Master thesis: The association between an increase in foaling date and delayed conception in a cohort of New Zealand Standardbred mares.

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Abstract

Background: Nutrient modelling of Thoroughbred mares managed under commercial management conditions has identified a potential negative energy balance later in the breeding season that could extend the interval from parturition to conception. Anecdotally, Standardbred mares are believed to have a greater feed conversion efficiency than Thoroughbred mares and are managed with lower levels of feed (pasture DM on offer) during breeding season. At present, there is no published data on the association between foaling date and delayed conception in Standardbred mares.

Objective: To investigate the association between increased foaling date (days after August 1) and delayed conception in a cohort of New Zealand Standardbred mares.

Methods: Official breeding records were collected from 558 Standardbred broodmares managed on two farms during the seasons 2016-2017 and 2018-2019 breeding seasons. Horse and breeding record data were obtained as an electronic extract from HRNZ. These records were collated and summarized in Microsoft Excel. Data were examined using simple descriptive statistics and then examined according to mare age, breeding status and foaling date. Pasture growth (kg DM/ha/day) were obtained from official records. Kaplan Meier Survival curves were used to examine the interval from parturition to conception, with and without mares that carried over.

Results: The mean foaling date was ~4 November for mares inseminated as dry mares and 14 November in wet mares. The mean conception date of the Standardbred mares was 27 November in dry mares and 13 December in wet mares. Mares that foaled earlier in season had the longest interval between foaling and conception, smallest percentage of mares bred on foal heat and smallest percentage of mares that carried over. The group of mares that foaled latest in season had the shortest interval, greatest percentage of mares bred on foal heat and greatest percentage of mares that carried over. Stocking density was relatively low and pasture growth was mostly sufficient during the year.

Conclusion: Foaling late in the season was not associated with a delay in conception in Standardbred mares. These findings indicate that they did not experience a negative energy balance. Further research is required to investigate to what extent farm management influences mare reproductivity.

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Introduction

The breeding and the production of horses for the export market is a major industry in New Zealand. In New Zealand the horse industry is primarily focused on racing and less about show jumping, dressage and eventing. There are jump races, flat races and harness races. For jump races and flat races, Thoroughbreds are used and for the harness races Standardbreds are used. There is a major export focus for the Thoroughbreds, with ~40% of the foal crop (1800 out of 4500) is going for export (Waldron et al., 2011). There is a greater focus on the domestic market with Standardbreds, with only about 15% exported (300 out of 2000). Standardbreds are older when they go for export (Rogers et al., 2017a).

The racing

Most of the racing in New Zealand is Thoroughbred flat racing. A large proportion of horses are offered for sale as yearlings and start race training after the yearling sales, when they are about 2 years old. Only 30% of the foal crop will race as 2-year olds. The majority of 2-year olds in training are trained primarily for education and conditioning and start racing when they are three years old (Bolwell et al., 2010, 2012). The racing life of a Thoroughbred in New Zealand is typically two -three years, with many horses retiring once older than 5 years (Bolwell et al., 2016b).

One third of the Thoroughbred horses that start racing are retired voluntary, because the horse has no talent. Another one third retire from racing due to involuntary reasons, the majority of which (78%) are due to musculoskeletal injury or retire due lameness (Perkins et al., 2005). The better performing horses have another destination after their racing careers. The mares and stallions are used for breeding and some of the geldings enter the equestrian sport (89% of eventing horses are Thoroughbreds) (Verhaar et al., 2014; Rogers & Firth, 2005). Most of these horses are not suitable for higher sport, they go for recreation or for consumption.

The Standardbreds are trained the same way, but 50% of the training is done by the trainer or owner. This means that there are more amateurs doing the training, so there is a greater variation in training pattern. The Standardbreds keep racing until they are older (Bolwell et al., 2016b). The wastage of Standardbreds is the same as Thoroughbreds (Tanner et al., 2011).

The commercial breeding

The commercial breeders want to have a live healthy foal every year and want the mare conceiving within 25 days postpartum. Those 25 days are two oestrus cycles, assuming the gestation length is 340 days. Otherwise it will cost (Bosh et al, 2009). If they carry the mare over, then it is a lost opportunity to get a foal on the ground to sell and it will cost a lot of money to carry her over, unless the mare has great value. That is why they attempt to have the foal born early in the season, so they can maximize growth rates and body size at the time of yearling sales in February next year, to maximise profits (Gee et al, 2017). They desire the foal to be born as close to the official birth date of all foals on the 1st of August. Commercial breeders attempt to have 3 foals in 4 years. The gestation period in New Zealand is 349 days, that is almost 11.5 months. Mares bred early in the season have longer gestation lengths, than the mares bred later in the season. These variable lengths are associated with day length, year and high pasture growth in October and November (Dicken et al., 2012). The commercial breeding season in New Zealand runs from 1 September to 1 December (Rogers et al, 2007). Most breeders impose a shorter breeding period, from 1 September to 30 November. In Thoroughbreds most (87%)

of the mating is occurs before the 30th of November. To increase the chance of getting a mare pregnant within the breeding season, most mares are served on their first post-partum oestrus (foal heat) (Gee et al, 2017). If the mare isn't pregnant in the breeding season, they don't have a foal that year and it will cost.

Commercial breeding occurs more often with the Thoroughbred mares. The Standardbred breeders are less commercial and more traditional. They are less concerned with meeting the yearling sales market and focus more on producing bloodstock (Hirst, 2011). They work with less pressure and a longer breeding season, so they are more willing to absorb cost and carry a mare over. Besides, the proportion of foals sold as yearlings is relatively lower than with the Thoroughbreds, only 25% of the annual foal crop (2000) is sold (Rogers et al., 2017a).

The last couple of years, at an industry level, the number of sires and mares has reduced. For example, the number of Thoroughbred stallions has reduced ~ 65% (265 to 94) in the last 25 years. This reduction comes with an increase in reproductivity, because commercial breeders use a robust and stringent selection criteria for the sires and mares (Rogers et al., 2017a). Sires cover more than 100 mares in the breeding season and 67% of the mares have registered foals (Rogers et al., 2009, 2016). Mare reproductivity is mainly increased, because breeders use mares younger than 12 years and there is a selection on winners (Rogers & Gee, 2011). A 12-year-old mare will have at least 2 foals racing and so the mare shows her merit as broodmare. If the youngstock had no success in racing, the mare is downgraded and not used anymore. If the stallion was successful, he is retired to stud at 3 or 4 years old. In his first breeding season he has to deliver 2-year-old winners, otherwise no mare is sent to him anymore. This effectively means that the breeding careers of most the commercial stallions are about 3 to 4 years (Rogers et al., 2017a).

Thereby a Thoroughbred stallion may only have the opportunity to serve a mare once at peak season. On top of that the mare may only be served naturally. Artificial insemination and embryo transplantation are not allowed. At peak, a Thoroughbred sire may serve 3-4 mares a day, so 21 – 28 mares a week. Hence, the reproductivity of the stallions is increased the last couple of years. The Standardbred farms on the other hand are allowed to use embryo transplantation and artificial insemination. The semen of a Standardbred sire may be collected 3-4 times a week and this can be used to serve 7 – 20 mares per collection (Rogers et al., 2017a). So, there is less pressure on the Standardbred sires than on the Thoroughbred sires.

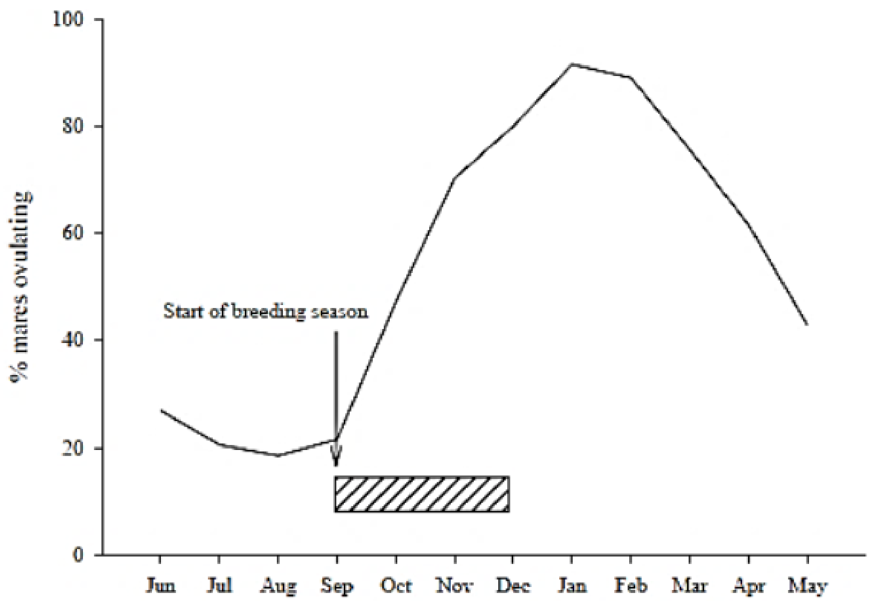
Commercial breeding and physiological breeding

However, the commercial breeding season provides constraints as it does not reflect the physiological breeding season of the mare (Gee et al., 2017). The mare is a long day breeder and is seasonally poly-oestrus (Nagy et al. 2000). The mare goes from anoestrus to oestrus when there is more than 16 hours light a day. Some breeders attempt to let the mare artificially go from anoestrus to oestrus with artificial lighting programmes and hormone therapy. With the hormone therapy they can use intra-vaginal implants or injections of GnRH, GnRH agonists, dopamine agonists, progestin and human chorionic gonadotropin (Aljarrah, 2004; McCue et al., 2007). They can also use rugs and an increasing plane of nutrition. The aim is to have empty horses with a BCS score of less than 4-5 out of 9 and then rise the plane of nutrition (Hanlon, 2012). As a result, the mares could transition into seasonal oestrus faster. This hypothesis is not proven yet, because of limited supportive data (Rogers et al., 2017a). With mares that just have foaled farms aim to shorten the interval within foaling to conception by breeding the mares at foal heat or "short cycle" on the foal heat using prostaglandin to shorten the dioestrus interval (Lofstedt, 1988).

This disparity between the commercial breeding season and the natural breeding season is highlighted by the number of dry mares ovulating at the start of the commercial breeding season (Figure 1) (Hanlon, 2012). This is only 20%. The highest amount of horses ovulating is seen in January, a month after the commercial breeding season ends (Hanlon, 2012).

Figure 1

Proportion of mares ovulating each month over a 12-month period in South Eastern Australia. Data obtained from Sydney horse abattoir. Hatched area represents commercial breeding season.



Note. Reprinted from "Reproductive performance and the transition period of Thoroughbred mares in New Zealand: evidence and implications for future alternative management strategies", Hanlon, D. W., 2012.

Under natural conditions the foaling takes place when the offspring has the best survival chance. This is during the time of the year with peak pasture availability (Ransom et al., 2013). With the long gestation length of horses, the natural conception occurs between December and March (late spring – summer) to ensure these optimal conditions for the offspring and the mare when the foal is born. The lactating mare has an increased energy demand, so the pasture must be adequate and from good quality. Hence, adequate (nutritional) management is necessary for the production cycle of the mare, especially if it is commercially induced.

Management of Standardbred broodmares

Adequate nutritional management at critical periods before and during pregnancy, and during lactation maximize the chance of reproductive success. The difficulty with this is the reliance on a pasture-based system production system, high stocking rates during the breeding season, and difficulty in estimation of voluntary feed intake in the horse when at pasture (Rogers et al., 2017). So, the supply of a balanced ration, which ensures adequate nutrition for each situation is important to maintain the production cycle.

In New Zealand all breeders use a pasture-based production system. This is very different from the systems used overseas and lies close to the ecological niche of the horse (Rogers et al., 2017a). The broodmares primary nutritional source is pasture supplemented with hay during the winter months. Year round they are managed at pasture or paddocks with ryegrass-clover. Broodmares are not stabled, not even when in-foal. Then they go to smaller paddocks. They are only stabled when they of their foals are treated (Rogers et al., 2017b). Horses spend 14-16 hours a day eating and travel 7-15 km a day (Rogers et al., 2012). Overseas, most horses spend the day in a box. This decreases the dry matter intake and increases the risks of stereotypical behaviour (Rogers et al., 2012; Rogers & Dittmer, 2019). An all year around pasture-based management reduces production costs and it reduces the reliance on concentrate feed to promote growth in young stock. The most used grass types in the pasture is Perennial ryegrass and white clover mixed with a ratio of 85 to 15 (Hirst, 2011; Randall et al., 2014). This perennial ryegrass-based pasture is regarded to be the best in the world for growing horses (Rogers et al., 2007).

