**parameters influencing body condition score**

**of mares and foals**



Research Project of Veterinary, Animal and Biomedical sciences

Massey University, Palmerston North, New Zealand

M. van der Meulen, BVSc, student Utrecht University (3155706), The Netherlands

**Supervisors:**

Dr. C.W. Rogers

Massey University, New Zealand

Prof. Dr. R. van Weeren,

University Utrecht, The Netherlands

# Abstract

**Introduction**

The New Zealand racing industry is a major contributor to the New Zealand economy. The large breeding industry in New Zealand encounters a significant commercial pressure to produce well grown colt foals for sale, as heavy and tall yearlings are expected to deliver better race performances at an earlier age.

Nutrient supply to the fetus is the major regulator of fetal growth, and is dependent of several factors, including placental function and maternal nutrition. Nutritional status of the mare is believed to play a major role in fetal and foal development.

Fatness of the horse can be determined by scoring the body condition. It is proposed that high body condition scored mares would produce foals with a higher body condition score than mares with a lower body condition score. Furthermore, parity and gestation length of the mare are also believed to be important factors in determining foal size and body condition at birth.

The aim of this study was to determine the associations between mare body condition score, parity, gestation length and foal body condition score, wither height and growth rate.

**Materials and methods**

Data were collected from two Thoroughbred stud farms. Mares and foals were body condition scored before, close after (within 3 days) and weekly up to 6 weeks after foaling. Foals wither height was measured close after birth and at 4 weeks of age. Official breeding data on mare age, mare parity, gestation length and last year of empty season were obtained from NZ Thoroughbred Racing. Pasture height was measured weekly using a rising plate meter and available energy calculated to assess if pastures met mares energy requirements.

**Results**

Mean body condition of mares and foals close after birth was 4.70 ± 1.16 and 5.18 ± 0.81 respectively. Data from the 2009 season tended to show a linear relation between mare BCS (at foaling) and foal BCS (at birth) but this was not significant. The 2010 data were best described with a cubic relationship. However, there was no significance difference between foal BCS from thin mares and foal BCS from moderate mares (p=0.147), nor between foals from moderate and fat mares (p=0.079). There was no correlation found between mare BCS and foal withers height close after birth (p= 0.745). However, we found a significant correlation between mare parity and foal BCS (close after birth) (quadratic, R2=0.092. p=0.037) as well for parity and foals wither height at birth (cubic correlation, R2=0.150, p=0.023). There was a significant difference between foal BCS from primiparous mares and foal BCS from multiparous mares (p=0.001). Furthermore, these data demonstrate that there is a negative correlation between last year empty season and foal BCS at birth (R2 = 0.144, p = 0.001). No correlation was found between gestation length and foal BCS. Mare age did not affect mare and foal parameters.

Interestingly, these data show that foals with low BCS (scored close after birth) gain body condition faster than fat foals do (negative linear correlation, R2= -0.301 en p=0.000), they will be at same level of body condition as foals which were fat at birth at 4 weeks of age.

**Conclusion**

Foal BCS is related to mare BCS, however, mare BCS had no influence on foals withers height. Moderate mares tend to give birth to foals with higher BCS than foals from thin and fat mares.

Parity and last year of empty season are important factors influencing foal BCS at birth. Primiparous mares give birth to foals with lower BCS than foals from multiparous mares. Furthermore, mares which have an empty season before a year in which they produce a foal will give birth to foals with lower BCS. Mare age is not an important factor determining BCS of the newborn foal.

Important factors which affect foal BCS are hence mainly mare BCS, parity of mare and last year of empty season.

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# 1. Introduction

**1.1 New Zealand racing industry**

The racing industry is of significant importance to the New Zealand economy. Annually the turnover in racing industry accounts for approximately 1% of New Zealand’s Gross Domestic Product. Within the Thoroughbred industry most horses are sold and exported as yearlings. The general industry perception is that taller and heavier foals become taller and heavier yearlings that usually sell for higher prices than smaller yearlings because of the expected better racing performances as 2- or 3-years old.1 In New Zealand the commercial foaling season starts at September 1 and ends in the first week of December. The official Southern Hemisphere birth day for the thoroughbred horse is August 1 and breeders try to breed the mares as close as possible after this date, hoping for a large well grown yearling to sell at the yearling sales. Mares that foal late in season are usually not bred the next following year, but will be rebred the year after that early in season 23 Unfortunately for the breeders, a dry mare results in financial losses. For that reason it is interesting to know if mares which had an empty year would produce heavier and faster growing foals.

**1.2. Body condition scoring**

Since live weights of mature horses differ between different types of horses, it is generally more informative to determine the fatness of a horse by examining the body condition. Moreover, there is no correlation between weight, height or chest size and body fat.4Body condition can be scored by the system of Henneke.5 This comprises a visual examination and palpation of the body in six areas. Areas that are examined include the lumbar spinous processes, ribs, tailhead, the area behind the shoulder, an area along the neck and an area along the withers. Mares and foals are evaluated on a scale from 1 to 9, with 1 being extremely emaciated and 9 being extremely fat.4 Appendix 1 shows the scoring system by Henneke.

