Equine Gestational Length and Location: Is There More That The Research Could Be Telling Us?

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Abstract

Clear definitions of 'normal' equine gestation length (GL) are elusive, with GL being subject to a considerable number of internal and external variables that have confounded interpretation and estimation of GL for over 50 years. Consequently, the mean GL of 340 d first established in 1967 by PD Rossdale for Thoroughbreds in northern Europe continues to be the benchmark value referenced by veterinarians, breeders and researchers worldwide.

Application of a 95% confidence limit to reported GL range values indicates a possible connection between geographical location and GL. Improved knowledge of this variable may help in assessing the degree of the neonate's prematurity and dysmaturity at or soon after birth, and identification of conditions such as incomplete ossification of the carpal and tarsal bones. Associated pathologies such as bone malformation and fracture, angular limb deformity and degenerative joint disease can cause chronic unsoundness, rendering horses unsuitable for athletic purpose and shortening ridden careers.

This review will examine the factors contributing to GL variation and the published data to establish whether there is potential to refine understanding of GL by establishing a more accurate and

regionally relevant GL range based on a 95% confidence limit, benefiting both equine industry economics and equine welfare by improving early identification of skeletally immature neonates, so that appropriate intervention may be considered.

Introduction

In common with other species with a long gestation, horses exhibit considerable variability in GL, with 320 - 360 d considered the normal limits for Thoroughbreds [1]. The mean GL is frequently calculated as 340 d from conception, with foals born under 320 d considered premature and those born under 300 d unviable.

Prematurity or dysmaturity are linked to skeletal developmental problems in later life and therefore accurate information at birth is necessary to allow better informed decision making at or soon after birth as to the level of intervention required. In cases where GL is less than 320 d and the neonate shows signs of an inability to thrive, veterinary assessment of physiological parameters can confirm the level of foal compromise. Premature foals frequently display incomplete ossification of the carpal and tarsal bones and, without early management strategies such as movement restriction or support of affected limbs, collapse and fracturing of the carpal and/or tarsal bones may occur. For mildly premature foals, the need for physiological and musculoskeletal assessments may not be immediately obvious [2]. For dysmature foals, potential problems are even less obvious, although they may have similar skeletal developmental problems. When the degree of ossification is unknown or unrecognised, management strategies are not implemented, and such foals may remain vulnerable to carpal and tarsal malformation and, subsequently, angular limb deformities (ALDs).

Due to the large variation in what is defined as a “normal”, GL can presently only provide a general indication of whether a neonate is mildly premature or dysmature, with even less clarity for dysmature foals. The question arises as to whether improved knowledge of the factors contributing to GL variation will help in the assessment of the degree of foal prematurity and dysmaturity at or soon after birth. This review will examine the factors contributing to GL variation, and whether there is potential to more accurately define normal term GL depending on climate and location.

Overview

Since the early 20th century, studies into GL have focused on establishing a mean for equine GL, while identifying causes of variability. A technical communication from the Commonwealth Agricultural Bureaux reported mean or range of GLs from 65 studies and texts , although some references are incomplete [3]. These values were varied, with means from 322 - 352 d (Figure 1). Presumably while the Kenneth (1953) communication was in publication, a University of California study produced two papers that provided experimental data for genetic and environmental variation, reporting an overall mean of 336.4 d, with season of breeding the most important source of variation (up to 4 d), with limited effect of mare's nutrition [4], and influence of the foal's additive genotype and maternal traits [5].

In the late 1960s, the research was brought into focus by P.D. Rossdale, who investigated GL in the context of a burgeoning veterinary field of equine perinatology. Rossdale's 1967 study of the newborn Thoroughbred foal is the seminal paper in establishing a mean GL of 340.7 d [6], which has subsequently been widely cited. Rossdale stated that this value was applicable only to particular Thoroughbred studs with a like management approach, and also repeated this in his later texts, including the seminal perinatology manual, *Equine Stud Farm Medicine* [7].

In response to Rossdale (1967a), individual validation studies have also been published, with the aim of establishing GL values for particular breeds in specific regions [8-10]. Many of these studies are descriptive, and present varied and conflicting values and findings, partly due to considerable variation in methodologies applied.

Since the 1980s, the widespread use of ultrasonography in pregnancy diagnosis has enabled greater accuracy in measuring GL. Used to confirm pregnancy at 14 d and 24 d, technological advances later enabled accurate identification of the ovulatory day, and therefore the most likely day of conception. Previously, conception date had been calculated in various ways, the most usual being the last day of mating [2]. Breeders and registries also used either the first day of mating [11] and last day of artificial insemination [12, 13].

An influential study by Davies Morel (2002) aimed to update Rossdale's findings with more accurate values based on ultrasound observations, with GL measured from ovulation rather than mating [14]. Although it was expected that the GL would be shorter than Rossdale (1967a), this study reported the longer mean GL of 344.1 ± 0.49 d. This study continues to be frequently cited by studies using similar ultrasound methodology [15] and breed registries have started requiring ultrasound confirmation of conception date as well as pregnancy.