The grazing behaviour of the horse

Horses are very different than the usual farmstock. Horses are monogastric hindgut fermenters, 50% of the feed must be forage to maintain gastrointestinal health. Horses exploit pasture with low digestible energy and high fibre (Rogers et al., 2017b). Their preference is a high sugar content and a low fibre content, so they will select the grass with a high non-structural carbohydrate and low fibre component, of which ryegrass is an example. Because horses prefer ryegrass, the voluntary feed intake will increase, which results in more growth. The voluntary feed intake is 3% of BWT DM/day with cut ryegrass, 2-2,4% of BWT DM/day with pasture and with hay it is 1,5% of BWT DM/day.

Horses are selective grazers. They prefer some pasture species and do not eat at the areas where they have urinated or defecated (Van den Berg et al., 2015; Rogers et al., 2017b). Roughs and lawns are a result of this behaviour and this makes it difficult to maintain the quality and consistency of the feed intake when the horses are grazing at the same pasture. Due to the grazing behaviour, the utilisation of a pasture is only 70%. Roughs and lawns are created by the selective grazing behaviour of horses. This provides an uneven distribution of nutrients and soil fertility and so promote the growth of weeds (Rogers et al., 2017b). Some farms harrow and some use cross grazing to solve this problem. General pasture management usually has first the horses eating 70% of the pasture DM in 4-6 weeks. After, this cattle goes in and eat the other 30% of the pasture in a shorter time. Cross grazing provides redistribution of nutrients and prevents overdistribution of less preferred species. Besides, it reduces the opportunity for intestinal parasites for cattle and horses, because grazing stops the lifecycle of the parasite.

Pasture content

In general, Standardbred farms are located at the Southern Island (Canterbury and Southland) and Thoroughbred on the Northern Island. The North Island has year-round pasture, only a small deficit in July and August whereas the Southern Island generally has no pasture growth in July and August. Farms located on the South Island need to feed conserved forage or standing oats and some mixed crops Italian rye grass (Rogers et al., 2017b).

Commercial breeders try to reach optimal growth rate and development without increasing the risk of evolving Developmental Orthopaedic Disease (DOD). Many commercial breeders will utilise improved pastures and feed grains and predominantly formulated pelleted rations to reach this. DOD affects cartilage and bone in growing animals and 10-15% wastage in yearlings is due to DOD. DOD is accepted to be a multifactorial condition and the incidence can fluctuate across the year due to changes in genetics and management system. Year-round pasture may confine the risk (Rogers et al., 2017b; Hirst, 2011).

Commercial farms have an average of 10 cm pasture sward height. This is approximately 3500 kg DM/ha (Rogers et al., 2007). The pasture in New Zealand provides enough K, Mg, Fe, S. However, it is low in Se, Cu and Ca. it is estimated that 30% of the New Zealand pasture is deficient for Se, with less than < 0,03 mg/kg DM, though the recommended intake is 0,1 mg Se/kg DM. Low Cu doesn't give diseases in monogastric animals, because the efficiency of absorption is high. However, pregnant mares in their third semester require supplementation of 0,5 mg/kg bodyweight a day to reduce the risk on DOD (Hoskin & Gee, 2004; Pearce et al., 1998a). Foals need a Ca:P ratio of 3:1 or 2:1 for growth and development of the foal. Majority of the commercial farms have these standards, because they supplement Ca and Cu in feed and Se in fertilizer (Rogers et al., 2017b).

On most Standardbred farms there is approximately 1 mare per ha in the non-breeding season. When the mares are in-foal, they are in groups of 6-12 mares per 2-4 ha and start with approximately 10 cm pasture height with 3500 kg DM/ha. Post grazing the pasture has approximately 1000 kg DM/ha left. When the pasture provides insufficient DM, hay is supplemented. Concentrate is only provided to mares during gestation, when they're supplemented with Cu, Zn, Ca and P (Rogers et al., 2017b).

The breeding season (Sep-Dec) gives a great influx of mares, which results in 2 mares per ha and the mares on very long rotations or the mares are set-stocked. Fortunately, the greatest pasture growth is during these months in spring (Rogers et al., 2017b).

The youngstock is divided in groups of 2-8 (4) foals on a 2-3 ha paddock. The pasture has 3000-4000 kg DM/ha at start of grazing and post grazing mass of approximately 1400 kg DM/ha. The foals are also offered 30-50% daily DE in pellets or muesli, which is lower on Standardbred farms, because they have a better feed efficiency conversion (Rogers et al., 2017b) and less focus maximising growth rate for sales as a yearling. After weaning 6-12 foals put in a 1,2-3,0 (average is 1,6) ha with 3500 kg DM/ha.

Requirements of the broodmare

The requirements of a broodmare are 76 MJ digestible energy per day (Rogers et al., 2017a; 2017b) and with late pregnancy the requirements increase by 10%. Most commercial farms feed mineral pellets in the third semester. These pellets have a low digestible energy, but include Cu, Ca, Zn and P (Rogers et al., 2017a). However, maintenance energy requirements are variable. Factors which can influence this are age, BCS, diet and living environment. This variation is due to little selection emphasis on feed conversion efficiency in the horse industry in comparison to another livestock industry and it often prevents a general approach for quantifying equine nutrient requirements (Rogers et al., 2017b).

Table 1

Daily nutritional requirement of horses (500 kg mare)

Horse class	BW (kg)	Average daily gain (g/day)	Requirement		
			Energy		Crude protein g/kg DM or (g)
			MJ DE/day	MJ DE/kg DM	
Maintenance	500		70	7	60 (530)
Pregnant 9 months	534	410	80	8	80 (797)
Pregnant 11 months	566	650	89	8.9	89 (893)
Lactating <3 months	500		133	10.6	121 (1511)
Lactating 3 months – weaning	500		123	9.8	109 (1365)

Note. Adapted from "Nutrient Requirement of Horses", National Research Council, 2007.

Table 1 (National Research Council, 2007) shows the daily nutritional requirements of a 500 kg horse in maintenance, gestation and lactation. These horses are fed with conserved forage and grain in contrast to the New Zealand pasture system. It is assumed that the feed intake of mare in maintenance is 2% DM of her bodyweight and that this is 2,5% DM of her bodyweight in a lactating mare. This is the minimal requirement of the lactating mare (National Research Council, 2007).

Pasture content and growth during the year

During spring the pasture has high growth rates and nutritional values, so it can meet the requirements for a lactating Thoroughbred mare (Grace et al., 2002). The lactation peaks at 1-2 months postpartum and the mare continues to lactate till 4-6 months. At 4 months farms start weaning the foals (Rogers et al., 2004). There is an increasing risk at early embryonic loss when this high energy demand is not met. Pasture must be well managed during summer (late lactation), with sufficient protein content (Rogers et al., 2017c).

The pasture is rarely deficient in energy, protein or fibre. There is low energy content in summer and sometimes in autumn, because of high dead matter content and reproductive stem content of the pasture (Hirst, 2011). High dead matter is caused by poor pasture utilisation or the lack of rainfall. Low animal performance is due to lower nutritional quality of pasture in regions where summer temperature is high, rainfall low, forage availability low and stocking density high. In the breeding season the stocking density is high. This has influence on pasture quality and availability (Hirst, 2011).

Pasture management

To keep the pasture quality and availability up, farmers can use a few management techniques. Management is crucial for high quality pasture. The quality depends on the ratio cell contents to cell walls and wall digestibility (Litherland & Lambert, 2007), it depends mostly dead matter amount. To maximize the amount of DM in the pasture, first to enhance soil fertility, they can use fertilizer and add new pasture species (productive persistent varieties). They can also top the pasture during the leafy stage in growing season. Harrowing or cross grazing with cattle for redistribution of nutrients will also enhance the pasture quality (Hirst, 2011).

Horses will intend to ingest a taller sward in preference to a shorter one, to maximise DM intake (Hirst, 2011). They eat grass with a sward height from 20 cm till 8 cm. Some farmers preserve paddocks for the breeding season. This is not good for the growth and health of the plants, because when it is over 20 cm there is significant wastage due to trampling. Thereby the pasture will recover slower once defoliated, because of the high proportion of stem is left (Hirst, 2011). As a result, pasture will open-up plus undesirable plants take their chance. When pasture grows above 14 cm, DM will drop. To avoid this, farmers can bailage the excess pasture and use it in feed shortage or sell it, which is good for the health of the pasture (Hirst, 2011).

On the other hand, when sward height drops under 8 cm, during high stocking density due to overgrazing pasture will also open up. This causes growing of weeds which are undesirable plus loss of high fertility grasses with preferred high sugar (Hirst, 2011).

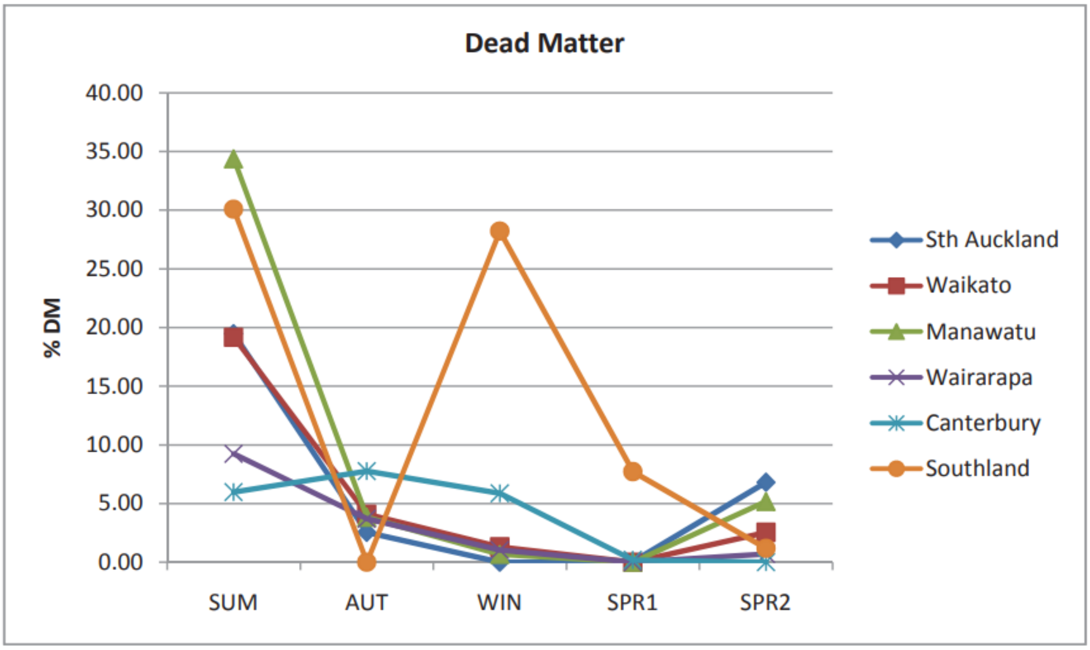
In addition to pasture height, the dry matter intake of horses can also be affected by the following factors: the horse's physiological state, dietary preferences, nutrient density of forage, forage availability and environmental conditions. Besides, the chemical and mineral composition of feed is affected by seasonal and environmental factors (Hirst, 2011). DM production of pasture is influenced by temperature and rainfall (Grace, 2005).

Pasture quantity and quality

Most Standardbred farms are located on the Southern Island in Canterbury and Southland, some are located on the Northern Island in Auckland and Waikato. The quality and quantity of the pasture is different in these regions of New Zealand. The temperature over the last 30 years is different between these regions, closer to the northern hemisphere it is warmer. The temperature during the year in Auckland and Waikato is warmer and Southland is overall colder. From warm to colder during the year, are Auckland > Waikato > Canterbury > Southland. The rainfall over the last 30 years is also different between these regions, there is less rain in the east because of the mountains. Seasonal, it rains the most in winter and least in summer. From most to less rain during the year are Waikato > Auckland > Southland > Canterbury. Farms located in the regions with less rainfall often use irrigation. Temperature and rainfall influence the proportion dead matter and DM production of the pasture and so the quality of the pasture (Figure 3, 4) (Hirst, 2011). Southland shows great differences from the other regions; dead matter is high in winter. This explains the lower metabolizable energy in winter (Hirst, 2011).

