TWIN CALVING AND ITS CONNECTION TO OTHER ECONOMICALLY IMPORTANT TRAITS IN DAIRY CATTLE

GÁSPÁRDY András[1] – SHERIDAN James[1] – ARI Melinda[2] – GULYÁS László[3]

[1]Department for Animal Breeding, Nutrition and Laboratory Animal Science, University of Veterinary Medicine Budapest, 1078 Budapest, István utca 2., gaspardy.andras@univet.hu, jamessheridan431@gmail.com, (36)1-478-4120
[2]National Association of Hungarian Holstein Friesian Breeders, 1134 Budapest, Lőportár u. 16., arime@holstein.hu, (36)1-412-5069
[3]Institute of Animal Science, Faculty of Agricultural and Food Science, Széchenyi István University, 9200 Mosonmagyaróvár, Vár 4., gulyas.laszlo@sze.hu, (36)96-566-718

Abstract

The occurrence of twin-calving in Holstein Friesian cattle is 3-5%. Reproductive problems found before and after the time of calving lead to serious economic losses. The aim of the authors was to form a compilation of data regarding the cause and effects of twin calving on dairy cows. Comparing the reproductive performance of cows before and after calving twins vs. single calves. Also analyzing the milk production of dairy cows both before and after twin calving. Cows that would twins became pregnant earlier; probably because of their better health and fertility, with shorter gestations and calving interval. However after calving cows that had twins showed poorer reproductive performance. The results show that twin-calving cows had better condition prior to calving, resulting in an earlier successful twin-calving. However the economic losses during parturition, metabolic disorders of the cow and low vitality of the twin calves, coupled with the decreased fertility and elevated culling rate in cows after twinning may discourage breeding twins in dairy cattle.

Keywords: Holstein-Friesian, twinning, reproductive traits, milk yield, fertility, culling reason

1. Introduction

Investigations on bovine twin-calving topic were published first in the early 1900's. Both breeders and experts were interested how cows that are normally uniparous animals can give birth to two or more healthy calves. In the 1930's [1] it is an important goal of research into twin-calving was highlighted: raising identical calves in different experimental conditions [2]. Approximately 10% of all pregnancies in dairy cattle result in twins. However in beef cattle the incidence of twins is less frequent [3, 4].

Superficially from an economical viewpoint, the idea of an excess number of calves per calving can seem advantageous. Nevertheless, when the outcome is analyzed twin-calving has several negative consequences. Abortion [5], dystocia [6], higher mortality of the calves around or during parturition [7] and placenta retention [8] are far more frequent in twin-calving cows. Twins born tend to be less developed than single-born herd mates of the same age, they have higher mortality rate [9] and rebreeding the dam can be delayed [10]. Leading to a longer calving interval and decreased profits. Use of sexed semen has been shown to result in a lower frequency of twin pregnancies [11]. However this lower twinning rate is due to damages caused to spermatozoa by the physical forces during the sexing process. Which in itself has other negative effects that are well known such as decreased conception rates [12] and is not dependent on the dam.

2. Factors impacting twinning

It has been well documented that [13, 14, 15] the natural frequency of twin calvings is influenced by a wide variety of genetic and environmental factors ranging from 0.5 to 4% depending on these factors.

Mainly environmental and genetic factors influence the number of twin Holstein Friesian calves born every year. The factors having most influence over multiple births are age, parity, seasons and climate, feeding, milk yield, hormonal influence, and genetic predisposition.

2.1 Genetics

It has been shown that there is a far higher incidence of twins in dairy cattle as opposed to beef cattle [16]. The frequency of twin births also shows variation by breed [17], with incidences of multiple ovulations much more frequently observed in Holstein Friesians cows than in other dairy cattle breeds [15].

The results drawn from a model calculation estimating the genetic determined number of calves per calving (or litter size), the real incidence of twinning, and the percentile contribution of triplet and quadruplet pregnancies are shown by Table 1.

[TABLE 1] Average litter size and percentage of triplet and quadruplet births predicted from percentage of multiple birth [18]

2.2 Age

Age is also a contributing factor when dealing with the rate of occurrence of twin and multiple births. Cows that have had several lactations have a higher number of twin and multiple births compared to that of heifers [19].