The growing field of quantitative genetics has focused on improving breeding efficiency by reducing gestational and neonatal loss, and optimising broodmare productivity. Researchers are addressing equine heredity with cohorts of a previously unseen scale. In France, where all breed registry data includes ultrasound confirmation of pregnancy under the *Haras Nationaux* (National Stud) regulations, researchers retrospectively studied over 350,000 gestations, with the aim of refining knowledge of the sire and dam's genetic contribution to gestation length and foetal health [11, 16, 17]. Such studies enable GL data to be collected on an equally major scale.

Full Term Gestation

Given that Rossdale clearly states that the GL values in his 1967 study relate only to Thoroughbreds and are relevant to the management practices of a small group of studs in the Newmarket area, it is interesting how widely the value is now used. It is difficult to determine how 340 d has become a ‘magic mean’ against which many subsequent studies have compared results, and by which breeders continue to calculate parturition dates.

In *Equine Stud Farm Medicine* [7], a half page addresses gestation length, and specifies that on Thoroughbred stud farms, parturition is usually calculated as 11 calendar months from the last service (333 - 336 days). The author states that mean GLs of 338 - 340 d have been established, citing German and American studies into Thoroughbred mares from the 1930s and 1940s, as well as his own 1967 paper [6]. Rossdale also references the means of 322 - 345 d presented in the compilation of data by Kenneth (1953).

An Australian study is also cited, which reported GL values of 345.3 d and 337.9 d for spring and summer months respectively [10]. In reporting their findings, Ropiha et al (1969) suggests that foal gender, month of conception and the genetics of the dam were strong influences on variation in GL. Rossdale also acknowledges the variability of GL, and refers to a heritability of 36% found by Rollins and Howell (1951) several times [7, 18]. Rossdale seems to offer revised or updated values in his publications. In a 1981 general text, he states that the normal range of GL is 320 - 355 d, for GL, without reference to a mean [19]. In a number of perinatology studies into prematurity, he focuses on the individual presentation of mare and foal, and the foal’s endocrinological readiness for birth, which determines whether the neonate is born prematurely or with dysmature characteristics [1]. Yet in a 2002 general text, he again gives 340 d as the mean for TBs found in his 1967 paper, but with a range of 320 - 360 d [20].

Although other studies using Thoroughbred mares have found different mean values to those reported earlier (Table 1), the generally held mean value of 340 d endures. This seems to be partially due to the author’s significant contribution to the field of study, as *Equine Stud Farm Medicine* continues to be referenced for all breeds in many recent papers and books [2, 21, 22].

Method of Date Calculation

When reviewing studies into equine GL, the variability and reliability of data sources must be considered. Many studies have used breeding farm and breed registries data, which can be subject to varied record keeping approaches. Dissimilar methods of determining fertilisation dates caused errors of up to 5 d in private breeder and national studbook data [23]; in data from Standardbred farms, 94 of 594 foaling records were excluded due to inaccuracies [24].

Registry regulations can encourage inaccurate recording. In the racing industry, a year's age is automatically imposed on Thoroughbreds and Standardbreds on the first day of the registration year. This is problematic for breeders of foals born near the start of the registration year, leading to registration irregularities when foals are born early, as has been noted in some GL studies [11]. In two studies of Thoroughbreds, no GL earlier than 315 d were reported [10, 14], resulting in high mean GL values (Table 1). It is particularly interesting that of these, Davies Morel (2002) used conception dates determined by ultrasound, and therefore anticipated a more accurate and shorter value than that established by Rossdale (1967a), yet reported a mean that was 4 d longer.

Ultrasound scanning may miss embryos that are small due to delayed fertilisation occurring several days after the sperm has entered the mare's tract [15]. To mitigate this, some researchers adopt daily ultrasound examinations for increased accuracy [25], observing the mare's ovulatory follicle (≥ 3.5cm) and calculating GL from the previous day [9, 14, 17].

Retrospective studies using different stud book sources may need to adjust data. Langlois (2010) benefited from a national studbook approach requiring ultrasound confirmation 14 and 20-d post-insemination, and a positive result at 43 - 45 d post-fertilization [11, 17]. Despite this, data required correction, for some breeders had declared first day of mating rather than the last. In an effort to reconcile recent data with older registry data, other studies have used service dates rather than ovulation dates, acknowledging that the actual GL could be up to a week shorter [26].

Records concerning premature or dysmature births, or stillbirths, are also treated in different ways by breeders, registries and researchers. Some Standardbred registries instruct breeders to use the term ‘foal died’ for a foal that is either still born, dies during birth, or fails to stand and suckle. It is noticeable that only a few studies provide figures for stillborn foals. Some studies only include GLs that resulted in a viable foal, or a foal that lived for a certain duration [10]. Others exclude gestations outside the researchers’ criteria for ‘normal term’ as outliers, including all gestations < 320 d [12, 27]. Langlois et al (2012b) treated a record of early stage embryo loss, abortion, still birth or premature birth resulting in death as a gestational loss, while foals that were born viable, but died from other causes before registration, were excluded altogether [16].