Figure 2

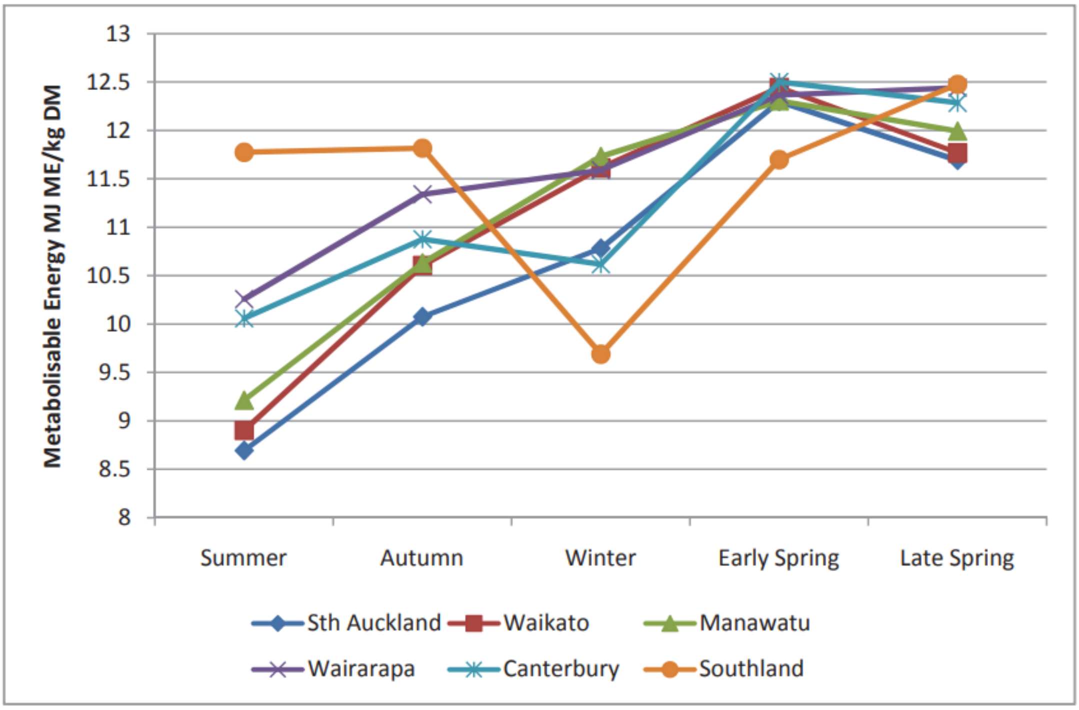
Seasonal variation in dead matter as a % of seasonal composition during the 2008-2009 breeding seasons.



Note. Reprinted from "Seasonal variation of pasture quality on commercial equine farms in New Zealand", Hirst, R. L., 2011, p. 58.

Figure 3

Seasonal variation in metabolizable energy (MJ ME/kg DM) for stud farms located in the six different regions during the 2008-2009 breeding seasons.

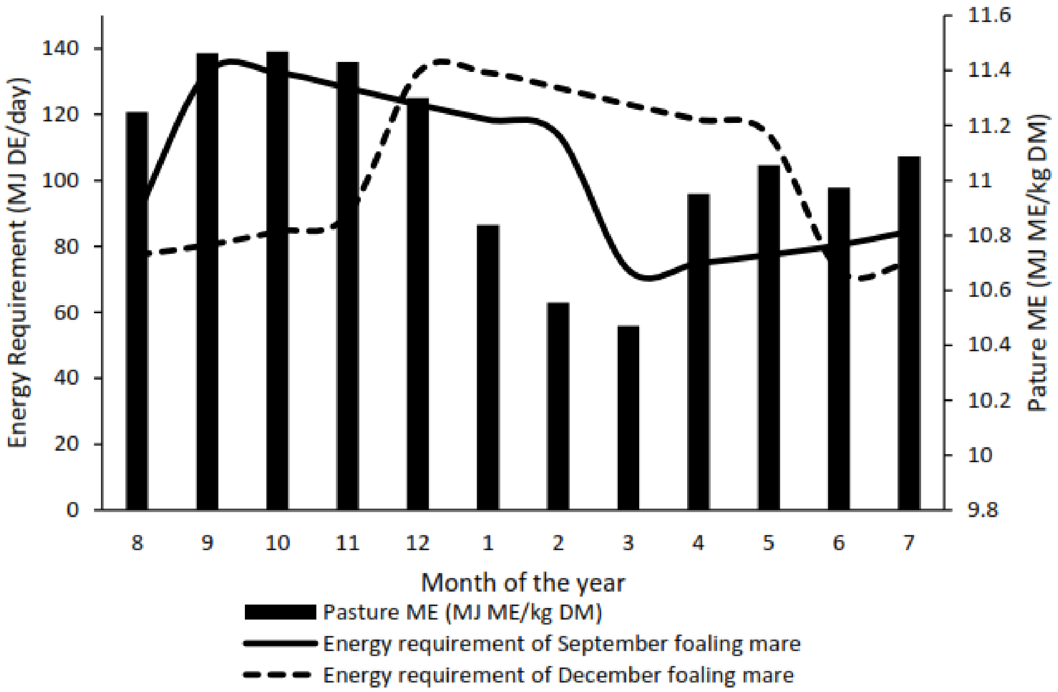


Note. Reprinted from "Seasonal variation of pasture quality on commercial equine farms in New Zealand", Hirst, R. L., 2011, p. 62.

Energy supply and energy demand

Figure 4

Energy requirement of a 500 kg mare foaling at different times of the year (MJ DE/day) versus the pasture metabolizable energy available (MJ ME/kg DM).



Note. Reprinted from "Deterministic modelling of energy supply and demand for foaling mares managed at pasture on commercial Thoroughbred stud farms.", Chin, Y. Y., 2018, p. 15.

Figure 4 (Chin, 2018) shows that the date of foaling affects the timing of energy requirement changes. The timing of energy requirement changes is affected by the date of foaling. The highest energy requirements coincide with the low pasture energy content. To what extent this coincides depends on the foaling date of the mare. A December foaling mare has more overlap, than a September foaling mare (Chin, 2018). This lack of synchronization may have a negative influence on the energy status of the mare. Pagan et al. (2006) found also an association of foaling date with mare energy status.

Energy balance and reproductive activity

Dietary energy is known as the main driver of changes in BSC (Henneke et al., 1984), leptin and metabolic hormones such as insulin and insulin growth factor-1 (IGF-1). An overall decrease in BCS due to a reduction in dietary energy intake at conception, during pregnancy and post-partum was found to prolong the partus to conception interval (Godoi et al., 2002), prolong the inter-ovulatory interval, increase the numbers of cycles per conception and decrease the pregnancy rate (Henneke et al., 1984). Fradinho et al. (2014) showed that mares that had a positive energy balance at conception and lactation had improved fertility in the first two oestrus cycles compared to mares that had a negative energy balance.

Leptin is known to have a short-term effect on reproductive activity. The plasma concentration of this adipocyte-derived hormone is related to body fat scores (Buff et al., 2002; 2005). Leptin reflects the adequacy of nutrition and metabolic reserve by modulating the reproductive activity by acting on the neuroendocrine system (Barash et al., 1996). Low BSC (<5) and leptin concentrations were associated with longer transition period for ovulating and profound seasonal anoestrus (Gentry et al., 2002). The mare's energy status may not only influence BCS, but also leptin without initiate BSC change through influences on glucose and insulin levels (Yin et al., 2019 – in press).

Insulin growth factor (IGF-1) is known to have a long-term effect on reproductive activity. An abrupt restriction in energy and protein creates a sudden decrease in plasma IGF-1 and changed plasma growth hormone (Sticker et al., 1995). The ovarian function of the mare is affected by the changes in plasma IGF-1. A longer restriction in energy intake modified the bioavailability of IGF-1 in ovaries and the systemic concentration of IGF-1(Salazar-Ortiz et al., 2014). Recruitment and selection of follicles is also affected.

Studies in dairy cows show similar results. Wathes et al. (2019) show that the interval partus to conception is associated with altered profiles of IGF-1, urea and BSC. Beam and Butler (1999) show that a prolonged decrease in post-partum energy balance and a negative energy balance were associated with an increased partus to ovulation interval and a failure in the first follicular wave in non-cystic cows.

Nutrient modelling of Thoroughbred mares managed under commercial management conditions has identified a potential negative energy balance later in breeding season that could extend the interval from parturition to conception (Chin, 2018). All mares were in an energy surplus during pregnancy, although the steady drop during the last months of pregnancy. Later foaling mares had greater post-partum energy deficit and experienced a longer decrease in energy balance, than mares who foaled earlier. The model also shows that horses with less requirements (REQ+25 instead of REQ+45) are in a greater surplus during pregnancy, energy balance is higher at foaling and mares that foaled <90 days after 1 September don't experience a negative energy balance. Mares that foaled ≥ 90 days after 1 September experience a smaller extent in negative energy balance.

Negative energy balance or nutritional deficit cannot be measured by BCS alone (Chin, 2018). There is limited BCS loss (0.2-point (1-9)) on mares on pasture, because mares utilize substantial internal (visceral) fat storage (Pagan et al., 2006). Internal fat is preferentially mobilized when BCS is higher than 4 and when the BCS is lower than 4, external fat will be mobilized (Dugdale et al., 2011). Manso Filho et al. (2008) found that lean body mass of well-fed mares drops 1.5% during lactation without a change in rump thickness (drops 7,5 kg on 500 kg mare). Thus, to measure a negative energy balance or nutritional deficit BCS and bodyweight or BCS and lean body mass changes can be used.

Hence, to uphold reproductive performance it is suggested to avoid a decrease in body weight, body condition and energy balance. It is proven in dairy cows and Thoroughbreds are modelled, however there is little information available on Standardbreds. Standardbred mares are more robust and believed to have a greater feed conversion efficiency than Thoroughbred mares and are generally managed with lower levels of feed (pasture DM on offer) during breeding season. However, they are usually run with a lower pasture dry matter on offer and should experience the same relative negative energy balance modelled for Thoroughbred mares under commercial conditions. The aim of this project was to examine if an increase in foaling date was associated with delayed conception with Standardbred mares managed on commercial breeding farms in New Zealand.

Materials and Methods

Horses

During the 2016-2017 and 2018-2019 breeding seasons 1066 official breeding records on 558 Standardbred broodmares were obtained as an electronic extract from “Infohorse” the official horse management database of Harness racing New Zealand. This database contains all the horse and breeding records for Standardbreds in New Zealand.

Data collection

Collected data from on farm official breeding records were stud farm, mare, brand, service location, age, season, first vet exam, wet/dry/maiden, foaling date, days between foaling and conception, stallion, conception date, foaling date after service, insemination dates and scan dates + results.

Information about pasture growth was collected from dairynz.co.nz from the region were the Standardbred farms were located.

<u>Brief survey of stud farms</u>

In addition to the analysis of official records there was an attempt to collect some production data from farms via a cross sectional survey. Due to timing during the height of the breeding season there was limited completion of the survey and the limited results are presented in Appendix 1 as background information.

Data analysis

Microsoft Excel was used to collate the on the on-farm breeding records. Extra calculated information was foaling date after 1 August, conception date after 1 August, gestation length, semen count and if the mare could have a valid foal. The mare could have a valid foal if gestation was longer than 303 days (Dickens, 2014). The gestation length of mares was erased if it was shorter than 303 days, those mares were stated as a mare with a non-valid foal and it was commented. The definition of a mare with a slip or loss is a mare with a conception date, but without a foaling date or with a gestation length shorter than 303 days.

Selection criteria for the mares used to make the Kaplan Meier survival curve to represent the time from parturition to conception, without the mares that carried over, included that the mares had a known interval between foaling and conception and had a known gestation length. Three groups were made using a graphic which compared quantity of mares that have foaled and conceived to pasture growth in kg DM/ha/day. Groups were approximately the same size. For the Kaplan Meier survival curves to represent the time from parturition to conception, with the mares that carried over, all mares were used.

Statistical analysis

ANNOVA in RStudio 1.2.1335 with a significance set at $P<0.05$ was used to analyse the data. Kaplan-Meier survival curves were used to represent the time from parturition to conception.