**1.3 Fetal nutrition supply**

Nutrient supply to the fetus is the major regulator of fetal growth, and is dependent of several factors, including placental function and maternal nutrition.6 7 A general thought is that if maternal nutrition is not adequate, fetal development may be retained and birth weight of the newborn foal will be lower.7

Fetal development is dependent of maternal glucose and oxygen supply, supporting a high metabolic rate, and must be accompanied by sufficient uterine blood flow and contact surface areas of maternal-placental tissues. The placenta provides the pathway for interchange of essential gases, nutrients and waste products between fetal and maternal vascular systems throughout gestation. The equine placenta is diffuse and characterized by branching chorionic villi that interdigitate with the endometrial epithelium to form microcotyledons, i.e. the maternal fetal contact area. Development of these bundles of microvilli is fully complete and functional by day 150. The microcotyledons cover the entire surface of the allantochorion and enable exchange across the placental interface. Age and parity of Thoroughbred mares seem to have a significant effect on the development of the microcotyledons on the placental surface, what will be discussed later.8

Despite the thickness of the equine placenta, the mare’s placenta is relatively efficient compared to other farm animals. As pregnancy progresses, the placenta stretches and the placenta becomes more efficient as the demand of the fetus increases. During the last stage of pregnancy the fetus requires the most nutrients, as in this stage fetal body weight gain is at its peak.9 9 The crown-rump length of the equine fetus reaches its maximum length in mid-gestation. The growth in body weight in the last trimester is mainly determined by an increase in body weight through development of skeleton, organs and muscles. 10

Foal birth weight is directly proportional to the surface area of the placenta, as this is the limiting factor controlling nutrient and gas exchange and therefore the development of the foal. Reduced transport of nutrients and oxygen may even cause inefficiency of placental function and will cause smaller foals at birth and possibly signs of immaturity.8 However, foal abnormality is more closely associated with the histological characteristics of the placenta than the percentage of placental area involved in abnormal processes.11 The condition of the placenta appears to be associated more with age than with parity of the mare.12 Age related degenerative changes in the endometrium may limit placentation by reducing the effective area for fetomaternal exchange, therefore leading to intrauterine growth retardation of the fetus. Therefore, older mares may show to have less surface contact area than younger mares.8 Mare age has been shown to have a cubic association with birth weight of the foal, i.e. in young and older mares foal birth weight will be lower than birth weight from foals from middle aged mares. 13

It is surprising that when genetic growth factors are limited in expression inside the uterus, growth may be enhanced after birth. For example, Allen and Wilsher found that a genetically large foal cannot reachits normal birth weight when gestated in a uterus that is smallerthan normal, which effect will persist throughout life. Genetically small foalswill be born heavier than usual if gestated in the uteri oflarger than normal mares and this increased sizepersists to adulthood. 13

**1.4 Gestation length and parity of the mare**

Mean gestation length of the horse is approximately 340 days, gestation length of Thoroughbreds ranges from 316 to 364 days. Most mares show similar gestation lengths between years, but tend to foal 5 days earlier than their first foaling and 5 to 10 days later as they get older.14 It is suggested that body condition of the mare will influences gestation length, however Henneke et al. showed that gestation length was not different between thin and fat mares.15 Lewis et al. stated that gestation length should not be affected by excess body weight of the mare, but that time of pregnancy may be lengthened in malnourished mares. 14 Conversely, it is interesting to know if extended gestation would result in to heavier and bigger foals at birth. In an Australian study with thoroughbreds there was no significant correlation between gestation length and foal birth weight, nor between gestation length and placental weight.16

Parity and age of the mare may play an essential role in determining foal birth weight and size, although parity and age are mostly linked to each other. 17 1317 However, parity rather than age influences placental weight and foal birth weight.16

Parity of the mare may affect foal birth weight by influencing development of microcotyledon density and microcotyledon surface area on the placental surface.138 Reduction of the fetomaternal contact area as well low placental weight was correlated with low foal birth weight. As there seems to be an apparent priming effect, young multiparous mares have a larger microcotyledon surface area than primiparous mares of the same age. This correlation seems to increases with parity and age up to a maximum in multiparous mares aged from 10-15 years, then plateaus or declines slightly in the older animals. Elliot et al. saw an increase in birth weight by 0.8 kg for every extra foaling. Furthermore, between maiden mares and mares in their 2nd till 4th parity he noted a large increase in mean foal weight.16 Multiparous mares ranging in age from 10 up to 15 years would produce the heaviest foals. Older mares seem to have less contact area, which is suggested as being an age-related degenerative effect.13

**1.5 Foal parameters at birth**

Foal birth weight is partially a reflection of the balance between fetomaternal contact and placental efficiency.11 Nutritional status of the dam is believed to be an important component influencing the birth weight and body condition of the offspring. Henneke et al. also showed that average birth weight from foals from thin mares tended to be lower compared to foals from fat mares, however this dissimilarity was not significant.15 Henneke also showed that foal weight at 90 days after parturition was similar for foals from mares with low and fat body condition score.