Twinning not only increased from first to second parity, but also from second to third parity, to then more or less plateau for the remainder of the reproductive life of the cow [9].

Older cows have a tendency to carry twins more frequently due to the cows' maturity and the increased occurrence of polyovulation [20]. The increase in incidence of double ovulations is approximately linear with increasing calving numbers [21]. One explanation that has been proposed for this, is that in twin pregnancies the increase in embryonic mortality in younger cows is due to the uterus having insufficient functional capacity. The total area of the uterus in heifers and in young cows is usually not sufficient to support several embryos [22].

2.3 Seasonality

Generally, it is found that more twin and multiple births take place in summer, spring and autumn than in the winter months. In summer the percentage of pregnancies that were twins was found to be 2.41%, in spring 2.04% and falling to 1.79% in autumn [17, 23, 24]. A study in the USA (Minnesota) [9] showed that the percentage of twin births in April-June to be 8.3%, July-September to be 9.7%, October-December to be 5.2% and January-March to be (2.3%) in the northern hemisphere.

The postpartum conception rate was higher in autumn than in spring due to the higher feed quality in the Autumn months and the lower temperature (so that heat stress is not a problem). The opposite was found to be true [25] when dealing with beef herds, in which twin births were seen to be 50% higher in autumn than in spring [19].

The University of Wisconsin performed an investigation on the North American Sires and found that the highest rate in twinning was in the lead up to the summer solstice and the lowest was at the winter solstice [26]. And it was also found [27] that most of the twin births could be observed during the summer ($p= 0.002$); the causative factors are still questionable, but one possible cause could be that during the autumn months, the weather is colder, and the hot summer months that would subject the cow to heat stress which could damage the embryo is over. The survival rate of the embryo or the fetus and the ovulation rates determine if there will be a single, twin or multiple calves born [28]. During the study period, 1,281 (3.94%) twin births occurred. The ratio of twin deliveries on the farms varied between 3.43-4.35%.

2.4 Nutritional influences

We see that food intake is reduced with the rise in temperature in the summer, along with the decline in reproductive performance and milk yields [29]. Better feed quality supplied in the autumn and optimum temperature (absence of heat stress) contribute to multiple ovulations in cows [30].

Cows with high milk yield show a threefold higher frequency of double ovulation than cows with medium to low lactation performance. Flushing could potentially be given as the reason for this [31].

Quality of feeding has a huge knock-on effect throughout the life of a cow: before fertilization, pre- and postpartum. Nutrition plays a great part with the aim of getting the maximum energy intake from the silage and feedstuff to optimize milk production and fertility performance of the herd. This goes hand in hand with good management and good farming practice.

Good nutrition can also lower the risk of postpartum disorders like ketosis, mastitis, milk fever which were associated with high reduction in milk production [16].

2.5 Milk Yield

Milk production is the primary factor affecting the incidence of double ovulation in lactating dairy cows [31].

High milk production near the time of ovulation can increase the incidence of double ovulation which would therefore subsequently result in an increase in twinning. Current dairy management strategies are aimed at maximizing the milk production of the cow. This intensive feeding strategy would in turn increase the incidence of double ovulation in the dairy cattle population in general. It is therefore not unexpected that given the annual increases in milk production that there should be an overall increase in twinning rates as well.

2.6 Hormonal influences

It was found [32] that the rate of twinning increased with increases in milk production, incidence of cystic ovarian disease, and the use of common pharmaceuticals, including GnRH, PGF2α, and antibiotics. For farmers and the milk industry only a functional cow with regular and healthy offspring is profitable. Any kind of disorder in relation to the reproductive system will cause losses. By increasing the number of insemination required, elongating the calving interval. To avoid or at least to reduce these issues a hormonal treatment could help to reach a successful pregnancy [33, 34]. For the "OV-Synch-method" the cows get two intramuscular injections of gonadotropin-releasing hormone (GnRH) as well as one prostaglandin (PGF2α) injection in a specific order to synchronize the ovulation of a herd [31]. Another benefit beside the synchronization is the use of this injection-combination to treat cysts of the ovaries [35]. Due to the effect of hormones on the cows' body 14.1 % of the cows have shown a double ovulation and with that in 5.2 % of the cases a twin pregnancy was detected [31].