Numerous studies include records of any viable foal considered viable, although unviable remains undefined, aside from the assumed non-viability limit of < 300 d [7]. Therefore gestations of 310 - 315 d are included [10, 25, 28, 29] and some shorter than 310 d [9, 12, 23, 30].

Such variation in data capture and analytical criteria contributes to an inaccurate picture of equine gestation length.

Extrinsic Effects

Many studies aim to establish a single mean GL value for the cohort, despite the seasonal variation reported in many studies. Some studies consider the month of conception [18] and others the month of foaling [29], yet it is widely accepted that the later the birth in the reproductive season, the shorter the subsequent mean GL.

Howell and Rollins (1951) found a difference of up to 10 d between winter and spring foalings [4], and concluded that season of breeding accounted for 43.4% of the total variance in GL [5]. Their study population was small (n=-186), but one of the largest studies to date (n=350,204) confirmed month of conception to be of the ‘greatest magnitude’ as a variable factor of the maternal environment [11]. The variation can be large: a Spanish study reported a total variation of 8 d in Andalucians and 17 d in Arabians [15], while in Finland, the mean GL of Standardbred mares was found to decrease by 11.9 d between April and August, and Finnhorse mares by 14.3 d [12].

Season and month are in this respect inseparable, impacting on mean temperature, and availability and quality of available forage, as well as light regime. The effect of season on the gestational process is now so widely accepted that it must be asked how applicable a mean GL can be if month, which relates to climate, nutrition and photoperiod, is not taken into account.

In Australia, Ropiha et al (1969) is unusual in reporting means for months, without giving an overall mean value. The longest GLs were found in October, with the shortest in the summer month of December [10]. This prioritises the seasonal over an annual value, which has greater applicability in practice. Earlier, Howell (1951) reported monthly and quarterly means, with a slightly shorter mean GL from Dec - Feb than from Mar - May. Supplementary feed during winter months was thought a possible cause of this difference. Davies Morel et al (2002) had similar findings in a UK study of Thoroughbreds, with a mean GL being shortest in January at 333.2 d and longest in April at 348 d, and 340 d in June and July. The researchers noted that the artificial lighting used to advance reproductive activity in winter may have influenced these results [14].

Seasonal management interacts with the effect of season and may affect GL, particularly when this involves use of stabling with artificial lighting. A Polish study using data sourced from studbooks over a 55 y period (n = 13,409) differed from other northern hemisphere studies by finding mean GLs to be shortest in the winter month of October. However, in this case the mares were accommodated in stables and yards for 23 h per day [23]. In racehorse breeding, Thoroughbred foalings are timed close to the start of the annual registration, which is the 1 January in the UK and 1 August in Australasia. This results in parturition during late winter / early spring, when GL is known to be longer.

Some studies also identify a second period of lower means outside the usual spring and summer reproductive season. Reilas et al (2014) suggest a GL 'wavelike pattern' throughout the year, while Langlois indicates two waves, and suggests these are effective in synchronizing foalings in spring (Mar - Apr), and early autumn (Sept). It is unclear how many horses were in the latter study (n=350,204) were stabled, but 50.9% were registered Thoroughbreds and French Trotters (n=178,558), which as racehorses would typically be boarded [11]. Stabling management affects nutritional intake and photoperiod through artificial lighting, which are inherent to seasonal effects.

Many recent studies provide latitudes for the breeding operations considered in the methods, although the effects are rarely considered further. However, in studies of Standardbreds in Finland and Michigan, mean GLs differed by 15 d around the spring equinox, when all latitudes share equal daylight hours [12, 24]. This suggests that the light regime may interact with other variables.

In nature, availability of nutrition is closely associated with season. Howell and Rollins (1951) found that well-fed, stabled mares had mean GLs 4 d shorter than pasture-kept mares on maintenance rations, even during seasons of high grass growth, and refuted the association between season and nutrition. However, both groups of mares showed seasonal variability to the same degree within their respective ranges. This indicates that high nutritional levels lead to shorter GLs, possibly due to higher placental sufficiency.

In contrast, after comparing long term GL data with climate records, other researchers have concluded that poor nutrition leads to a slower maturation of the foetus, and therefore longer GLs [15]. Severe malnutrition of the dam may lead to foetal compromise and early delivery due to failure of placental exchange, resulting in a premature or dysmature foal [31-33].

Quality and availability of nutrition is, of course, subject to variable management practices. In small studies, researchers need to ensure that stud farms are in the same region and also have like husbandry approaches, as in the Thoroughbred stud farms selected by Rossdale (1967) and Davies Morel (2002). To produce comparable results, studies need to produce values for each stage of the breeding season, and also align these by lighting regime and available nutrition. If unaccounted for in the methodology, these highly interconnected environmental variables can render mean values of limited use in advancing knowledge of equine gestation.