**1.6 Foal development**

Growth and development of the foal from conception to maturity is subject to numerous genetic and environmental influences. The newborn foal is in its first weeks of life completely dependent on maternal feeding. Consequently, as milk from the mare is the major substrate for nutrition, foal growth is almost completely dependent of milk supply from the mare. After two to three months of lactation milk yield of the mare starts to diminish and simultaneously nutrients from the pasture will becomes the major supply for growth of the foal.3 Growth rate of the foal is highest in the first 12 months of life. Furthermore, at the age of one month old, daily gain of the foal is at its maximum.

As milk supply is a major influencer of growth of the foal in the first weeks of life, it would be important to know if milk composition and milk yield vary between thin and fat mares. Doreau et al. demonstrated that milk composition in fat mares tended to contain a higher percentage of fat, but did not vary significantly with body condition. However, in fat mares the protein content showed to be lower and to contain less short- and medium-chain fatty acids.18 18 When mares are fed below NRC recommendations, milk yield will decrease and foal energy intake consequently will be lower. 14

**1.7 Energy requirements of the pregnant and lactating mare**

The horse is an herbivore and utilizes carbohydrates as a primary source for its energy requirements. Digestible energy (DE) is a common term used to indicate energy requirements of the horse.

Nutrient requirements of the horse are based on age, body weight, mature body size and growth rate (also called average daily gain (ADG)) However, numerous factors such as individual variation, body composition of the animal, environmental temperature and humidity, intensity and duration of work, weight and ability of the rider, conditions of the running surface, and degree of fatigue can also influence energy requirements of the horse. Furthermore, pregnancy and lactation will take energy to provide fetal and foal nutrition. It is widely recognized that mares require gradually increasing energy uptake during these stages. As fetal development is at its highest rate during the last trimester of pregnancy, digestible energy (DE) requirements are not greatly increased until these last 3 months of gestation.19 1, 20 Estimates of DE requirements for the 9th, 10th and 11th month of gestation were formulated by multiplying the maintenance requirements by 1.11, 1.13 and 1.20 respectively. DE requirements of the lactating mares also depend upon the composition and amount of milk produced. Assumptions for daily energy requirement for an adult horse weighing 500 kg are shown in table 1.

The National Research Council (NRC) nutrient requirements for horses are widely accepted. Beside the requirements as mentioned above and in table 1, the NRC also stated that pregnant mares would need a voluntary intake of 2% of their non-pregnant body weight in dry matter per day. Lactating mares would need 2.5% of their live weights in dry matter per day.20

|  |  |  |  |
| --- | --- | --- | --- |
| **‘work’ of horse** | **DE (Mcal) requirement** | **Crude protein (g) requirement** | **% of DE maintenance energy requirement** |
| **Maintenance** | 16.4 | 656 | 100% |
| **Pregnant mare, 9 months** | 18.2 | 801 | 111% |
| **Pregnant mare, 10 months** | 18.5 | 815 | 113% |
| **Pregnant mare, 11 months** | 19.7 | 866 | 120% |
| **Lactating mare, foaling to 3 months** | 28.3 | 1.427 | 180% |

### Table 1. Daily nutrient requirements of the adult (500 kg) horse.20,14

Pagan and Hintz et al. also stated the maintenance (zero body weight change plus normal activity for non working horses) energy requirements for the horse weighing 500 kg as:

*DE(Mcal/day) = 0.975 + 0.021 W* (whereby W= weight of horse) 20

The daily energy requirement for the lactating mare (until 3 months after foaling) is stated by the NRC as:

*DE(Mcal/day)= (maintenance DE) + (0.04 BW x 0.792)* 20

During pregnancy the mare must increase her energy intake to maintain body condition. Most mares and mares which are fed below the NRC recommendation will lose body condition during late pregnancy and early lactation as these stages will have the greatest energy costs. Also mares which are kept in high BCS also will lose body fat. This observation was also seen in dairy cattle and rats. Most likely stored body fat serves as a primary source of energy during the initiation of lactation.15 15

Although maternal nutrition is of great relevance, it is important to consider that relatively extreme changes in maternal nutrition result in relatively small changes in size at birth. 7 As the foetus access to on nutrients in the maternal bloodstream, the mare will mobilize stored body nutrients to insure adequate growth and development when the dietary intake is limited. Weight gain of the mare or weight loss during pregnancy or at foaling seems to have a limited influence on birth weight of the foal.