3. Reproductive traits in twin and single calving cows before calving

Data from 393,002 parturitions were recorded along with the cows' performance in the following production cycle [30]. This data was collected from 145,457 Polish Holstein Friesian cows. The animals initially calved between 2000 and 2012 and were either in use or culled by the end of 2013. Among the factors analyzed, the cow's age had the strongest effect on the rate of occurrence of multiple pregnancies. Showing multiple pregnancies to be much more frequent in cows than in heifers. Each consecutive lactation raises the chance of multiple ovulations, and occurrence of twin births increases linearly with the frequency of double ovulation [31, 36]. The incidence of twin pregnancies goes from 1% in maiden heifers to about 10 % in following lactations. The rate of twin pregnancies increase the most between the first and second lactation. After the second lactation the incidence increases to a lesser extent [23]. It should also be noted that heifers have an increased mortality of one of the fetuses in multiple pregnancy, due to the high nutrient requirement of the growing body of the heifer coupled with the demands of the twin fetuses [37].

In an analysis [38] of 4,000 cows calving between 2000 and 2010 in a herd in northern Hungary (Table 2) when ages were compared at first breeding, at first conception and at first calving of twinning and non-twinning cattle. The average age at first breeding at the farm was 17.9 months (544 days), and no significant difference was found between future twinning and non-twinning heifers. The average age of first conception was 18.3 months (557 days). There was no significant difference between non-twinning and twinning heifers. On average heifers became pregnant by the 13th day of service if the first or second insemination was successful. On analysis of age of first calving, it was demonstrated that on average the age of first calving in pregnant heifers was 27.5 months, and there was also no significant difference in the comparison between twinning and non-twinning heifers. The lack of deviation is due to the management system and when the farmer chose to inseminate them. The calving to service period prior to a viable pregnancy was on average 73.9 days, showing no significant difference between twinning and non-twinning cows. The cows that were non-twinning took 73.6 days.

There is a statistically proven difference between twinning and non-twinning cows ($p= 0.047$) in the length of open period which was 109.3 days for non-twinning and 104.6 for twin-calving cows. Meaning that twin-calving cows required a shorter service period by 4-5 days than non-twinning cows, due to their better fertility and higher chance for conception.

[TABLE 2]

Reproductive traits of cows with single and twin birth before (BF) and after calving (AF) [38, 39]

Cows carrying twins had an average gestation length of 274.0 days, which was confirmed to be shorter than their herd mates carrying single calves for 278.7 days. There was a significant ($p< 0.001$) difference in this study of nearly 5 days due to the type of calving. The average length of gestation was 276.3 days. The significant contributing factors to the total variance were the following: type of calving, calf gender, and calving season, 64.22%, 17.32%, and 10.92%, respectively.

Calving interval of the herd was 398.2 days. A relevant difference was detected between the twin calving and single calving cows. The calving interval in twin-calving cows was 392.2 days. Shorter than the calving interval in non-twinning cows which was 404.2 days. A difference of 12 days which is significant ($p< 0.001$).

This farm study assumed that cows that would carry twins have a better body condition which leads to better fertility provided the housing and feeding all the cattle receive is the same. It was concluded that the beginning of the breeding phase for young animals is dependent on the decision of the farmer and it will be similar for every heifer on that farm. The first part of the investigation was concerned with events only occurring once in life of a heifer. However later characteristics that occur

repeatedly in life of a dairy cow were analyzed, in all cases the characteristics were taken into consideration before calving, demonstrating differences between the length of the calving interval, open days and gestation during the herd's life. This shorter calving interval can be seen as advantageous in a dairy herd.