Results

On farm records

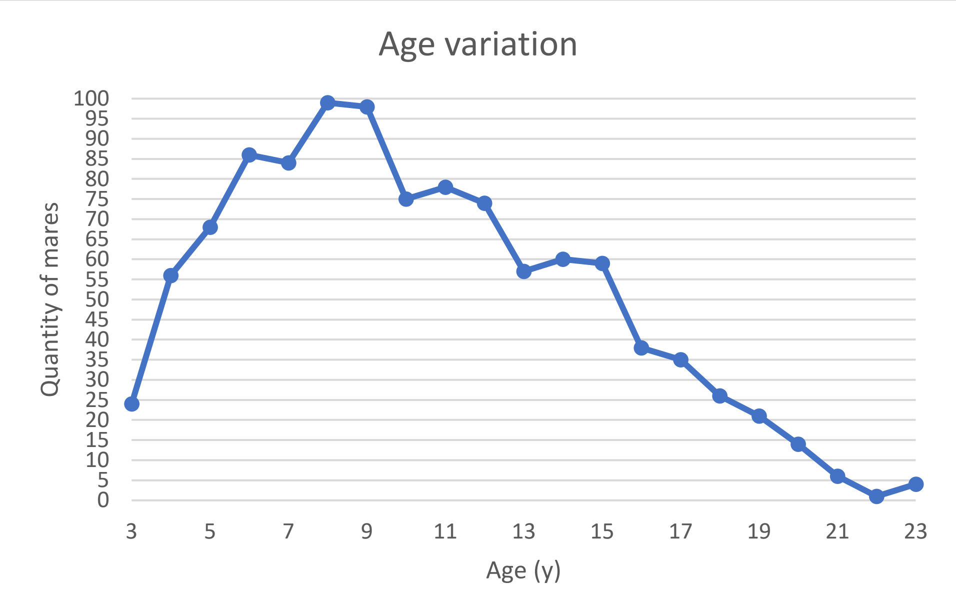
1066 records were collected from 558 Standardbred broodmares (table 2). Table 2 shows a summary of the records of the mare population over the breeding seasons 2016-2017 and 2018-2019. The mean age of the mares was 10 years old; this is shown in figure 5. The mean gestation length was ~349 days (figure 6), with a mean foaling date of the 11th of November and a mean conception date of the 6th of December. Only 6.7% of the first breeding service is done before mid-October (80 days) and only 57.2% before the end of November (121 days) as shown in figure 7 and 8. Approximately 11.7% of the mares were bred on foal heat. The mean interval between foaling and conception was 34.4 days and 33.0 days without the mares with a slip or loss. The total slips and losses were ~21.4% of which ~10.1% were mares bred on foal heat. Within these mares ~60.0% were mares bred on a foal heat <10 days after foaling and the rest >10 days after foaling. The mean age of the mares that had a slip or loss was 0.1 year higher than the mean age of all the mares.

Table 2
Summary of records on Standardbred broodmares during breeding seasons 2016-2017 and 2018-2019.

Descriptor		SD	%	Date
Records	1066			
Unique mares	558			
Mean age of mares	10,4	4,3		
Mean gestation length (valid foal)	348,6	10,5		
Mean foaling date after 1 Aug	102,5	30,1		11-nov
Conception date after 1 Aug	127,1	28,0		6-dec
Services				
- %First services done between before mid-October			6,66%	
- %First services done between before 30 November			57,22%	
- %Breeding on foal heat			11,73%	
Interval between foaling and conception				
- Mean interval between foaling and conception	34,4	24,6		
- Mean interval between foaling and conception (without slips/losses)	33,0			
Total slips/losses	228		21,39%	
- Foal heat slips/losses	23		10,09%	
- <10 Days FH interval slips/losses	14		60,87%	
- >10 Days FH interval slips/losses	9		39,13%	
- Age of mares (slips/losses)	10,5			

The mean age was 10 years old with a great variation from 3 – 23 years old (figure 5), most mares were 8 or 9 years old.

Figure 5
Age variation of the Standardbred broodmares.



The mean gestation length was ~349 days, which is ~11.5 month. Most mares foaled with a gestation length of 344 days (38 mares). Mare started foaling with a gestation length of 306 days and all mares had foaled before reaching a gestation length of 381 days (figure 6).

Figure 6
Gestation length variation of the Standardbred broodmares

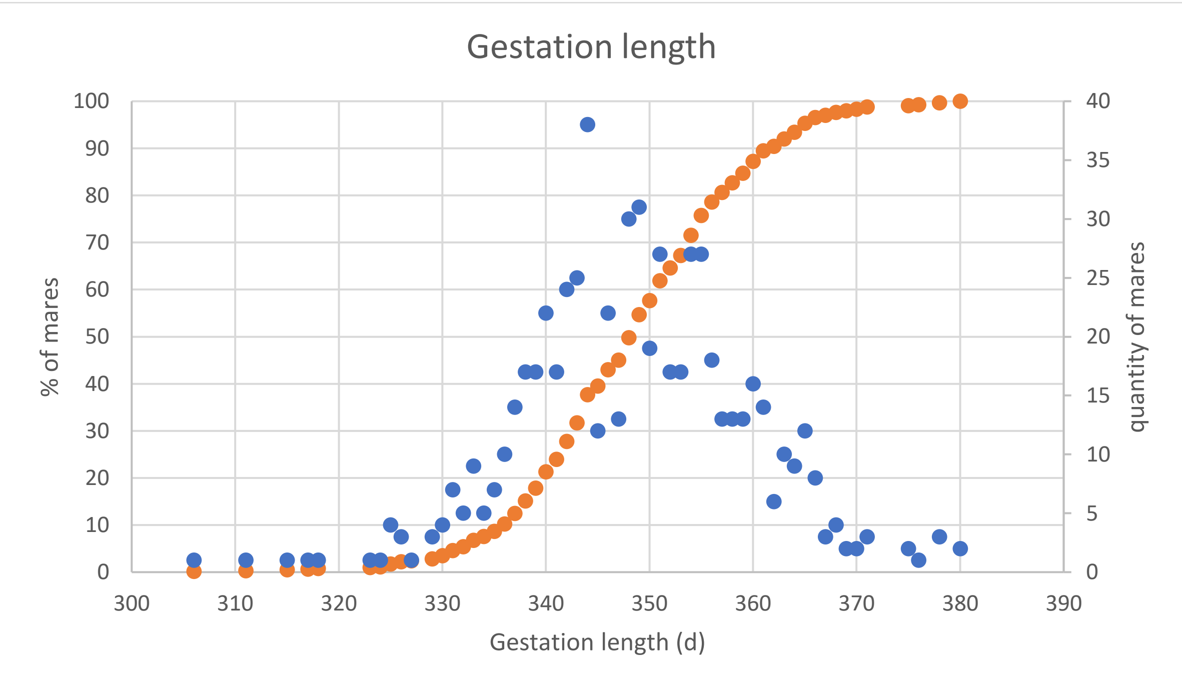


Figure 7 shows that when the conception date after the 1st of August increases the gestation length decreases.

Figure 7

Gestation length compared to conception date after the 1st of August.

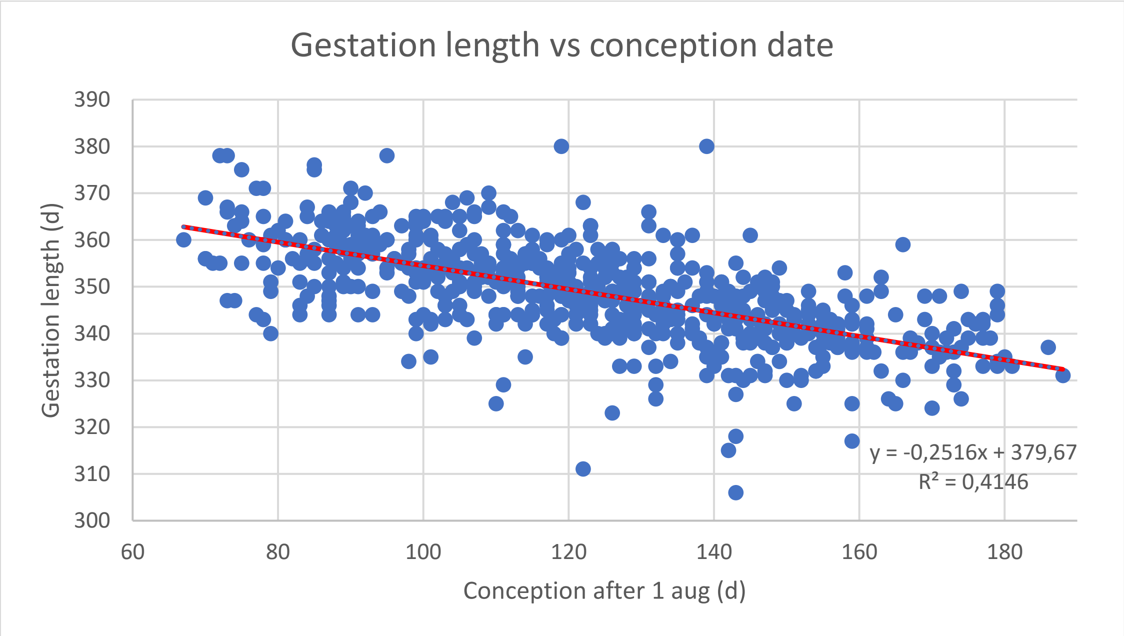
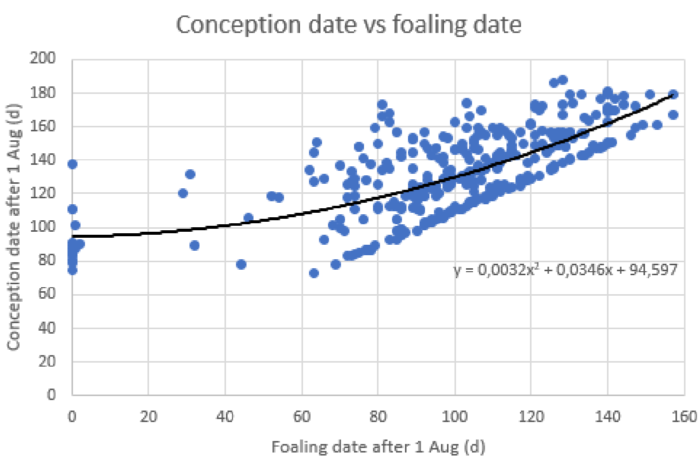


Figure 8a shows that only a few horses conceive in the first period after foaling (<80 days). It also shows that the interval between foaling and conception in the first period decreases. At the 1st of August it is around 100 days and it decreases till around 80 days after the 1st of August to 25 days. After the first 80 days more horses conceive, and the interval stays the same (Figure 8b).

Figure 8

a). Conception date compared to foaling date after the 1st of August. b) Conception date compared to foaling date after the 1st of August. Foaling date from 80 days after the 1st of August.



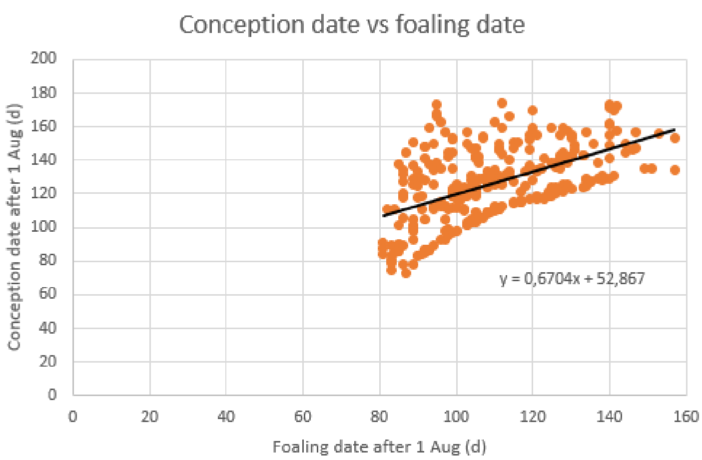


Figure 9 shows that there is no relation between the conception date and the interval from foaling to foal heat and that there is no difference with or without the mares with a slip or a loss.

Figure 9

a) Conception date compared to the interval between foaling to foal heat. b) Conception date compared to the interval between foaling to foal heat without mares that had losses or slips.