If the mare is provided with sufficient feed, she will store body fat for utilization late in pregnancy and during lactation, as these periods will take more energy. Lawrence et al showed that when mares were fed at libitum, they will increase body condition mainly during the second trimester of gestation.17 Although obesity does not influence gestation length or placenta weight, it may decrease mares’ milk production and consequently the growth rate of the foal. Furthermore, it has been postulated that in humans obesity may cause dystocia, however it does not appear to be so in horses.14 To ensure that weanlings will be well grown, mares must be fed adequate amounts of energy, protein and microelements to maintain adequate energy intake.21

**1.8 New Zealand pastures**

Typically Thoroughbred mares in New Zealand are not stabled at night and have access to pasture all day and year round, which will satisfy most energy requirements. Due to the short but intense breeding season i.e. spring and summer, some pastures can be over or under stocked and grass quality can differ. If pastures are lacking in quality or quantity, the shortfall is mostly made up by meadow or more rarely clover hay. Pastures in New Zealand are mainly ryegrass clover or clover mixtures. Rainfall, daylight and temperature are main factors for pasture growth. Pasture growth is high in spring and summer, and sward heights tend to be lower in fall and winter. 22

Pasture contents from the North Island of New Zealand have been determined by Gee et al, showing that the energy content of the spring and summer lies between 8.0 and 11.8 MJ/kg dry matter (DM).   
Table 2 shows the digestible energy and crude energy contents in the different seasons.

|  |  |  |
| --- | --- | --- |
|  | **Energy (MJ/kg DM)** | **Crude protein (g/kg DM)** |
| **Autumn** | 10.8 | 250-254 |
| **Winter** | 11.4-11.2 | 222-268 |
| **Spring** | 10.8-11.8 | 148-220 |
| **Spring leafy** | 12.0 | 220-236 |
| **Summer leafy** | 10.3 | 150-219 |
| **Summer stalky** | 8.0 | 100 |

Table 2. Mean energy and protein contents of pastures for horses in New Zealand.23

Furthermore, Grace et al. estimated digestible energy (DE) and crude protein content of pastures in the North Island of New Zealand to be respectively 10.8 MJ/kg DM and 190 g/kg DM. DE intake of the lactating mare was 146.9 MJ/DE/day and dry matter intake was 13.6 kg/day. This is similar to NRC recommendations of 134 DE MJ/day, and therefore means that we can assume that broodmares of the North Island of New Zealand will gain enough DE from the pasture.21

# 2. Hypotheses

(1). Mares with high BCS (>6) will give birth to foals with significantly higher BCS and wither height than mares with low BCS.

(2). Foals with low BCS (<4) at birth will gain body condition faster than high body condition scored foals (if obtaining sufficient milk from the mother and not suffering from disease) and will reach the mean BCS of other foals by one month of age. Mare BCS during lactation has no influence on foal growth (including body condition score and height), when energy requirements for the mare are met.

(3). Parity of the mare is an important factor for fetal nutrition and in that way affects foal BCS at birth. Mares in their first parity will give birth to foals with lower BCS than foals from multiparous mares.

(4). Mares with longer gestation periods will bring foals with higher BCS score and higher foals.

(5). Mare age will significantly influence BCS of the newborn foal.

(6) Mares which had an empty year in the previous breeding season will give birth to foals with higher body condition score.

# 3. Materials and methods

Data were collected from two Thoroughbred stud farms located in the area around Palmerston North, New Zealand (Goodwood stud and Wellfield lodge). The mares on the farms were commercial mares and were in foal to a number of different sires. Data were collected from the 27th of September 2010 to the 25th of November 2010. In total 131 mares had body condition scored before foaling, close after foaling (within 3 days) and up to 7 weeks after foaling. Foals had body condition scored close after birth and up to 6 weeks after birth. Foal wither height was measured close after birth and at 4 weeks of age. Body condition score was determined using the system of Henneke et al.5 (Appendix 1).

Pastures sward heights were determined using a rising plate meter. Subsequently, dry matter mass and total yield were calculated using paddock size and stocking rate information. Recommendations from the National Research Council were used to examine whether energy requirements were adequate.20

At the two stud farms, mares were kept on pasture for 24 hours a day, except at the time of foaling. At Wellfield lodge mares were stabled inside until one day after foaling. For the next three days mares and their foals were kept at pasture with no other horses in the paddock. Nutrition on this stud farm included the first days: 1 biscuit of hay (approximately 2 kg), 1 scoop white chaff (oaten) (0.5 kg), 1 double handful chaffage (fiber-pro) (approximately 0.3 kg) and 1 scoop NRM asset (approximately 1 kg). After that, mares and foals were moved to the large paddocks with other mares and foals, and nutrition included only grass from pasture. Approximately 50 percent of the mares at this stud farm were outside mares and nutrition before entering and after leaving the stud farm was unknown.