4. Production traits in twin and single calving cows before calving

In another study [30] the rate of occurrence of multiple pregnancies was found to increase noticeably ($P \leq 0.01$) as the milk production level of the cows increased. Higher yielding cows are predisposed to double ovulations, which directly affects the incidence of twinning [40]. High energy diets offered in the early lactation are a contributing factor in the rate of double ovulations [23, 24]. For breeders, it is worth noting that the rate of twin births increased significantly ($P \leq 0.01$) from 0.43 % in heifers between 2000–2003 to 0.77 % in heifers between 2010 and 2012. This is thought to be linked to increased production levels of the active population, because the yield of cows in their first lactation in 2000 was 5,969 kg compared to 8,215 kg for cows in their first lactation that calved in 2012.
Milk yield is positively correlated to frequency of multiple pregnancies [3, 4]. In an analysis of 91,008 calvings between 1974 and 1985, it was shown that twinning was much more frequently in Holstein Friesians compared to the Polish Black-and-White breed.

5. Reproductive traits in twin and single calving cows after calving

In Table 2 reproductive characteristics after calving are also presented. With respect to the time from the calving to the service period [39]. The average number of days in the resting period on the farm were 75.8. The number of the calves had a strong effect on the length of the studied period ($p= 0.043$). The cows that had single calves took 73.6 days compared to the cows that had calved twins 78.0 days to recover.

[FIGURE 1]
Cumulative proportion of cows which became pregnant on the course of insemination period [41]

The service period was analyzed in a separate study of the same herd data [41] the average service period length was 44.6 for the herd overall. The single calving cows had a shorter (44.4 days) service period than twin calving cows (51.2 days), but this difference was not considered statistically significant ($p= 0.111$). It was found that roughly a third of the cows were put in calf by the very first insemination. Fifty % of the cows that had single or twin calves were put in calf by the 40th and 48th day of service period respectively. However it was found that this eight days difference was not a statistically significant proven difference ($p= 0.653$) between the groups of cows. This shows us that cows with single calvings and twin calvings respond in a similar way to the re-breeding.
On examination of the number of open days after calving [39] a relationship was found to twinning (Table 2). The average number of open days was 116.1. Based on the number of the calves it was significantly different ($p< 0.001$). For the single calving cows, there were 109.3 open days on average. Whereas for the twin calving cows it took 123.1 days. In case of the twin calving cows the open days was 7 days more than the farm average.
Analyzing gestation length after calving [39] it was found that the average was 278.9 days. There was no significant difference between twin calving and single calving cows.
The length of the calving interval after calving was on average 403.9 days. However, there was significant deviation from the average in the twin and non-twin calving cows ($p< 0.001$). The calving interval following a twin calving was 6 days longer than the calving interval of single calving cows, and 13 days longer than the farm average. This is thought to be because after the twin calving the involution of the uterus takes longer, increasing the time between two calvings [6].
Another study [14] analyzed the reasons for culling of in a herd of 23,588 cows of a local breed improved with Holstein Friesian between the years 2000 and 2008. After having single calves vs. having twins or triplets. The culling patterns reveal some of the reproductive issues associated with multiple pregnancies. After single pregnancies udder diseases account for 11.83% of culling, and fertility and reproductive diseases account for 34.58% of culling. Whereas these figures are higher in multiple pregnancies with udder diseases accounting for 13.54% of culling and fertility and reproductive diseases accounting for 37.99% of culling.

[TABLE 3]
Culling patterns in cows after single and multiple pregnancy (chi^2= 28.26) [14]

This study also showed that triplet calving cows have even worse reproductive issues than twins. Showing that the calving interval was 416 days in single calving cows, 430 days in twin calving cows and an excessive 487 days in cows that had triplets. The rest period after calving was shown to be 87 days for single calving cows, 96 days for twin calving cows and 104 days for cows that had triplets. Similar delays were found in the service period, which was found to be 45 days in single calving cows, 52 days in twin calving cows and 93 days in cows that had triplets. The percentage of successful first inseminations was found to be 49.11 for single calving cows, 45.76 for twin calving cows and 28.57 for cows that had triplets. The effect of twin calving on open days in Holsteins was studied in the USA [42]. The effects of twin calving in Holsteins were studied from a compilation of calving records from the Eastern Artificial Insemination Cooperative. Cows were grouped according to whether the twin calving was associated with dystocia. Records of each cow that had a twin calving were paired with records of a single-calving control herdmate. In the twin group of 175 cows associated with dystocia, after twin pregnancy open days following twin calving was increased by how much. In the twinning group of 367 cows with no dystocia at twinning open days after twinning were increased by roughly 22 days. Indicating a negative economic effect of twin calving suggesting increased rates of twinning via artificial selection or artificial induction of twinning in dairy cattle would not be desirable.