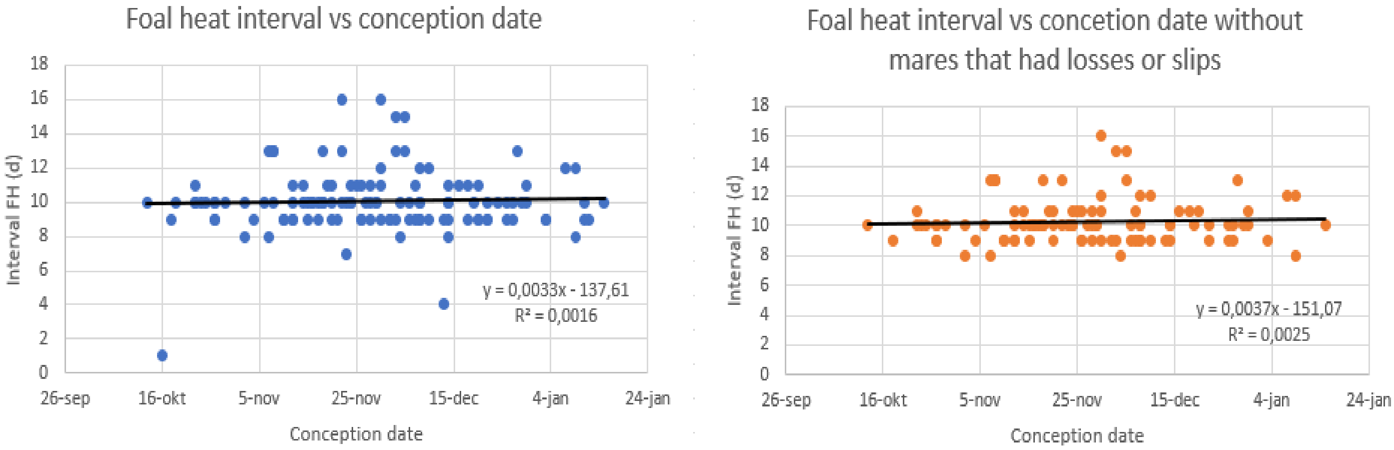
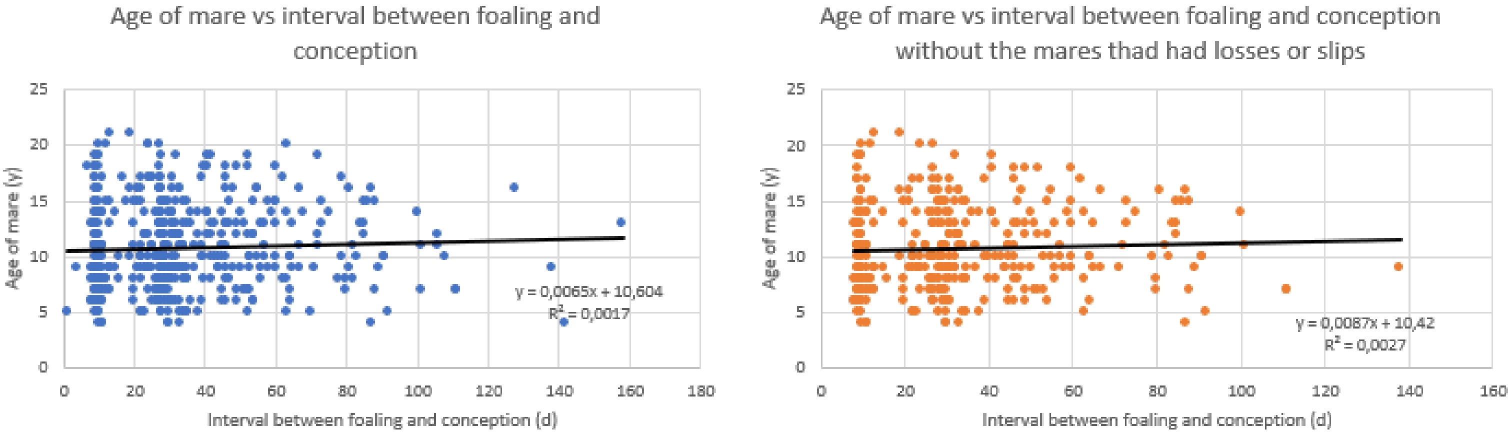


Figure 10 shows that there is no relationship between age of mare and interval between foaling and conception, with or without the mares with a slip or loss.

Figure 10

a) Age of mare compared to the interval between foaling and conception. b) Age of mare compared to the interval between foaling and conception without the mares that had losses or slips.



Maiden, dry and wet mares

Table 3 shows the distribution of maiden, dry and wet Standardbred mares per season. Almost every season there were more wet horses than dry horses and in every season there the maiden mares were the minority.

Table 3
Maiden, dry and wet mares per season.

Season	Dry			Wet	Total
	Normal	Maiden	Total		
2016	58	33	91	116	**207**
2017	81	46	127	166	**293**
2018	90	51	141	140	**281**
2019	79	53	132	153	**285**
Total	308	183	**491**	**575**	**1066**

Table 4 shows a summary of the records on maiden, dry and wet mares per season. The maiden mares were overall the youngest mares and the dry mares the oldest. During the seasons there was not a great difference between the conception date of the maiden and dry mares. The wet mares conceived overall later, had the shortest gestation length and foaled the latest. The mean conception date, gestation length and foaling date did not differ much between the maiden and dry mares. Dry mares needed the least inseminations to conceive. Overall the greatest part of the maiden mares got pregnant, but this was different per season. Around 82% of all mares got pregnant during the seasons, but with a wide variation. Between September and November more than half of the maiden and dry mares got their first service, when only ~45% of the wet mares got their first service. The percentage of mares that had a slip or loss is the greatest in the maiden and dry mare group, with a wide variation over the years.

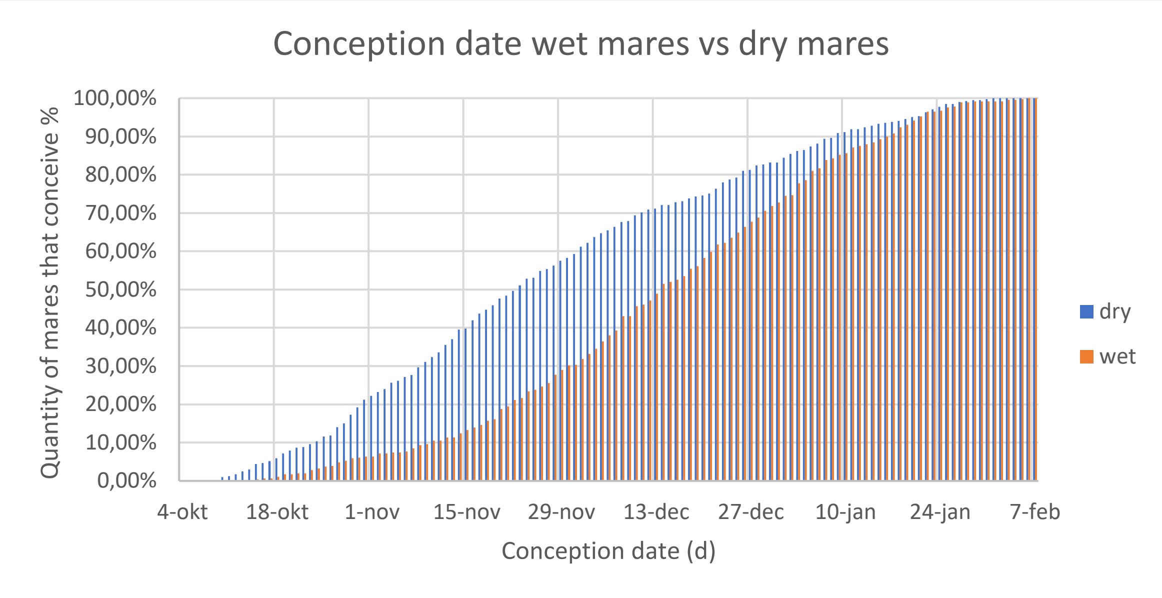
Table 4
Summary of records on the maiden, dry and wet mares per season.

Descriptor		**Dry mares**		**Maiden**		**Wet mares**		**Significance**
	Year		**Date**		**Date**		**Date**	
Age		12,19^{a}		5,65^{b}		10,90^{c}		P<0.001
	2016	*11,88*		*5,45*		*10,74*		
	2017	*11,94*		*5,39*		*10,60*		
	2018	*12,61*		*5,98*		*10,99*		
	2019	*12,19*		*5,68*		*11,27*		
Conception date		118,63^{a}	27-nov	118,14^{a}	27-nov	134,74^{b}	13-dec	P<0.001
	2016	*116,02*	*25-nov*	*110,25*	*19-nov*	*132,30*	*11-dec*	
	2017	*120,86*	*29-nov*	*122,03*	*1-dec*	*137,03*	*16-dec*	
	2018	*120,99*	*29-nov*	*120,23*	*29-nov*	*134,85*	*13-dec*	
	2019	*115,81*	*24-nov*	*117,85*	*26-nov*	*133,82*	*12-dec*	
Gestation length		352,45^{a}		351,68^{a}		345,64^{b}		P<0.001
	2016	*353,24*		*351,68*		*346,34*		
	2017	*351,13*		*351,92*		*345,06*		

2018	*352,95*		*352,32*		*344,46*		
2019	*352,76*		*350,89*		*347,26*		
Mean foaling date	96,39[a]	5-nov	93,68[a]	2-nov	105,89[b]	14-nov	P<0.001
2016	96,62	5-nov	81,18	21-okt	104,47	13-nov	
2017	100,41	9-nov	103,28	12-nov	107,35	16-nov	
2018	91,76	31-okt	94,08	3-nov	108,18	17-nov	
2019	96,89	5-nov	94,25	3-nov	102,86	11-nov	
Insemination count	2,01±0,07[a]		1,95±0,09[a]		1,75±0,03[b]		P<0.001
2016	2,10		1,67		1,72		
2017	1,89		1,98		1,81		
2018	2,08		1,84		1,73		
2019	1,97		2,21		1,72		
%Mares that gets pregnant incl. slips/losses	81,17%		84,70%		79,65%		Not significant
2016	70,69%		84,85%		78,45%		
2017	80,25%		80,43%		83,73%		
2018	78,89%		84,31%		78,57%		
2019	92,41%		88,68%		77,12%		
%First services done between Sept-Nov	73,38%[a]		70,49%[a]		44,35%[b]		P<0.001
2016	70,69%		78,79%		50,86%		
2017	70,37%		58,70%		44,58%		
2018	71,11%		72,55%		45,71%		
2019	81,01%		73,58%		37,91%		
%Slips/losses	23,70%		23,50%		19,48%		Not significant
2016	13,79%		27,27%		6,90%		
2017	20,99%		28,26%		19,88%		
2018	33,33%		17,65%		15,00%		
2019	22,78%		22,64%		32,68%		

Figure 11 shows the percentage of dry mares compared to the percentage of wet mares that conceived over time. The first dry mares conceived at 7 October, the first wet mares started at the 13th. Half of the dry mares conceived before the 23th of November, when only ~22% of the wet mares conceived at this time. At the 14th of December the half of the wet mares had a conception, and dry mares had reached 72%. 78% of the wet mares had a conception at the 3rd of January, when 86% of the dry mares had conceived. On the first of February all the dry mares had conceived and only a few days later all the wet mares had conceived as well.

Figure 11
The percentage of dry mares compared to the percentage of wet mares that conceive over time.



Pasture growth, foaling and conception

Pasture growth, foaling and conception is shown in Figure 12. Pasture growth was 9 kg DM/ha/day in the beginning of August, then it increased rapidly to a maximum of 45 kg DM/ha/day on the first of November. After the first of November it dropped to 22 kg DM/ha/day on the first of December, when it slightly increased to 26 kg DM/ha in the beginning of January and decreased to 25 kg DM/ha in the beginning of February. A few mares foaled in the beginning of August, a few mares also foaled in the beginning of September. Most mares started foaling in October. 50% of the mares had foaled mid-November and all mares had foaled by the end of December. The curve of conception was mostly parallel to the curve of foaling. Only mares started conceiving after mid-October. 50% of the mare had conceived mid-December and all the mares had conceived in the beginning of February.

Figure 12
Pasture growth, foaling and conception during breeding seasons 2016-2017 and 2018-2019.