Intrinsic Effects

It has been established that mares have approximately the same gestation length, year on year [34], with studies reporting the mare's previous GL as the strongest indicator of present GL [15, 28]. Views differ on the extent to which the mare's age affects GL. Howell and Rollins (1951) reported both the mare's age, and the number of foals previously borne as factors. However, the study by Langlois (2012a), based on over 350,000 records, found only a slight positive and linear increase of GL with the age of mare, and Davies Morel (2002) reported none. In contrast, Valera et al (2006) identified 4 years of age as the age at which mares' longest gestation occurred, after which it decreased, as did fertility levels [35]. Several studies have reported difference between primiparous and multiparous mares [15, 25, 30]. Elsewhere, mares were found to have a longer gestation if they had not foaled the previous year [11].

Numerous studies report that the foal's gender has an effect on GL with mean differences of 2 - 4 d longer in colts [12, 15, 23, 28, 30]. Attempts have been made to link foal gender and GL to the sire, but these have not all proved statistically significant [24]. Significant sire effect on GL has been reported, with differences in mean GLs of foals sired by different stallions of up to 8 d difference from the overall mean [24, 36], and up to 12 d difference [30]. Other studies report no sire effect [14]. Howell and Rollins (1951) attribute 24% of GL variance to the mare's permanent difference, without dividing these into genetic and non-genetic. Ropiha (1969) failed to find an effect of the either the sire, or the dam's sire, although attributed this as possibly due to the close relationships within the breeding cohort.

Many studies have attempted to determine a mean GL for different breeds in different countries, based on the unstated assumption of a similar reproductive endocrinology. Thoroughbreds and Standardbreds form relatively standardised breed cohorts, sharing a high level of selective breeding and close genetic relationships. Two New Zealand studies of Standardbreds reported means of 349.1 d ± 0.5 d [13] and 348.8 ± 0.4 d [29]. Referring to the similarity of these results, Dicken et al (2012) concluded that the breed's close international genetic pool along with similar latitudes were major factors limiting variability. This conclusion is not fully supported in other studies: in the USA and Finland, where Standardbreds have been reported to have mean GLs of 343.3 d [24] and 331.7 d [12].

The influence of breed appears to be clearer in studies that use a single methodology. Valera (2006) utilised records of Arabians and Andalucians from a single farm over 31 breeding seasons. With country, year, climate and management standardized for both breeds, the researchers found a difference of 4 d between the breeds' with respective mean GLs of 340.3 ± 0.63 d and 336.8 ± 0.48 d.

In the Netherlands, Bos (1980) reported 337.7 d and Sevinga (2004) reported 331.6d for Friesian horses. The Friesian horse has an especially small gene pool, having been founded over 130 years ago and with no new blood since introduced [37]. Record keeping is a variable in these studies: Bos (1980) calculated GL as the interval between mating and foal delivery, while Sevinga (2004) used last insemination date and foal delivery. Both sourced records from the breed studbook. The differing values suggest that in this comparison, either breed is not a major variable, or that other variables override its influence.

While single breed horses provide standardisation within individual studies, there is little cross-study similarity in values. When different breeds are used within an individual study, different mean values are reported [15, 38]. This suggests that breed is a variable, albeit one of limited significance.

An Adaptive Full Term Range

With the concept of a "normal" full term GL being based on non-standard methods for date calculation and variable research methods, the mean values derived in recent studies are as diverse as those from 60 years ago. A small number of studies, including Rossdale (1967a), provide values for the 95% confidence limit (CL) and/or standard deviations from the mean (Figure 2). Over half of these present lower boundary CLs < 320 d, with all those > 320 d being located in Northern Europe.

It appears that with an average 95% CL range of 43 d, locations with lower latitude exhibit lower values for both upper and lower 95% boundaries (Figure 3). These values are subject to the aforementioned variables, particularly seasonal variation and method of date calculation. However, the effect of photoperiod is less clear, as locations closer to the equator do not have longer days. It is possible that a climatic variation is also present, as suggested in two recent studies, and discussed by Davies Morel (2002). Valera (2006) discusses the effect of coastal climate and sunlight hours, rather than simply daylight, as a possible cause for the shorter mean GL of Arabians on the Iberian Peninsula compared with Andalucians in Cadiz. Langlois (2012a) established that different GLs across France correlated more closely to regions defined by altitude, rather than latitude.

The effect of temperature variation is also evident in earlier studies. Cilek (2008a) reported a mean GL for TBs in 1999 that was 10 d longer than that of 1998 and 2000, with the value for Halfbreds also longest in 1999, and attributes this unusually cold temperatures [27, 39]. Perez et al (2003) reported that at the end of a 5-yr drought in Spain, from 1994-1995, GLs were significantly shortened [9]. Valera (2006) concurs with Perez et al (2003), but conversely attributes longer GLs of 1980 – 1988 to the drier conditions and higher temperatures of that earlier period. Meanwhile, Langlois (2012a) found year to be a significant contributor to variation in GL, with one year in 14 having significantly longer GLs (1 d), and one in 14 significantly shorter GLs. [11].