6. Production traits in twin and single calving cows after calving

A study of the same dairy farm in northern Hungary [41] compared the total lactation performance data of 10,666 cows, in detail examining the most economically important traits such as milk yield (kg), fat yield (kg) and protein yield (kg). Taking into account factors such as whether the cow had a single or twin calving, the proportion of Holstein Friesian genetics, the season the calving occurred in, the number of lactations and the year of calving. The average total milk yield produced was 7,140 kg, a noticeable difference was seen in comparison of single calving and twin calving cows in favor of single calving cows (p= 0.013). On average single calving cows were found to produce 7,390 kilos of milk whereas the twin calving cows were found to produce 6,890 kg on average. In terms of the type of calving, it was shown that cows that had twins yield on average, 500 kg less milk than single calving cows. As mentioned above, not only was total lactation yield (kg) evaluated but also fat yield (kg) and protein yield (kg). Regarding the fat yield a meaningful distinction was recognized between single calving cows and twin calving cows (p= 0.030); single calving cows gave 17 kg more fat.
The overall standard lactation milk yield is 6,685 kg. When the milk yield (p= 0.002), the fat yield (p= 0.001) and the protein yield (p= 0.004) were examined, and found to have significant differences based on the type of calving. Twin calving cows produced in average 410 kg less milk than single calving cows.
However contradicting results were found in another study [30]. Examining a herd of 23,588 cows of a local breed improved with Holstein Friesian between the years 2000 and 2008. It was found that the average milk yield in kg after calving was found to be 6,219 for single calving cows, 6,434 for twin calving cows and 7,097 for cows calving triplets.

In a study performed in the USA [42] the effects of twin calving on the lactation in Holsteins were studied from a compilation of calving records from the Eastern Artificial Insemination Cooperative. The records of cows were grouped according to whether or not the twin calving was associated with dystocia. Records of each twin calving cow were paired with records of a single-calving control herdmate. In the twin group of 175 cows that had difficult calvings, twin pregnancy was not found to have an effect on the cows' production; milk and fat yield in the lactation initiated by twinning was depressed however this was not significant. In the group of 367 twin calving cows with no dystocia at calving, milk and fat production were depressed by 285 kg and 14 kg in the lactation after the calving. It was shown that twinning associated with dystocia seemed to depress the milk yield in the subsequent lactation (year 2). Compared to controls showing that twin calving cows outperformed their herdmates in both the lactation before the twin calving (year 1) and the lactation after the next successful calving year 3). Separate analysis of the 172 individuals with milk records for year 1 and 2 gave mean yields for year 1 of 7,848 kg for twin calving cows and 7,722 kg for the control cows. For year 2, the mean for twin calving cows was 7,794 kg compared to a mean of 7,811 kg for control cows. Although these means also indicate a depressive effect of twinning, this interaction was not considered significant. Mean values for cows where twinning was not associated with dystocia showed that twinning also depressed subsequent milk yield. The twin calvers outperformed their herdmates in year 1 and 3. No depression was noted for milk yield in the twin pregnancy lactation (year 1). There was also significant depression in fat percentage with twinning combined with a depression in milk yield to depress fat yield. In a group of 305 pairs in which no dystocia with twinning was

observed, fat yield also was depressed in the twin pregnancy lactation. Twin calvers outproduced their herdmates in year 3, the year not directly affected by a twin calving. Both groups showed roughly the same effect of twinning on the number of open days following a twinning (Table 2). The 100 twin calvers associated with dystocia showed a noticeable increase in the number of open days following twinning. The 157 twin calving cows with records for years 2 and 3 were open for an average of 105 days prior to conception of twins and 132 days after birth of twins as compared to means for the controls of 101 and 106 days. Analysis of the conception rate of 212 pairs of cows in which twin calvers had no difficulty calving showed that conceptions with twins averaged 9 days earlier when compared to conceptions of single calving herdmate controls. After the twin birth, twin calvers took 22 days longer to conceive than their herdmates. When 316 pairs were examined for years 2 and 3 only, twin calvers showed a mean number of days open prior to conception of twins of 100 days and a mean of 131 days to conception following the twinning as compared to means of the controls of 105 and 108 days.

