date of mating per breeding season, date of parturition, status of mare at the beginning of the breeding season, sex of foal and the identification number of the stallion that had been confirmed as the sire after a foal was born. All mares were bred by natural mating. Breeding seasons started on the 1st of February and ended on the 30th of July. Only breeding records of mares that were mated in Germany and gave birth to a viable foal were included in the study. The pedigree records included ancestors up to the birth year of 1950 with a total of 158,711 animals.

A total of 16,226 records of full-term pregnancies of 5,959 mares being mated by 290 stallion were analyzed in the present study. It was not possible to extract the exact ovulation to mating interval from the mating records. The last mating was, therefore, used to define the start of the gestation period. The GL was defined as the number of days between the last mating of a mare during the breeding season preceding and the foaling date (i.e., day of parturition). The same method for calculation of GL has been used in previous studies when the date of ovulation was not known (Christmann et al. 2017; Dicken et al., 2012; Elliott et al. 2009; Reilas et al. 2014). Records of mares with a GL shorter than 305 days (n = 32) and 824 records longer than 390 days (n = 824) were excluded from the study.

The mares were divided into five age groups: Groups 1 (6 years and younger); 2 (7-9 years); 3 (10–12 years); 4 (13–15 years) and 5 (16 years and older). In addition, the group parity accounted for the reproductive efficiency of the mare and thus, mares were classified into three parity groups: Groups 1 (0-1 foalings), 2 (2–4 foalings) and 3 (5 foalings and more).

The reproductive status of the mares (maiden – never mated; barren – mated in the previous year but did not conceive; aborted; foaled (mare with a live full term foal; rested – not mated after the last foaling) was combined with a parity group resulting in 13 different groups of observation, including maiden mares as a separate observation (see Table 4). This was done because maiden mares and mares without a reported foaling (Parity Group 1) are confounded and, therefore, could not be sorted into one effect class that