These changes to the mean GL suggest an adaptive mechanism to extended periods of unusually high or low temperature, rather than a short-term, annual adjustment. It seems that temperature should be considered alongside photoperiod, in terms of adaptation to regional climates and even to more localised temperatures zones. In practice, many stud farm breeders are integrating this influence into their knowledge of individual mares' full term GLs, particularly if AI or mating occurs at the same time and in the same location on an annual basis. However, if there is a strong regional variation in the 'normal' full term gestation, then the GLs at which foals are identified as premature, or at risk of being dysmature, need to be similarly adjusted.

Conclusion

With greater clarity of GL date calculation, it may be possible to define more regionally applicable "normality" ranges, enabling more relevant definitions of premature GL to be applied. This in turn will provide greater guidance as to the degree of immaturity and the classification of dysmature foals vulnerable to longer term skeletal health issues. While equine parturition and neonatal outcomes will always be subject to a degree of variability unrelated to gestation dates, a reduction in youngstock requiring surgical intervention for potentially career-ending limb deformities could potentially benefit the industry in terms of economics, as well as equine health and welfare.

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[1] Rossdale PD, Silver M. The concept of readiness for birth. Journal of reproduction and fertility Supplement. 1982;32:507-10.
[2] Rossdale PD, Ousey JC, Silver M, Fowden A. Studies on equine prematurity 6: Guidelines for assessment of foal maturity. Equine veterinary journal. 1984;16:300-2.
[3] Kenneth J. Gestation periods : a table and bibliography. In: Genetics CBoABa, editor. Farnham Royal, Slough, Bucks: Commonwealth Agricultural Bureaux; 1953.
[4] Howell CaWR. Environmental sources of variation in the gestation length of the horse. Journal of Animal Science. 1951;10:789-96.
[5] Rollins WaCH. Genetic Sources of Variation in the Gestation Length of the Horse. Journal of animal science. 1951;10:797-806.
[6] Rossdale PD. Clinical studies on the newborn thoroughbred foal. I. Perinatal behaviour. British Veterinary Journal. 1967a;123:470-81.
[7] Rossdale P, SW Ricketts. Equine Stud Farm Medicine. 1980.
[8] Hintz HF, R.L. Hintz, and Van Vleck, L. D. Growth Rate of Thouroughbreds. Effects of Age of Dam, Year and Month of Birth, and Sex of Foal. Journal of Animal Science. 1979;48:480-7.
[9] Pérez CC, Rodríguez I, Mota J, Dorado J, Hidalgo M, Felipe M, et al. Gestation length in Carthusian Spanishbred mares. Livestock Production Science. 2003;82:181-7.