7. Consequences of twinning

Twinning in dairy cattle can have both favorable and unfavorable results, but it is not seen as a desirable trait in dairy cattle. Delayed re-breeding and other reproductive problems in twinning cows are some of the reasons for culling by farmers, whereas cows calving singles are culled more due to low milk production [26]. Twinning in the dairy herd population appears to be increasing over time. Cows having twins are at greater risk for many periparturient reproductive and metabolic disorders than cows having single calves. Abortion, stillbirth, neonatal calf mortality, and reduced birth weights are seen more with the birth of twins than single calves [30].

7.1 Gestation length

It was found in a study by [27] that the length of gestation before calving on the studied farm. The average length of this period of time was 276.3 days. Here we experienced significant ($p < 0.001$) difference of approximately 5 days by type of calving. Twin-calving cows' gestation length (274 days) has proven to be shorter than that of non-twinning (278.7 days) herd-mates. As their gestation is shorter and their reproductive performances is better, with shorter regeneration time and higher conception rates, they have a short calving interval. However, the benefits of this shortened calving interval before twinning are negated by the reproductive problems following twinning. There are more factors influencing the profitability of dairy cows than calving interval alone.

7.2 Dystocia and perinatal mortality

Dystocia means a difficult or abnormal delivery which occurs more frequently with twin births than with single births. In any calving dystocia can be due to fetopelvic disproportion, an oversized calf or a dam with incomplete development or incomplete cervical dilation. Or due to abnormal presentation of the calf. However, twin calvings have the added complication of both calves entering the birth canal at the same time. These are usually dealt with by some sort of intervention.

Multiple births can cause difficulties at parturition, if parts of more than one fetus enters the birth canal at the same time [43, 44, 45, 46, 47, 48, 49]. These abnormalities can occur when two of the fetuses are released from the uterine horns at the same time and meet in front of the pelvis [50].

The symptoms of dystocia are highly variable, since each of the fetuses may be presenting in the anterior or posterior positions with variable positioning of the head and legs [51]. Therefore, these presentation anomalies occur more regularly in twin births than in single births [28, 43, 44, 46, 47, 52, 53, 54].

The occurrence of posterior presentation in twin birth is approximately four times higher (10.7%) than in single births (2.5%) [55]. Abnormal presentation was the cause of dystocia in 15.3% of the singletons and 77.8% of the twins. However this can be easily corrected in twins due to their relatively low body weight, but nevertheless these factors still can result in stillbirths when there is a lack of observation during parturition. Obstetrical intervention was implemented in 42.2% of twin births and 20.4% of single births [28].

Some studies in the USA have demonstrated that the incidence of calving difficulty has decreased within the last number of years [26] whereas conflicting studies have shown the opposite, that it has not changed [56]. In this period of time, a gradual increase of twinning and periparturient mortality was detected [26, 56].

An analysis of the relationship between multiple births and dystocia [57] data was drawn from the SYMLEK database and providing information on 148,385 calvings of Polish Black-and-White Holstein Friesian cows. The animals used for the study first calved in 2006 and were in use or had been culled by the end of 2012. All the data was classified in accordance with the SYMLEK database. The calving ease was classified as unassisted (natural, without human intervention), easy, difficult (using much more force than normal), very difficult (surgical procedure, injury to the cow or calf, embryotomy) or caesarean section. Calf mortality was classified as: live calf (normal live calf born), dead calf (stillborn calf or calf having died within 24 hours