At Goodwood stud, mares and foals were kept in a foaling pasture for the first two days after foaling. Nutrition consisted of only grass from pasture (no additional feeding was given). The following four or five days, mares and their foals were kept in larger paddocks with two or three other mares and foals. After approximately a week after foaling, mares and foals were transferred to large pastures with other mares and foals.

Information about mare age, parity, last day of service, last year of empty season and gestation length was obtained from the online database of New Zealand Thoroughbred Racing Inc (http://www.nzracing.co.nz). These parameters were related to foal and mare BCS, foal wither height and foal and mare BCS gain.

Statistical analysis was performed using SPSS v17.0 with a significance level set at p<0.05. Data were analyzed using ANOVA. Linear, quadratic or cubic regression models were fitted to identify best fit.

# 4. Results

**4.1 Horses and stud farms**

In this project we scored a total of 130 mares, 68 mares were located at Goodwood stud, 62 mares were located at Wellfield lodge. At Goodwood stud 35 were mares were resident mares, 11 mares were from outside, and from 29 mares it was unknown. At Wellfield lodge 27 mares were resident mares, 25 were outside mares and for 10 mares it was unknown.

The first foal we scored was born the 27th of September 2010, the latest foal which was scored was born the 25th of November 2010. The average date of foaling in this project was 18 October 2010. Not all mares were scored at every stage of the programme, because they were removed (mainly outside mares), had died or ran away in the paddock making it impracticable to score body condition.

**4.2 Body condition score mares and foals before and close after foaling**

Forty-eight mares were scored before foaling, with a mean body condition of 5.25 ± 1.13. Mean body condition score at Goodwood stud before foaling was 5.23 ± 1.09 (34 mares were scored) and mean body condition at Wellfield lodge was 4.96 ± 1.21 (14 mares were scored). There was no significant difference in mare BCS before foaling between the two stud farms.

In total 83 mares and foals were scored for body condition close after birth. Mean body condition of mares and foals close after birth was 4.70 ± 1.16 and 5.18 ± 0.81 respectively, ranging from 3.0 - 7.5 for the mares and from 3.5 - 7 for the foals. Mean body condition of mares and foals at birth was not significantly different between the two stud farms. Mean wither height of 72 foals measured close after birth was 10.06 ± 0.47 hands.

It was proposed that fat mares would give birth to fat foals, however this project identified a trend reflecting that thin as well as fat mares will give birth to foals with lower body condition than moderate mares. There is a weak relationship between mare and foal BCS at foaling, which was best described by a cubic regression (R2= 0.104, p=0.012) (plot 1).

Plot 1. Association between mare BCS and foal BCS close after foaling (R2=0.104, p=0.012).



Subsequently, mares were separated in three different groups; thin mares (BCS < 5), moderate mares (BCS 5 – 6) and fat mares (BCS 6 >) to illustrate the differences in foal BCS between the mares. (Plot 2 and 3) There was no significant difference in BCS between foals from thin mares and foals from moderate mares (p=0.147), however there was a trend between foal BCS from moderate and fat mares (p=0.079).

There was no significant correlation between mare BCS and foal withers height at birth (p=0.607) (Plot 4). Furthermore, no relation was found between foal BCS and wither height (p= 0.745).

There was no correlation was found between mare BCS before foaling and foal BCS at birth (p=0.173).



### Plot 2 and 3. Foals and mares were scored close after foaling for body condition. Mares are divided in three different groups; thin mares (BCS < 5), moderate mares (BCS 5 – 6) and fat mares (BCS > 6). The mean foal body condition score is indicated with a red line in the upper plot. N(thin mares) = 49, N(moderate mares) = 23, N(fat mares) = 11.

**Foal wither**

**height at birth**

### Plot 4. Mare BCS was associated with foal wither height (close after birth). No correlation was found (R2=0.004 ,p=0.607).

**4.3 Parity**

Parity of the mare is an important (indirect) factor for fetal nutrition.8 It is known there is a priming effect on the primiparous mares, which make them develop their microcotyledons. Therefore, one would expect to see mares which are in their first parity to have lighter foals than multiparous mares. Mean parity of all 102 mares was 4.51 ± 3.02. We scored 71 mares close after birth from which the parity was known; mean parity was 4.51 ± 3.02. 14 mares were in their first parity and 54 mares were multiparous ranging from parity 2 till 14.

Parity and BCS of the newborn foal have a quadratic relation (R2=0.092. p=0.037) as seen in plot 4. Furthermore, there was a significant difference in foal BCS (close after birth) from mares who were in their first parity and foal BCS from multiparous mares (p=0.002) (Plot 5).

Between mare parity and foal wither height a cubic correlation with R2=0.150 (p=0.023) exists (Plot 7). No significant relation was found between parity and gestation length (p=0.529).



### Plot 5. Mare parity and foal BCS (close after birth) show to have a quadratic association (R2=0.092. p=0.037).



Plot 6. Difference in foal BCS close after birth between primiparous (N=14) and multiparous (N=54) mares. Primiparous mares give birth to foals with lower BCS (p=0.002).