[10] Ropiha RT, Matthews RG, Butterfield RM, Moss FP, McFadden WJ. The duration of pregnancy in thoroughbred mares. Veterinary Record. 1969;84:552-5.
[11] Langlois B, C. Blouin. Genetic parameters for gestation length in French horse breeds. Livestock Science. 2012a;146:133-9.
[12] Reilas T, Virtala AM, Katila T. Gestation lengths of finnhorse and standardbred mares in finland: Effects of breeding season and reproductive status. Pferdeheilkunde. 2014;30:45-51.
[13] Dicken M, Gee EK, Rogers CW, Mayhew IG. Gestation length and occurrence of daytime foaling of Standardbred mares on two stud farms in New Zealand. New Zealand Veterinary Journal. 2011;60:42-6.
[14] Davies Morel MCG, Newcombe JR, Holland SJ. Factors affecting gestation length in the Thoroughbred mare. Animal Reproduction Science. 2002;74:175-85.
[15] Valera M, Blesa F, Santos RD, Molina A. Genetic study of gestation length in andalusian and arabian mares. Animal Reproduction Science. 2006;95:75-96.
[16] Langlois B, C. Blouin, S. Chaffaux. Analysis of several factors of variation of gestation loss in breeding mares. Animal. 2012b;6:1925-30.
[17] Langlois B, C. Blouin, S. Chaffaux. Analysis of several factors of variation in gestation loss in breeding mares. European Federation of Animal Science (EAAP). Crete2010.
[18] Rossdale PD, and R. V. Short. The Time of Foaling of Thoroughbred Mares. Journal of Reproduction and Fertility. 1967b;13:341-3.
[19] Rossdale PD. Horse Breeding. 1981.
[20] Rossdale PDaMB. The Horse From Conception To Maturity. London: J A Allen; 2002.
[21] Madigan J. Manual of Equine Neonatal Medicine. 4th ed. Woodland, California: Live Oak Publishing; 2014
[22] Blanchard TL, Thompson JA, Love CC, Brinsko SP, Ramsey J, O'Meara A, et al. Influence of day of postpartum breeding on pregnancy rate, pregnancy loss rate, and foaling rate in Thoroughbred mares. Theriogenology. 2012;77:1290-6.
[23] Walkowicz E, Unold O, Maciejewski H, Skrobanek P. The effect of selected factors on the length of gestation period in Silesian mares. Animal Science Papers and Reports. 2014;32:55-64.
[24] Marteniuk JV CC, Lloyd JW, Shea ME. Association of sex of fetus, sire, month of conception, or year of foaling with duration of gestation in standardbred mares. Journal of American Veterinary Medicine Association. 1998;212:1743-5.
[25] Winter GHZ, Rubin MIB, De La Corte FD, Silva CAM. Gestational Length and First Postpartum Ovulation of Criollo Mares on a Stud Farm in Southern Brazil. Journal of Equine Veterinary Science. 2007;27:531-4.
[26] Sevinga M, Barkema HW, Stryhn H, Hesselink JW. Retained placenta in Friesian mares: Incidence, and potential risk factors with special emphasis on gestational length. Theriogenology. 2004;61:851-9.
[27] Cilek S. The survey of reproductive success in Arabian horse breeding from 1976-2007 at Anadolu state farm in Turkey. Journal of Animal and Veterinary Advances. 2009(b);8:389-96.
[28] Aoki T, Yamakawa K, Ishii M. Factors Affecting Gestation Length in Heavy Draft Mares. Journal of Equine Veterinary Science. 2013;33:437-40.
[29] Vincent SM, Evans MJ, Alexander SL, Irvine CHG. Establishing normal foaling characteristics in Standardbred mares in New Zealand. Journal of Equine Veterinary Science. 2014;34:217-9.
[30] Satué K, Felipe M, Mota J, Muñoz A. Gestational length in Carthusian broodmares: Effects of breeding season, foal gender, age of mare, year of parturition, parity and sire. Polish Journal of Veterinary Sciences. 2011;14:173-80.
[31] Silver M, Fowden AL. Uterine prostaglandin F metabolite production in relation to glucose availability in late pregnancy and a possible influence of diet on time of delivery in the mare. J Reprod Fertil Suppl. 1982;32:511-9.
[32] Morresey PR. Prenatal and perinatal indicators of neonatal viability. Clinical Techniques in Equine Practice. 2005;4:238-49.

[33] Morley SA, Murray J-A. Effects of Body Condition Score on the Reproductive Physiology of the Broodmare: A Review. Journal of Equine Veterinary Science. 2014;34:842-53.
[34] Samper JC, J. Pycock and A.O McKinnon. Current Therapy in Equine Reproduction. Missouri: Saunders; 2007.
[35] Ahmed WM, Zaabal MM, Hanafi EM, Abu Atia EF, Elkhadrawy HS, El-Battawy KA. Relationship between immunogenetic markers and some reproductive parameters in purebred Arabian mares. Global Veterinaria. 2013;11:702-7.
[36] Bene S, Giczi A, Benedek Z, Peter PJ, Szabo F. Some effects on gestation length of different horse breeds in Hungary. Magyar Allatorvosok Lapja. 2013;135:206-12.
[37] van der Holst W. Breeding problems in the Friesian horse. Genet Sel Evol. 1982;14:1-2.
[38] Bos H, van der Mey GJW. Length of gestation periods of horses and ponies belonging to different breeds. Livestock Production Science. 1980;7:181-7.
[39] Cilek S. Environmental factors affecting fertility traits of Thoroughbred and Halfbred horses reared in Turkey. Indian Journal of Animal Sciences. 2008;78:1353-8.

Table 1. Mean gestation lengths for Thoroughbreds, showing the values found in studies before and after 1980, the publication year of *Equine Stud Farm Medicine,* Rossdale (1980), and commencement of ultrasonographic scanning for confirmation of conception.

Mean GL (d)	**Pre-1980**		**Post-1980**	
330.0			Valente (2006)	Brazil
334.5	Cortez E (1950) *	Brazil		
337.0	McNellis, R (1945) * ✧	Switzerland		
337.7	Bilek, F. (1936) * ✧	USA		
338.8	Jennings, WE (1950)	USA		
339.0	Britton, JW (1943)	USA		
339.5	Uppenborn, W (1933) * ✧	Germany		
340.1	Jordao, LP (1950) *	Bolivia		
340.7	Rossdale, PD (1967a) ✧	UK		
340.9			Dring (1981)	Canada
342.3	Ropiha, RT (1969) ✧	Australia		
344.1			Davies Morel (2002)	UK

* Bibliographic data from Kenneth (1953)
✧ Cited in Rossdale (1980)

Figure 1. Values for mean GL in the literature, 1900 - 2015. Where studies provide values for two breed groups, two values are included in the chart. Bibliographic data is from Kenneth (1953).