after birth), and the perinatal mortality. The goal being to investigate the relationship number of fetuses and gender of the fetuses on the outcome of the birth. The study found in the analyzed population there were 2.11% twin pregnancies and just 0.01% triplet pregnancies. Of the calves born. The proportion of unassisted parturitions was around 31% for single and twin births, and only 7% when triplets were born. The proportion of difficult births increased from 4.3 to 28.6%with the increasing number of fetuses. Very difficult births and caesarean sections were sporadic and occurred with similar frequency when single calves and twins were born. For single calvings out of a total number of 145,241 calvings 31.14% were unassisted, 64.35% were easy, 4.30% were difficult, 0.15% were very difficult and 0.05% required a caesarean section. For twin calvings out of a total number of 3,130 calvings 30.96% were unassisted, 63.67% were easy, 5.21% were difficult, 0.10% were very difficult and 0.06% required a caesarean section. For triplet births out of a total number of 14, 7.14% were unassisted 64.29% were easy, 28.57 were difficult with no births described as very difficult or requiring a caesarean section. Analyzing the gender ratio, most single calves were bull calves. In twin calvings, opposite sex twins were the most common, with bull calves being the least frequent. Opposite-sex calves were most common among triplets.
The mortality rate is four times higher in twin born calves due to an increased dystocia and a reduced gestation length, furthermore twin calves had a lower birth weight [6].
Perinatal mortality is also a major factor related to parturition. Twinning-associated perinatal mortality was three times higher than that of pluriparous [52]. However the number of calves born alive was higher among mothers of twins and triplets compared to mothers of single-born calves [14].

[TABLE 4]
Calving difficulty by number and gender of calves born [57]

Analysis of the results (Table 4) show that heifer calves tend to be born more easily than bull calves, however this relationship only was significant in single births ($P \leq 0.01$). In twin births, when two heifers were born they tended to be easier, whereas difficult births, very difficult births and caesarean sections tended to be more frequent when a bull and a heifer calf were born. The results show a higher perinatal mortality in twins, however even including the losses on average 1.81 live calves were produced from twin calvings compared to only 0.92 from single calvings. When analyzing calf mortalities relationship to gender, in single calvings, the number of bulls and heifers born live was similar (46%). However the percentage of stillborn bull calves was over 3 times that of heifer calves. Examination of twin births showed that the proportion of both calves being live-born was highest (39.84%) when twins were of opposite sex, and lowest (22.81%) when twin bulls were born. Perinatal mortality tended to be highest (3.19%) when twin bulls calves were born, and over twice as low when twin heifer calves were born. When opposite gender twins were born perinatal mortality was 2.65%, and when one of the calves was alive and the other was dead, heifers tended to survive more often. The proportionally small number of triplet calvings (only 14 cases) and the various gender combinations in triplets made the results difficult to interpret. Examination of the results confirms that bull calves were more likely to die perinatal than heifers, and multiple pregnancies increase calves risk of perinatal mortality. The increased calving difficulty associated with multiple births majorly increases the risk of perinatal mortality in calves. In calvings classed as very difficult, the risk of calves being born dead or dying within 24 hours after birth, increased 10-fold, independent of gender, in relation to unassisted calving.
Twin pregnancies have a higher risk of fetal death or abortion in the final months of gestation [58, 59]. The limited energy reserves and vitality of twin calves during and after pregnancy are seen as the primary reasons for the elevated proportion of stillbirths [60, 61]. The shorter intrauterine period is also thought to be a reason for the lower birth weight.
This is preventable by supplying a targeted diet with adequate nutrients to the dam in late pregnancy. Also drying cows off early when twins are expected. The rate of stillbirth in twin calves was 19.0% and 12.9% and in single calves 5.0% and 4.1% [5, 28, 62]. Two different types of embryonic death can be distinguished [18]: "independent loss" describes the phase prior to implantation and in this phase, losing one or more embryos does not affect the rest. Whereas "dependent loss" where the embryo dies after implantation. Causing a loss of all other embryos. Due to the placental anastomosis.
At parturition twin calves are at a higher risk of hypoxia if the umbilical cord becomes entangled in a leg of the other fetus [63].

7.3 Milk yield
A study in America [64] showed the effect of twin birth calving on milk production. Primiparous and multiparous cows with singletons produced more milk than cows with live twins or at least 1 dead twin (primiparous, 33.1 vs. 31.9 vs. 31.2 liters; multiparous, 36.5 vs. 35.7 vs. 35.0 liters, respectively) which is in good concordance with results of another study [41]. In

contrary to these reports mothers of twins have been shown to be superior to mothers of single calves in terms of milk yield in a third investigation [30].

7.4 Fertility and reproduction

The reproductive health of the herd is a great indicator of how a management system is working, by high-lighting the profit or losses seen financially. With dairy cattle these results can be seen from the view point of reproduction (calving interval, dry period, services per conception) and milk production (milk yield, fat- and protein %).