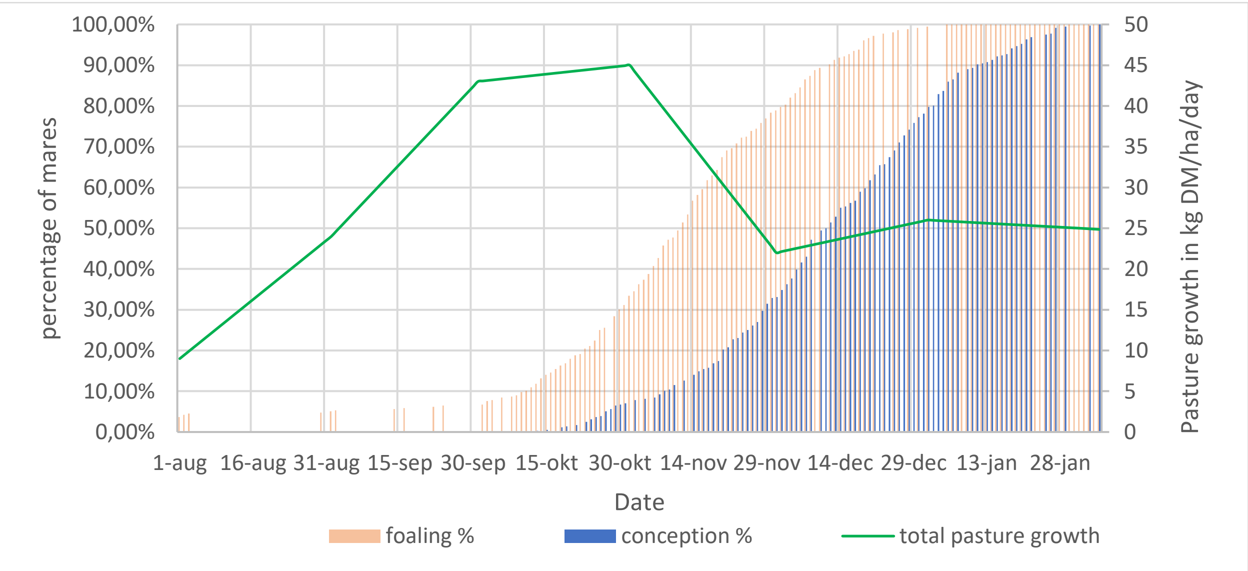
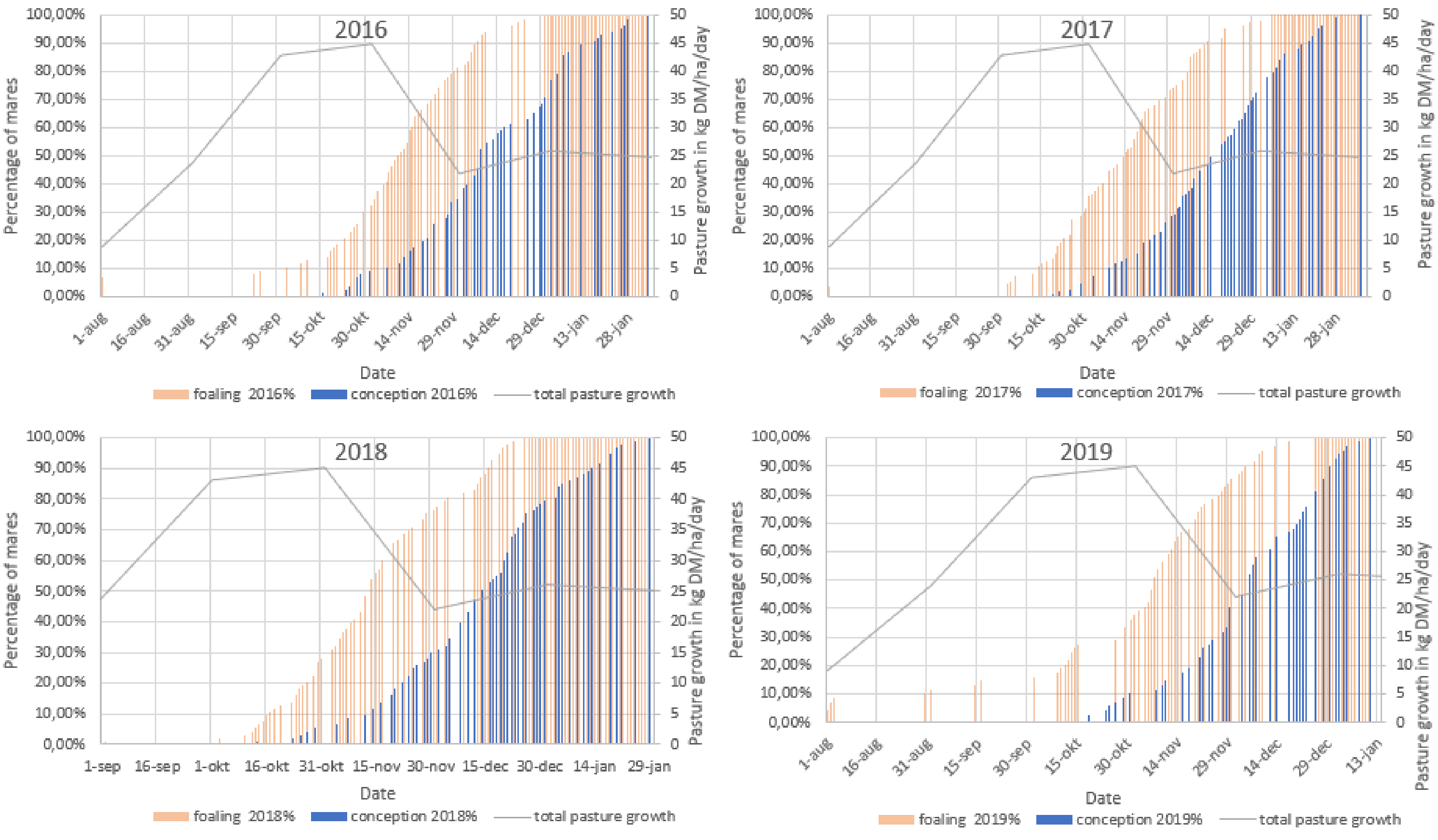


Figure 13 shows the pasture growth, foaling and conception between the seasons. Every year, except for 2018 had a few mares that foaled in August. Every year, except for 2017 the mares foaled before the end of December, in 2017 all mares foaled before mid-January. All mares started conceiving mid-October. Start December 50% of mares had a conception in 2016 and 2019. In 2017 and 2019 this was later, mid-December. In 2016 and 2017 all mares had a conception in the beginning of February. In 2018 all the mares had a conception before the end of January and in 2019 all the mares had conceived earlier, before mid-January.

Figure 13

Pasture growth, foaling and conception between the seasons.



Three groups were made using a graphic which compared quantity of mares that have foaled to pasture growth in kg DM/ha/day (figure 12). The first group contained mares with a foaling date from the beginning of August to the first of November. The second group was from 2 November till 20 November and the third group was from 21 November to 5 January. These groups had approximately the same number of mares (group 1: 119, group 2: 121, group 3: 116). An increase in insemination on foal heat was seen between these groups (group 1: 19,33%, group 2: 33,88%, group 3: 35,34%). A Kaplan-Meier survival curve to represent the time from parturition to conception within these groups is shown in figure 14a, b. Mares in group 1 had the longest interval between foaling and conception. Group 1 had the shortest interval between foaling and conception until all the mares conceived and group 2 was in between.

Figure 14

Kaplan Meier survival curve with 95% confidence on interval between foaling and conception for these groups.

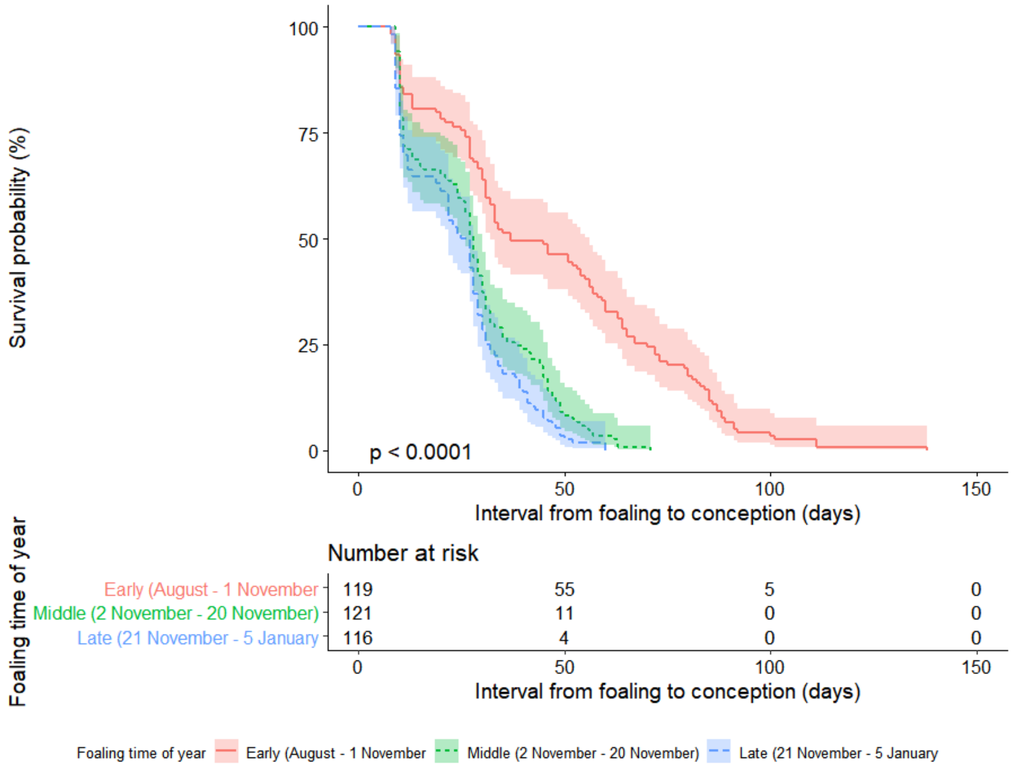


Table 5 shows a summary of the three groups with records of horses all horses with a foaling date, distributed over the three groups, including the mares that carried over. The mares that carried over had an interval between foaling and conception of 365 days. Group 3 contained the greatest number of mares. these mares were also the oldest mares and had the shortest gestation length. The % of mares that conceived decreased over the time of foaling. Mares that carried over increased over the time of foaling, just like the number of mares bred on foal heat. Less inseminations were done per mare in the last group and it also took less insemination per mare before a conception. Group 3 also contained the least mares with viable foals and the greatest % of mares that had a slip or loss. The mares with a loss or slip were the youngest in the first group.

Table 5

Summary of records between the three groups.

Descriptor	**Group 1 (< 1 Nov)**	**Group 2 (1 Nov – 20 Nov)**	**Group 3 (> 21 Nov)**
Number of mares	173	191	211
Mean age mares	10,7	10,7	11,3
Mean gestation length	349,1	345,7	341,8
%Mares Conception	85,55%	80,10%	74,41%
%Carry overs	14,45%	19,90%	25,59%
%Bred on foal heat	15,61%	24,08%	24,64%
Inseminations			
- Total number of inseminations	322	354	329
- Mean number of inseminations	1,9	1,9	1,6

- Total number of inseminations before conception (incl. mares with slips/losses)	197	206	168
- Mean number of inseminations before conception (incl. mares with slips/losses)	1,7	1,6	1,51
Viable foals			
- Number of mares with viable foal	114	125	107
- %Mares with viable foal of mares that conceived	77,03%	81,70%	68,15%
- %Mares with viable foal of all mares in group	65,90%	65,45%	50,71%
Slips/losses			
- Number of mares	34	28	50
- %Mares of mares that conceived	22,97%	18,30%	31,85%
- Mean age of mares	10,4	11,7	11,5

Two different Kaplan-Meier survival curves to represent the time from parturition to conception are shown in figure 15 and 16. Between these figures there is a difference in the mares described as carry overs. In figure 15 mares were carried over if they had a foal date, but not a conception date, so this includes the mares that had a slip or loss (gestation length <303 days). In figure 16 mares were carried over if they had a foal date, a gestation longer than 300 days, but not a conception date. In figure 15 group 1 had the least carry overs and group 3 the most. Although this survival curve is not significant ($p>0.05$). Figure 16 shows also that group 3 had the most carry overs, group 1 and 2 were had almost the same number of carry overs. This survival curve is significant ($p<0.05$).

Figure 15

Kaplan Meier survival curve with 95% confidence on interval between foaling and conception with carry overs (including the mares with a slip or loss).