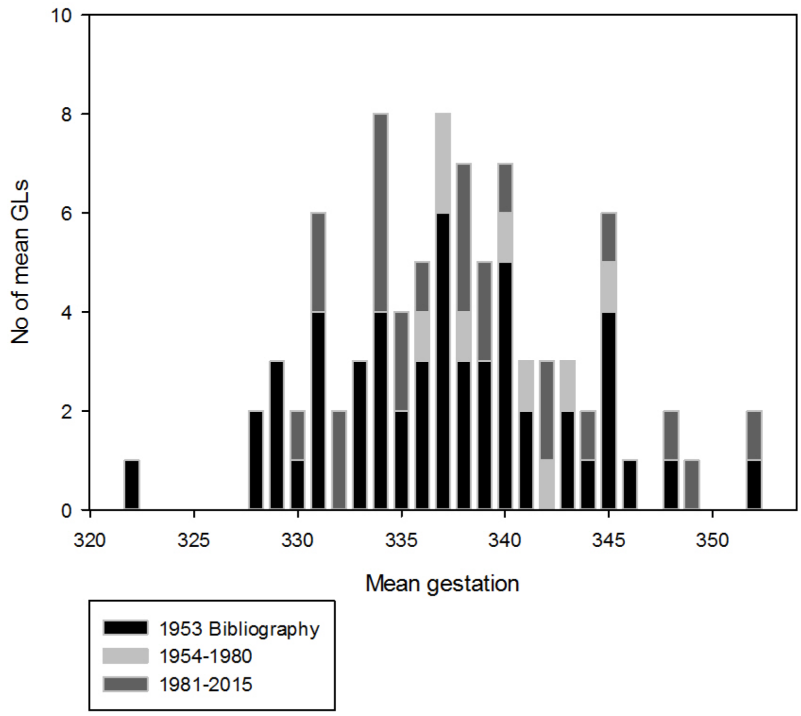

Figure 2: Gestation length and ranges reported in literature

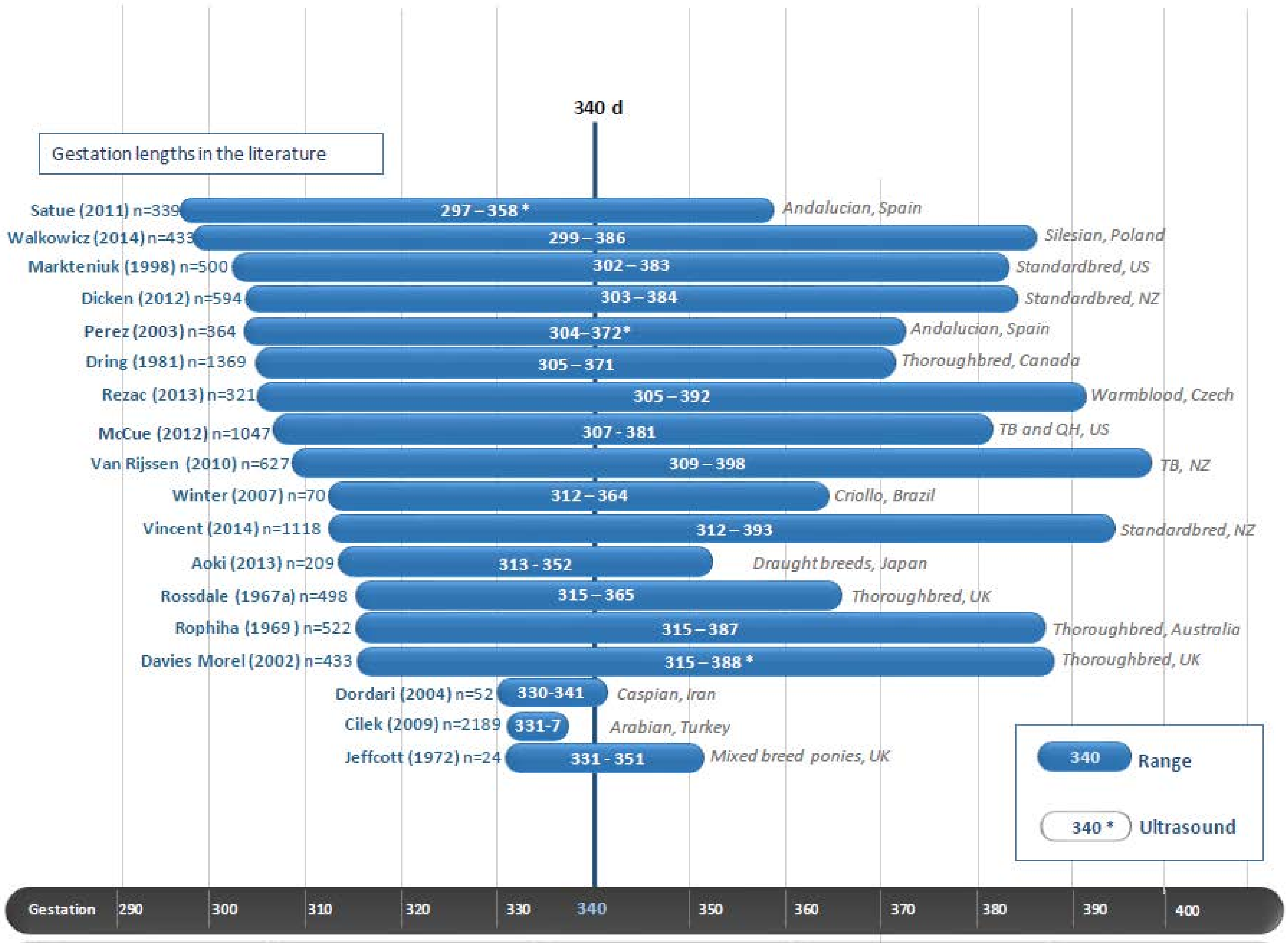