### Plot 7. Mare parity associated with foal wither height shows a cubic relation R2=0.150 (p=0.023).

**4.4 Gestation length**

Mean gestation length of 98 mares (48 mares at Goodwood lodge, 50 mares at Wellfield lodge) was 348.69 days ± 9.69, ranging from 331 to 375 days. Mean gestation length was not significantly different between the two stud farms.

Of the 70 mares that we scored short after foaling, gestation length was known. There was a significant cubic correlation between mare BCS and gestation length with R2=0.235 and p=0.000 (Plot 6). However, there was no significant linear relationship between foal BCS and gestation length (linear, p=0.391) and gestation length and foal withers height close after foaling (linear R2 = 0.04, p =0.547).



### Plot 8. There is a cubic association (R2=0.235, p=0.000) between mare BCS (close after foaling) and gestation length.

Data was collected concerning last dates of services and foaling dates. The number of days between August 1 2009 and day of last service were calculated and related to gestation length of the mare. There was a strong and significant linear correlation (R2=0.138,p=0.00)



### Plot 9. Mares which have their last service date early in season show to have a longer gestation length (R2=0.138, p=0.000)

**4.5 Mare age**

The average age of 107 mares was 11.24 years ± 3.92. From 24 mares age was unknown. There was no significant difference between the two stud farms concerning mare age. Mare age ranged from 5 years old to 21 years.

As we know that age may have a degenerative effect on microcotyledon efficiency in the uterus in time, we might expect that older mares give birth to foals with a lower body condition or foals of smaller size. However, there was no correlation between mare age and foal BCS (p=0.079) and wither height of the newborn foal. Furthermore, mare age was also associated with foal BCS gain the first four weeks after birth but no correlation was detected (p= 0.266).

**4.6 Last year of empty season**

Mares which are foaling late in the season will often not be rebred that season and carried over as empty. Therefore they can be bred again early in season the next year. This is advantageous as it is believed that an early foal will sell better at the yearling sales. In this project 70 mares were scored at BCS (close after birth) from which the breeding status of last years of the mare was known. From this 70 mares, 31 mares had an empty season in 2009 and 39 mares had a foal in season 2009. Foal body condition close after birth was related to last year of empty season and a linear correlation with R2 = 0.144, p = 0.001 was found.

Furthermore, foal BCS of mares which were kept empty in 2009 and foal BCS of mares which had a foal in season 2009 were compared. There was a significant difference between those two groups (p=0.003)

Furthermore, foal BCS at 4 weeks was related to last year of empty season, but there was no correlation between those parameters (p=0.547).



### Plot 10. There is a significant relationship between foal BCS and last season of emptiness with R2 =0.144 en p=0.001 .

**4.7 Foal and mare BCS at 4weeks of age and BCS gain**

Foals and mares were weekly scored for body condition to see the trend of body condition gain and to determine whether thin foals gain faster body condition than fat foals, so they would be at the same level at four weeks of age. 36 foals were scored close after birth as well at four weeks of age. Foals which already had a high level of body condition at birth showed to have a slower rate of body condition gain. There is a linear correlation between foal BCS close after birth and foal BCS gain with R2= -0.301 and p=0.000. There was no significant association between foal BCS close after birth and foal BCS at 4 weeks of age (p=0.145).



### Plot 11. There is a negative linear correlation between foal BCS close after birth and foal BCS gain.

The 37 foals scored close after birth and at 4 weeks of age, were separated into two groups on the basis of the body condition score close after birth (thin foals (BCS < 6) and fat foals (BCS > 5.5)) to see whether thin foals would reach the same BCS in this period as fat foals. Thin foals indeed gained body condition faster, as there was no significant difference anymore in BCS at 4weeks between thin and fatter foals.



### Plot 12. Body condition scores of thin and fat foals.

As it is believed that fat mares have a higher content of protein in their milk and more energy to utilize for milk production, we would expect the newborn foals from these to grow faster, as they have a greater source of nutrition at their disposal. We scored 36 mares and foals at foaling and at 4 weeks of age, and gain of body condition was calculated. A linear association (R2 = 0.136, p=0.030) was detected between mare BCS (close after foaling) and foal BCS at 4 weeks of age (Plot 12). Interestingly, mare BCS scored before foaling had even a stronger relation with foal BCS at 4 weeks of age (R2=0.243, p=0.032).

Foal body condition gain (in 4 weeks) tended to have a positive linear correlation (R2=0.081) with mare body condition, however this was not significant (p=0.088) (Plot 14). Associating mare BC gain and foal BC gain resulted in no significant relationship (p=0.487). Also, parity of the mare did not affect foal BCS gain untill 4 weeks after birth (p= 0.306 linear).