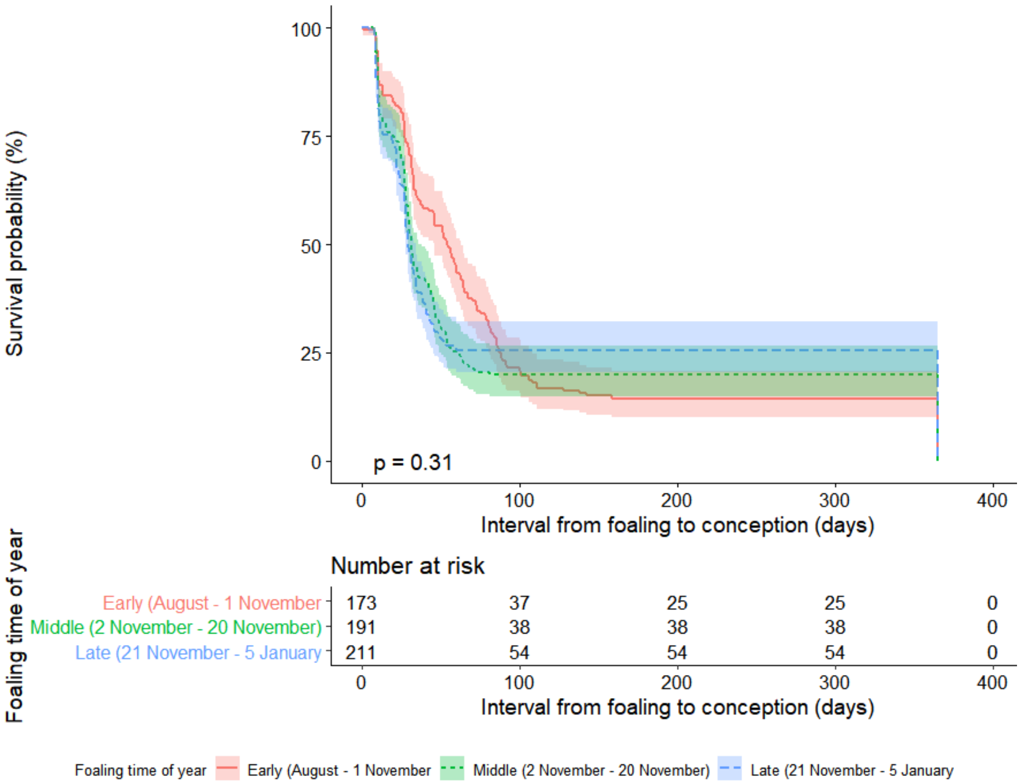
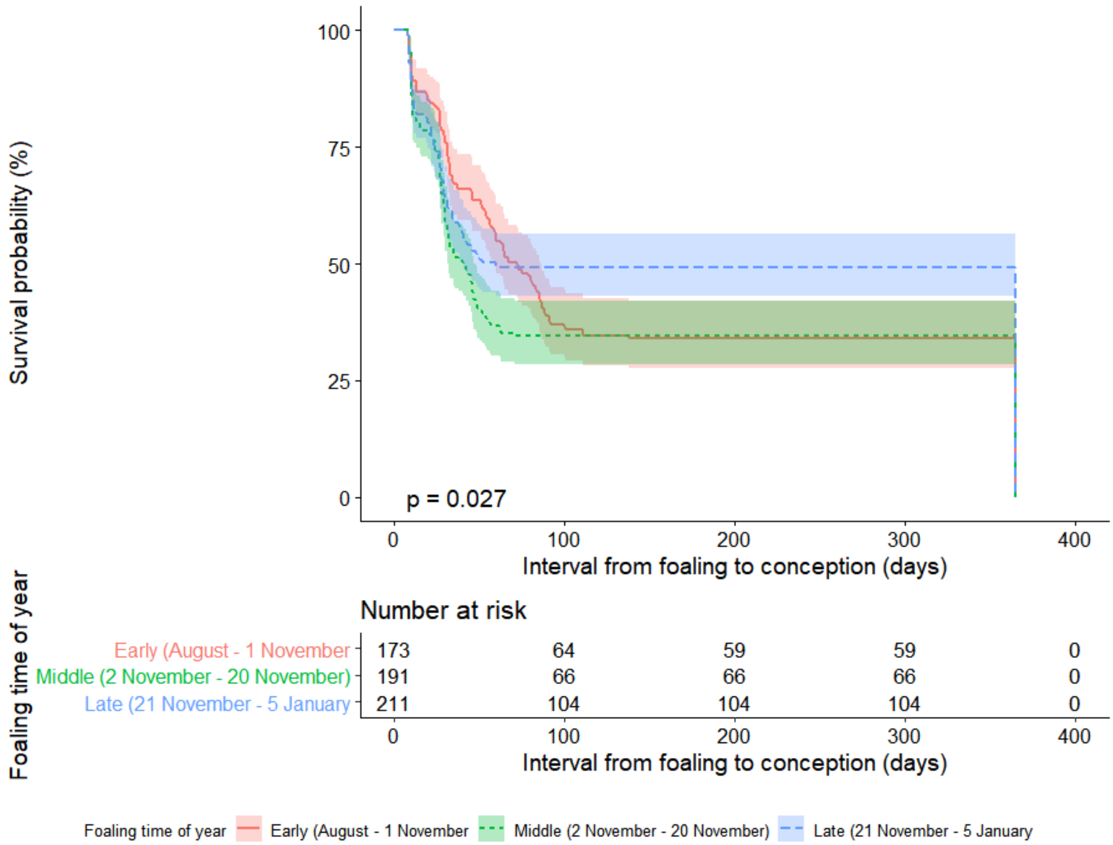


Figure 16

Kaplan Meier survival curve with 95% confidence on interval between foaling and conception with carry overs (excluding the mares with a slip or loss).



Pasture growth and requirements

Table 6 shows the requirements of a 500 kg broodmare converted from DE to ME (National Research Council, 2007). 80% of digestible energy (DE) is usable as metabolizable energy (ME) (Hirst, 2011).

Table 6

Requirements of a 500 kg broodmare.

Horse class	Requirements in MJ DE/day	Requirements in MJ ME/day
Maintenance	70	84
Pregnant 9 months	80	96
Pregnant 11 months	89	106,8
Lactating <3 months	133	159,6
Lactating 3 months – weaning	123	147,6

Note. Adapted from "Nutrient Requirement of Horses", National Research Council, 2007.

Table 7 shows a model of the requirements of the mare, pasture growth, stocking density and the consumed pasture per month. Due to selective grazing behaviour only 70% of the pasture can be consumed. For mare status data of the official records of the Standardbred mares are used, with mean foaling date 11th of November and mean conception date 6th of December. As a result, the mare is 9 months pregnant at the 6th of September, 3 months in lactation at the 10th of February and >3 months lactating to weaning from March to May as foals are weaned at 4-6 months. The highest stocking density of the farms is used, this was 1.08 mare per hectare. The total pasture that is consumed is stocking density*requirements/metabolizable energy. Residual is pasture growth minus consumed pasture. It shows that there is a pasture deficit during June, July and August and a pasture surplus during the rest of the year.

Table 7

The modelled requirements of the mare, pasture growth, stocking density and the consumed pasture per month.

Month	Pasture growth (kg DM/ha/day) [1]	70% of Pasture growth (kg DM/ha/day)	Metabolizable energy (MJ ME/kg DM) [2]	Mare status	Requirements (MJ ME/day)	Stocking density (mares/ha)	Total pasture consumed	Residual
Jan	26	18,2	11,7	Lactation	159,6	1,08	14,7	11,3
Feb	25	17,5	11,75	3 m lact	159,6	1,08	14,6	10,4
Mar	24	16,8	11,8	>3 m lact - weaning	147,6	1,08	13,5	10,5
Apr	17	11,9	11,1	>3 m lact - weaning	147,6	1,08	14,3	2,7
May	10	7	10,3	>3 m lact - weaning	84	1,08	8,8	1,2
Jun	2	1,4	9,6	Normal	84	1,08	9,4	-7,4
Jul	1	0,7	10,3	Normal	84	1,08	8,8	-7,8
Aug	9	6,3	11	Normal	84	1,08	8,2	0,8
Sep	24	16,8	11,7	9 mo pregnant	96	1,08	8,8	15,2
Oct	43	30,1	12,15	10 mo pregnant	106,8	1,08	9,5	33,5
Nov	45	31,5	12,6	11 mo pregnant-foaling	106,8	1,08	9,1	35,9
Dec	22	15,4	12,15	Lactation (conception)	159,6	1,08	14,1	7,9

Note. [1] *Adapted from "Average Pasture Growth Data, South Island", DairyNZ, 2018.* [2]*.Adapted from "Seasonal variation of pasture quality on commercial equine farms in New Zealand", Hirst, R. L., 2011, p. 62.*

Discussion

This study was the first to investigate the association of foaling date and the interval between foaling and conception in Standardbred mares managed on commercial Standardbred farms. Yin (2019) had previously used a deterministic model to describe an increasing foaling to conception interval in Thoroughbred mares foaling later in the season. However, to date there is little production and reproduction data published on Standardbred horses in New Zealand, and no data on the effect of foaling date on the interval from foaling to conception.

Anecdotally, Standardbred mares are believed to have a greater feed conversion efficiency than Thoroughbred mares and are generally managed with lower levels of feed (pasture DM on offer) during breeding season. However, as they are usually run with a lower pasture dry matter on offer, they should experience the same relative negative energy balance modelled for Thoroughbred mares under commercial conditions. Although, within the population of Standardbred mares examined in this study there was no association of foaling date and the interval between foaling and conception. This was contradictory to the hypothesized association.

Mare records and breeding pattern

The study population consisted of a cohort of Standardbred broodmares on two different stud farms located on the South Island of New Zealand. This population was typical for a Standardbred stud farm, as most of the Standardbred production in New Zealand occurs in the South Island, under pasture-based conditions.

The age distribution of the mares bred may represent the structure of the New Zealand Standardbred industry, with most breeders breeding horses to race, rather than a focus on breeding horses to sell as yearlings. While mean age of the mares was 10 years old there was a large range in age from 3 -23 years old. The distribution of broodmare age did not show the left skew (young horse bias, i.e. less than 12-years-old) often observed in Thoroughbred broodmares. This may have been driven by the ownership structure and lack focus on the sale of yearlings. Hence breeders are not driven to make quick decisions on a mare’s merit based on the ability to sell resultant progeny. This more relaxed approach to horse production was also observed in the median conception date, with the breeding season in Standardbreds appearing to be more closely aligned with the natural breeding season, rather than the focus on early conception and foals with Thoroughbred breeding.

The mean conception date (6th December) for broodmares was relatively late in the breeding season, with only 6.7% of the mares having their first service before mid-October and only 57.2% of the first service before the end of November. This is in stark contrast to Thoroughbred breeding in New Zealand, where 87% of first services are completed before the end of November (Hanlon, 2012).

The less intense focus on producing a foal born early in the season can also be seen in the interval between foaling and conception of the early foaling mares. There was a long interval (~100 days) to start with the few early foaling mares. The interval decreased at mid-October to 25 days, where after it remained constant. The stallion leaves at the end of December, so all the mares must be bred before that. After mid-October, more mares start foaling and more mares must be bred. Hence, after mid-October the pressure is higher and the interval between foaling and conception becomes similar as the Thoroughbreds, also more mares were bred on foal heat during this period. The pattern of breeding on Standardbred farms appears to reflect the natural breeding season which in the Southern Hemisphere, is from December to March (Hanlon, 2012).

The median breeding (conception) dates of wet mares (13 December) and dry mares (27 November) also reflected less intense focus on the production of an early foal. Dry mares show a similar pattern as wet mares, what indicates that breeders give dry mares greater opportunity to conceive, when they are no longer in seasonal transition and breeders are more driven by getting progeny of that mare. In New Zealand the Standardbred breeders are allowed to use AI and the stallion can cover more mares per day (7-20 per collection) Thoroughbred broodmares must be bred natural, and at peak season a stallion can cover max 4 mares a day (Rogers et al., 2017a). Hence, there is less pressure on the Standardbred stallion during the season.

When the mares are foaling later, there is less time to get the mare pregnant. In the beginning of the season, only a few dry mares are cycling, and limited pregnant mares have foaled down and thus there are a limited number of mares ready for insemination. Possibly because of this there is limited use of breeding mares on the foal heat. A higher percentage of the Standardbred mares that foal late are bred on foal heat, also there are less inseminations used per mare, more mares are carried over and the interval between foaling and conception is shorter than the interval of the Standardbred mares that foaled earlier.

New Zealand Standardbred breeders appear to change their management as breeding season progresses. When the Standardbred mare had any problems during and after partus, like dystocia, endometritis or retained foetal membranes, the mare is not bred on foal heat. This is similar as stated by Hanlon (2012). Hanlon (2012) also found that foal heat interval is longer early in season and it decreases later in season. However, in New Zealand Standardbred there is no association between the conception date and the interval from foaling to foal heat and that there is no difference with or without the mares with a slip or a loss. New Zealand Standardbreds did not show a higher amount of slips and losses if the mares were bred on a foal heat interval less than 10 days, due to uterus involution of 14 days, despite what Hanlon (2012) observed with Thoroughbred mares. The most slips and losses were found in the maiden and dry Standardbred mares. It could be that these Standardbred dry mares, had reproductivity problems before and were already less fertile. Dry mares were also the oldest group (12.2 years old) compared to the maiden and dry Standardbred broodmares. Hanlon (2012) found that from 11-14 years reproductivity declines, more loss and a longer interval between foaling and conception However, in Standardbred broodmares is no association between age and interval between foaling and conception, with or without the mares with a slip or a loss.