Figure 3a: Gestation length ranges arrayed by latitude

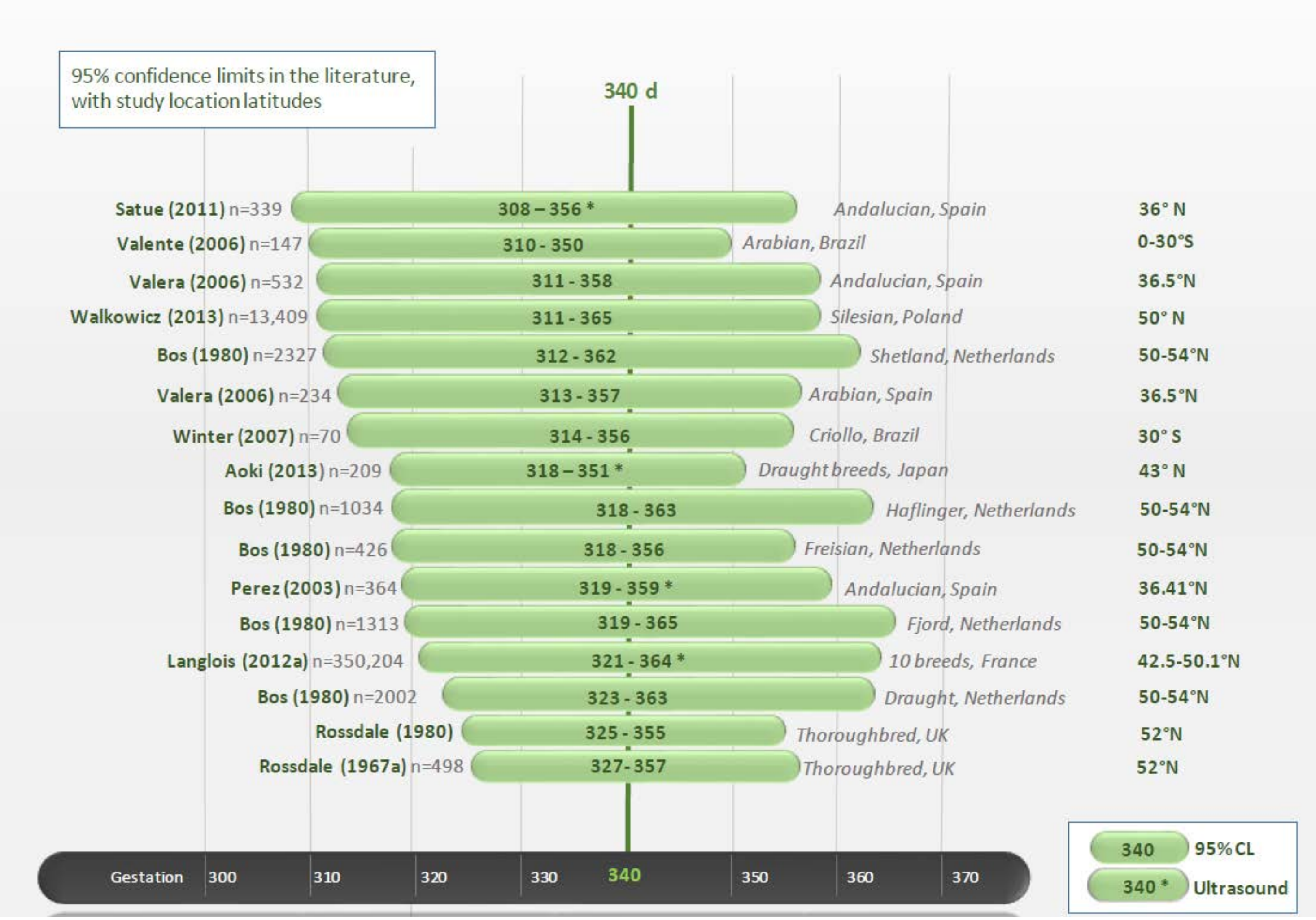

Figure 3b: Gestation length by latitude: 95% confidence intervals

(alternative to figure 3a)