### Plot 13. No significant relation between mare BCS close after foaling and foal BCS at 4 weeks of age R2=0.136, p=0.030.



### Plot 14. There is a linear relation between mare BCS pre-foaling and BCS of the newborn foal (R2=0.243, p=0.032)



### Plot 15. Although it seems that there is an association between mare BCS (scored close after foaling) and BCS gain of the foal in 4 weeks, this is not significant (R2= 0.081, p=0.088).

**4.8 Determining major influencers**

In this project 21 mares and foals were scored pre-foaling (mares), close after foaling resp. birth, at 4 weeks after foaling resp. birth, and data was collected concerning mare age, last year of empty season, gestation length and parity. Using linear coregression analyses, we calculated which parameters have most influence at BCS and withers height of the foal. We saw that last year of empty season, mare age and mare BCS (at foaling) are major influencers, as shown in table 4.

|  |  |  |
| --- | --- | --- |
|  | **Strongest association** | **Next strongest association** |
| **Foal BCS (close after birth)** | Last year of empty season (R=-.542, p=0.003, n=24) | Parity (R= 0.346, p=0.049, n=24) |
| **Foal withers height (close after birth)** | Mare age (R2=-.258, p=0.129, n=21) | Parity (R2=0.180, p=0.217, n=21) |
| **Foal BCS (at 4 weeks age)** | Mare BCS (at foaling) (R2=0.694, p=0.009, n=11) | Mare BCS (pre-foaling) (R2=0.627, p=0.019, n=11) |

# Table 3. Summery of descriptive statistics using Pearson Correlation

**4.9 Results of 2009 season**

A year before, the association between mare BCS and foal BCS was made as well. Sixty mares and foals were scored. The result of this association tended to support that mares with high BCS would give birth to foals with high BCS than thinner mares do (R2= 0.018, p=0.302), but this was not significant. However, this year we saw more a cubic relation instead of a linear relation , consequently that thin and fat mares give birth to foals with lower BCS (R2=0.104, p=0.012).

# 5. Conclusion

These data from this study show that there appears to be a cubic correlation between mare BCS (close after foaling) and foal BCS (close after birth). However there was no significant difference between foal BCS from thin and moderate mares (p=0.147), nor between moderate and fat mares (p=0.079). Also, no relationship was found between mare BCS and foal withers height.

We expected thin foals to be at the same level of BCS as fat foals within one month after birth. This hypothesis was supported by the results from this project and we may assume that thin foals gain body condition faster than foals born with a high body condition score. There was a linear correlation between foal BCS close after birth and foal BCS gain (R2= -0.301, p=0.000). Mare BCS (close after birth) and foal BCS (at 4weeks of age) showed to have a linear association with R2 = 0.136, p=0.03 .

Mare parity which had a significant association with BCS of the newborn foal with a quadratic correlation (R2=0.092. p=0.037) Primiparous mares appear to give birth foals with lower BCS (p=0.001). Also, a (cubic) correlation (R2=0.150, p=0.023) existed between mare parity and foal wither height (close after birth).

Gestation length was compared with mare BCS and showed a significant cubic correlation (R2=0.235, p=0.000). However, there was no significant linear relationship between gestation length and foal BCS (close after birth) (linear, p=0.391), neither between gestation length and foal withers height (close after birth) (linear R2 = 0.04, p =0.547).Mare age and foal BCS (close after birth) did not seem being correlated to each other (p=0.079), neither were mare age and withers height of the newborn foal.

There was linear correlation between last year of empty season and foal body condition at birth. (R2 = 0.144, p = 0.001)

The abovementioned data demonstrate that mare BCS affects foal BCS and body condition gain after birth. As an empty season appears to have a positive influence at BCS of the newborn foal, breeders may expect those mares to deliver foals with higher BCS. On the other hand, primiparous mares will give birth to foals with lower BC. However, as we saw that thin foals get at the same level of body condition as fat foals at 4 weeks of age, it may be reassuring for breeders that those foals will achieve the same level.

# 6. Discussion

In this project we scored mares and foals for body condition using the system of Henneke.5 (See appendix 1). This system is made for scoring adult horses. However, we also used this system to score body condition in foals, for lack of better. There is need for a specific system for body condition scoring in foals.

Since mares and foals were in large paddocks it was often impossible to score the foals by palpation (as it is part of the system of Henneke). Therefore those foals which were not physically reachable were scored by visual examination. At the moment of scoring foals close after birth, mares and foals were in smaller paddocks or inside a foaling box, making it possible to score the body condition of the foals by palpation.

There were a few differences in the management of the two studfarms that may have influenced body condition (gain) of mares and foals. At Goodwood stud, foals wore a blanket when outside temperatures were low. In meantime, at Wellfield lodge, mares were provided hard feed the first day after foaling, resulting in more available energy for maintaining body condition and milk production.