Standardbred mares in New Zealand are bred later in season and the relationship between conception date and gestation length (349 days) were similar to the results reported by Dickens (2014). This is as expected as both used farms in similar location in New Zealand. There were typical differences between maiden, dry and wet mares. Mares status influences when bred and hence gestation length is longer in dry and maiden mares and shorter in wet mares, because mares want to foal around the same time (Hanlon, 2012). Under natural conditions, mares want to foal when the foal has the best survival chance, which is at peak pasture availability (Ransom et al., 2013).

Seasonal pasture growth

The Standardbred farms were located in Southland. Peak pasture is highest in October and November and pasture supply is lowest during winter. When pasture quality and quantity were low, farms supplemented with hay for example also took some measurements to increase the quantity and quality of the grass. With horses as selective grazers, there are a few measurements to maintain the quality and consistency of feed intake when horses are grazing the same pasture. Recommended are harrowing and cross grazing with cattle (Rogers et al., 2017b; Hirst 2011). The standardbred breeders in this research used both harrowing and cross grazing. To keep pasture quality and quantity up, it is recommended that farms use fertilizer and mow and resow their land (Litherland & Lambert, 2007: Hirst, 2011). Both questioned farms used these management techniques to increase the quality of their pasture. This indicates that pasture management on these farms is optimal. On top of that, stocking density is low on the Standardbred farms in New Zealand. There is more than enough pasture. Hence, there is enough pasture, feed intake is optimal and therefore Standardbred mares do not experience a negative energy balance during lactation. Standardbred mares in lactation will come back to their normal body condition score in one month. This is different than the minimum of 100 days modelled for Thoroughbred broodmares and first expected for Standardbred broodmares (Yin, 2019).

Thus, this research indicates that these Standardbred farms are located where pasture growth is enough all year round and the pasture is managed well. Stocking density was not high, and the mares get enough feed during the year, even older mares can keep up. Standardbred breeders have a different focus as Thoroughbred breeders, because they rather want to race than sell the yearlings. This reduces the drive to breed early in season and so they breed close to the mare's natural breeding season. Therefore, Standardbred broodmares may not experience a negative energy balance and therefore not show the association between late foaling mares and the longer interval between foaling and conception.

Limitations

The reported study has several limitations, such as the number of farms that cooperated on the survey and breeding records were collected from. There were 2 farms that filled in the survey. These farms were located near Auckland, so it could be that they use different management then the farms located on the South Island. The farms where the breeding records were collected from are located on the South Island in Southland. Unfortunately, there were only two of them. The records were valid, because they were official records, which can be found on harness.racing.co.nz. In addition, another limitation is the data on pasture growth. This data was not measured on the farms, but in the region of the farms. The actual pasture growth on these farms could be subtly different. Also, the pasture growth data was average seasonal data is collected over 2007 till 2012, and not relatable to the years the breeding records are from.

Another limitation of the current study is the reliability of the date obtained from the breeders. It could be that the breeders interpreted some questions of the survey different. Some data they gave were estimated, like the size, percentages and number of mares.

For future research, some of these limitations could be reduced. Reproduction data could be obtained from more farms, on both North and South Island. Thereby, not only reproduction data could be obtained from these farms, but also other data on farm and pasture management could be collected from these farms. These farms could be followed over a couple of years, for exact measurements on pasture growth and farm management. On top of that, mares could be monitored on feed intake, bodyweight and body condition score monthly to see changes per mare over the years. With these extra data, research is more precise. In this manner, the exact influence of farm management on mare reproductivity can be measured and so also the differences between the Standard- and Thoroughbreds.

Conclusion

The present study did not provide evidence of an association between an increase in foaling date and a delayed conception in Standardbred broodmares. Standardbred broodmares were managed on farms with sufficient pasture growth, low stocking density and they were bred close to the mare's natural breeding season. The findings indicate that Standardbred broodmares did not experience a negative energy balance and therefore didn't show a delay in conception. Further research is required to investigate to what extend farm management influences mare reproductivity.

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Appendix

Survey

Materials and methods

Data were collected via a survey for each farm on typical breeding and management practices. Information was gathered about: pasture mass on offer (pasture DM kg/ ha) and if any supplementary feed offered, mare body condition score (Henneke et al., 1984) and mare body weight (+ foal weight) (if measured) (at foaling, foal heat, and at time of breeding / conception), typical breeding records (when breed, if short cycled, et.) and mare and pasture management.

Results

The survey consisted of 23 open and closed questions. A copy of the survey can be found below. The farms that participated the Survey were located on North Island. Two farms were located near Auckland in the Auckland region. The average seize of the farms was 110 ha and they had minimal 170~ broodmares per farm with a total of 380 mares together. Both farms were fully devoted to horses, but not all the land was used by the horses during the year.

<u>Breeding</u>

Both farms bred horses on foal heat, one farm bred 70% on foal heat and the other 25%. To be bred on foal heat the mare must had have a good foaling and good follicle on foal heat. One farm also used only horses younger than 10 years and only fresh semen. One farm used embryo transplantation for the older valuable horses or for the racehorses. One farm only used artificial methods when it was necessary, like ciders. The other farm used artificial lights which go on in July and used rugs for all racehorses. Farms stopped breeding the horses after Christmas or January, depending on when the stallion left.

<u>BCS and bodyweight</u>

All mares had a body condition score of ~6 during the year. Farms found this the ideal body condition score for the mare. One farm had mares with an increase in body condition score during the last trimester (6-7). All mares had a decrease in body condition score during lactation (1-1.5). One farm had the mares during lactation in a body condition score of 4.5, this farm saw the mare getting back to her normal body condition score within a month.

Both farms did not weigh the mares routinely during the year. They also did not weigh the foals.

<u>Feed and pasture management</u>

All mares were on pasture all year round. One farm fed extra hay during the winter and one farm fed bailage all year round. The farms only fed supplementary feed when it was needed during last trimester or first 3 months of lactating. One farm mostly fed the young and older mares extra, when it was needed in last trimester. The average pasture length of one farm was 15 cm all year round.

Both farms didn't use pasture analysis. As extra pasture management farms harrowed all the land, mostly after rain. Both farms also used cross grazing in autumn and winter with cattle, one farm used 40-50 dairy heifers on fast rotation (3 days) which only eat the rubbish (till 15 cm). Both farms didn't use irrigation, because it rains enough. One farm was known to do other pasture management as well, like partly resowing and rolling and mowing in spring.

Mare management

Both farms were semi set stocked. One farm had fast rotation (3 days) in autumn and winter because of the cross grazing and wet ground, during the rest of the year it was set stocked.

Survey example

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date:

Farm:

Name:

Location farm:

Size farm:

---

1. Do you breed on foal heat? (what % of mares)
   a. What are the criteria to breed on foal heat?
   b. Season? (early, mid, late)

……
……
……
……
……

2. Do you use embryo transplantation?
   a. On what mares (no? or %) and why ….

……
……
……
……
……

3. Do you use artificial methods to get your empty mares cycling?
   a. Rugs (y/n)
   b. Feeding – e.g. increasing pasture – or pasture and grain (how much?)
   c. Do you aim to have the mares increase in body condition score? (show figure p. 43) (during winter, at mating)
   d. Lights or blue lights
   e. Hormones – how? progesterone or ciders?

a……
b……
c……
d……
e……
……

4. What do you think is the optimum BCS for mating a lactating mare?

……
……
………..

5. Is there a date when it is too late in the season to breed a mare?

……
……
………..

6. Do you routinely weight the mares during the year? (y/n) – when / how often / why – how do you use this data?

……
……
……
……
…….

7. What is the typical BCS of the pregnant mares during last 3 months of pregnancy?
   a. Is this the ideal that you work towards?

……
……
……
……
………..

8. Do you feed supplementary feed, like extra hay or minerals in the last 3 months of pregnancy? (y/n, what, how much, why?)

……
……
………..

9. What is the typical BCS score when the mare is foaling?

……
……
…….

10. Do you weight the foals? When born / any other measures at birth (y/n, why?)
    a. Do you weight the foals to monitor growth?

……
……
…….

11. Do you see a change in the mare's BCS score in the first 3months of lactating?
    a. Increasing/decreasing? How much?
    b. Is this the ideal that you work towards during the first months of lactating?

……
……
……
……
…….

12. Do you feed supplementary feed, like extra hay or minerals in the first 3 months of lactation?
    a. (y/n, how much, why?)

……
……
…….

Pasture

Fill in the table.

13. Typical number of mares on the farm?
14. What is the area of the farm devoted to horses?
15. What is the typical sward height during the year?
16. What is the typical paddock size and does this change during autumn, winter, spring 1, spring 2, summer?
17. Typical number of mares (a. empty / b. in foal and c. mares with foals at foot) per paddock during the year?
18. Is all your pasture used by the horses during the year?

Table

	Spring1 (Aug/Sep)	Spring2 (Nov)	Summer (Feb)	Autumn (April)	Winter (Jun/Jul)
13. No. of mares					
14. Area of farm devoted to horses					
15. typical pasture height (sward height)					
16. Paddock size					
17a.Empty Mares / paddock					
17b. In foal mares / paddock					
17c. Mares with foals at foot / paddock					
18. Pasture used by the horses					
21b. Cross grazing					

19. Do you ever have pasture analysis performed?
    a. Which pasture?
    b. DM? fiber? Ash? Protein? Dead matter?)

………
………
………

20. Do you irrigate your land?
    a. How much?
    b. Which paddocks?
    c. How much hectare?

………
………
………
………
………

21. Do you work with cross grazing?
    a. Which paddocks?
    b. When (during autumn, winter, spring 1, spring 2, summer) (table)
    c. When goes the cattle out – what sward length?

………
………
………
………
………

22. Do you harrow your land?
    a. Which land? When?

………
………
………
………

23. What best described mare management?
    a. Set stocked…e.g.……………………………………………………………………………………………
    b. Semi set stocked e.g. (rotation length) …………………………………………………………

………
………
………
………
………

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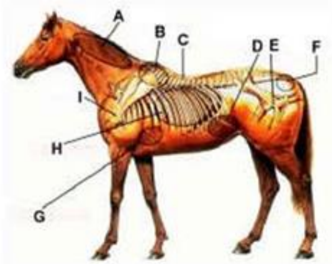
BODY CONDITION SCORING CHART



Areas of Emphasis for Body Condition Scoring

- **A:** Thickening of the neck
- **B:** Fat covering the withers
- **C:** Fat deposits along backbone
- **D:** Fat deposit on flanks
- **E:** Fat deposits on inner thigh
- **F:** Fat deposits around tailhead
- **G:** Fat deposit behind shoulder
- **H:** Fat covering ribs
- **I:** Shoulder blends into neck

1 *Poor*

Animal extremely emaciated; spinous processes, ribs, tailhead, tuber coxae, and tuber ischii projecting prominently; bone structure of withers, shoulders, and neck easily noticeable; no fatty tissue can be felt.

2 *Very Thin*

Animal emaciated; slight fat covering over base of spinous processes; transverse processes of lumbar vertebrae feel rounded; spinous processes, ribs, tailhead, tuber coxae, and tuber ischii prominent; withers, shoulders, and neck structure faintly discernable.

3 *Thin*

Fat buildup about halfway on spinous processes; transverse processes cannot be felt; slight fat cover over ribs; spinous processes and ribs easily discernable; tailhead prominent, but individual vertebrae cannot be identified visually; tuber coxae appear rounded but easily discernable; tuber ischii not distinguishable; withers, shoulders, and neck accentuated.

4 *Moderately Thin*

Slight ridge along back; faint outline of ribs discernable; tailhead prominence depends on conformation, fat can be felt around it; tuber coxae not discernable; withers, shoulders, and net not obviously thin.

5 *Moderate*

Back is flat (no crease or ridge); ribs not visually distinguishable but easily felt; fat around tailhead beginning to feel spongy; withers appear rounded over spinous processes; shoulders and neck blend smoothly into body.

6 *Moderately Fleshy*

May have slight crease down back; fat over ribs fleshy/spongy; fat around tailhead soft; fat beginning to be deposited along sides of withers, behind shoulders, and along sides of neck.

7 *Fleshy*

May have crease down back; individual ribs can be felt, but noticeable filling between ribs with fat; fat around tailhead soft; fat deposited along withers, behind shoulders, and along neck.

8 *Fat*

Crease down back; dificult to feel ribs; fat around tailhead very soft; area along withers filled with fat; area behind shoulder filled with fat; noticeable thickening of neck; fat deposited along inner thighs.

9 *Extremely Fat*

Obvious crease down back; patchy fat appearing.

ASSURANCE
Excellence in Equine Nutrition

Henneke et al., 1983

Illustrations by Japan Racing Association