As mentioned before, Thoroughbred breeders desire a foal that is large and well-grown at the yearling sales. However, although height and weight are important, attaining maximal growth rate is certainly no guarantee for optimal skeletal development. In contrast, the risk of skeletal abnormalities is at maximal risk when weight gain is high. Rapid growth, grow spurts and excesses and deficiencies of nutrients, as fluctuations in hormone levels caused by irregular meals, during the first 12 months of life can cause abnormalities in bone development. New Zealand has the advantage for newborn foals to grow up outside in (mostly large) pastures, providing free exercise and which stimulates optimal musculoskeletal development. Nutrition comes merely from pasture. These are better conditions than in many situations overseas, whereby breeders tend to overfeed with concentrates in an attempt to get their yearlings as big as possible for the sales, a way of working that stimulates the developing of orthopaedic problems such as OCD.24

A general birth date of August 1 stimulates breeders to breed their mares as early as possible in the season. Mares that foal late in season are usually not bred the same year, but are re-bred early in season the following year, resulting in financial losses. Brown Douglas et al. investigated whether autumn foals would grow at the same rate or faster than foals which were born in spring. He showed that autumn foals live weights were significantly higher at the age of one year, because of higher growth rates during the winter months. When autumn foals would achieve an acceptable bodyweight by the time of sale an opportunity exists for breeders to produce offspring from late foaling mares which could result in an increase in production and reduction of losses of empty mares.3 In this project we saw that mares which had an empty season delivered a foal with lower BCS than mares that had a foal in 2009. This makes it interesting for breeders to decide if they rather should bred their late mares, or keep them dry to rebreed those late mares next year.

Parity, which is mostly linked to age, seems to be of high importance for birth weight of the foal. Barron found by surveying racetrack performances that foals born from multiparous mares aged between 7 and 11 years, were more successful than foals from maiden mares or older animals. Wilsher et al. stated that ideally the recipient mare should be between 5 and 9 years of age, should have already produced at least one healthy foal, and should have a body size that is equal to or bigger than that of the mare producing the embryo. 12 25 Most probably the criteria for a mare if a large and heavy foal is to produced are: moderate body condition, middle-aged and multiparous.

Data from the preceding 2009 season showed that there was a linear trend between mare BCS and foal BCS (at birth), although this was not significant (n=60). This year we scored 83 mares and foals close after birth and found a (significant) cubic relation between mare BCS and foal BCS, which is a remarkable contrast. More research is needed to investigate which correlation is the right one.

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**Appendix 1. Body condition scoring system by Henneke et al. 1983** 5

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Condition** | **Neck** | **Withers** | **Shoulder** | **Ribs** | **Loin** | **Tailhead** |
| **1 Poor** | Bone structure easily noticeable | Bone structure easily noticeable | Bone structure easily noticeable | Ribs protruding prominently | Spinous processes projecting prominently | Tailhead, pinbones, and hook bones projecting prominently |
| **2 Very Thin** | Bone structure faintly discernible | Bone structure faintly discernible | Bone structure faintly discernible | Ribs prominent | Slight fat covering over base of spinous processes. Transverse processes of lumbar vertebrae feel rounded. Spinous processes are prominent | Tailhead prominent |
| **3 Thin** | Neck accentuated | Withers accentuated | Shoulder accentuated | Slight fat over ribs. Ribs easily discernible | Fat buildup halfway on spinous processes, but easily discernible. Traverse processes cannot be felt | Tailhead prominent but individual vertebrae cannot be visually identified. Hook bones appear rounded, but are still easily discernible. Pin bones not distinguishable |
| **4 Moderately Thin** | Neck not obviously thin | Withers not obviously thin | Shoulder not obviously thin | Faint outline of ribs discernible | Negative crease (peaked appearance) along back | Prominence depends on conformation. Fat can be felt. Hook bones not discernible |
| **5 Moderate (Ideal Weight)** | Neck blends smoothly into body | Withers rounded over spinous processes | Shoulder blends smoothly into body | Ribs cannot be visually distinguished, but can be easily felt | Back is level | Fat around tailhead beginning to feel soft |
| **6 Moderately Fleshy** | Fat beginning to be deposited | Fat beginning to be deposited | Fat beginning to be deposited | Fat over ribs feels spongy | May have a slight positive crease (a groove) down back | Fat around tailhead feels soft |
| **7 Fleshy** | Fat deposited along neck | Fat deposited along withers | Fat deposited behind shoulder | Individual ribs can be felt with pressure, but noticeable fat filling between ribs | May have a positive crease down the back | Fat around tailhead is soft |
| **8 Fat** | Noticeable thickening of neck | Area along withers filled with fat | Area behind shoulder filled in flush with body | Difficult to feel ribs | Positive crease down the back | Fat around tailhead very soft |
| **9 Extremely Fat** | Bulging fat | Bulging fat | Bulging fat | Patchy fat appearing over ribs | Obvious crease down the back | Bulging fat around tailhead |