Ideally every farmer would like to their herd increase every year, with each cow having at least one calf, and in turn increase the milk yield with every subsequent lactation. In reality multiple births come with unwanted problems. Unfortunately more calves per cow does not automatically mean more profits seen.

From higher incidence of abortions, reduced birth weight or higher numbers of stillbirths, mastitis and problems related to dystocia. The increase in costs in the case of multiple births adds up to 40% per cow [65].

There is a higher incidence of pregnancy loss, with number of fertile heifers herd replacement [15].

Increase of calf mortality is 18% [30] and fertility of the cows was shown to deteriorate after multiple pregnancies, with the most unfavorable indicators of fertility found in triplet births [14].

Other studies show that twinning increases open days and services per conception on average and therefore decreases reproductive performance of the dam during subsequent lactations [31].

There is a longer regeneration time of the uterus and this in turn causes the elongation of the resting period after calving – these were increasing with the number of lactations, relating to twin calving and shorter gestation. This was more evident with calving in the summer period.

Cows with dead twins also had increased time to conception, compared with live twins. The natural incidence of multiple births in cattle is largely due to multiple ovulations and is around 1-5%, depending on breed, parity and environmental conditions [66].

7.5 Freemartinism

The double ovulation occurs when 2 mature follicles are released at the same time in one cycle of ovulation [21]. Adhesion of the outer layers of the amniotic sacs can occur in twin and multiple pregnancies because of their proximity. This may result in fusion of the chorion layers at which point an anastomosis of the vessels occurs in most cases leading to a union of the blood circulations of both embryo. In case of twins with different sex (bull and heifer), in 98% of all occurrences heifers are not suitable for breeding because of freemartinism [67]. Causing infertility in the female calf born with a male twin. As fertile heifer calves are far more valuable than bull calves, this is an issue on dairy farms.

7.6 Culling reasons and life span

It has been shown [14] that multiple pregnancies considerably decreased the chance of survival until the next calving and increased the culling rate. When analyzing the reasons for culling cows from the herds, it was found that multiple births gave rise to a greater proportion of cows culled due to udder diseases, infertility, reproductive diseases, old age, metabolic and gastrointestinal diseases, and diseases of the locomotor system.

The lifespan of 3,581 cows that had never had twins and 386 cows which had twins at least once were examined [39]. On average the total lifespan was 68 months. Whether or not the cows had twins had a significant impact on their lifespan ($p < 0.001$). The cows that never had twins reached on average 60 months (roughly 5 and half years old), and cows that had at least one set of twins reached on average 76 months old (roughly 6 and a half years). The difference in life expectancy between these two groups was 15.8 months (a year and 3 months approximately).

7.7 Economic outcome and selection

Losses due to the higher incidence of abortions, ketosis (subclinical or clinical), reduced birth weight or higher numbers of stillbirths, mastitis and problems related to dystocia. Multiparous cows with dead twins produced less milk than cows with live twins. Compared with dams with singleton birth, cows with twins were 0.78 times as likely to conceive and 1.42 times as likely to die or be culled. Cows with dead twins also had increased time to conception, compared with live twins [64].

This increased cost in the case of multiple births adds up to 40% per cow [65]. Elevated incidence of pregnancy loss, and reduced milk yield along with number of fertile heifers herd replacement [15].

Total losses were on average \$171 – \$63 = \$108 per twin birth. Realistic changes in input variables could not change this negative outcome to a positive result. Therefore, it was concluded that it is not profitable to select to increase the number of twins in dairy cattle [68].

Dairy cattle breeders could develop strategies to manage twinning based e.g. on ultrasonic examination of corpus luteum, and its direct use in selection. While it is obvious when cows give birth to twins it is much less obvious when cows that would have twins suffer embryonic reduction of one of their embryos. An examination [69] of 770 pregnancies showed 13 cows with 3 or more corpora lutea and 757 with 2 corpora lutea. Of those with two corpora lutea, 464 were carrying twins and 293 were carrying single calves. Subsequently 69 (23.5%) of the single pregnancies and 132 (28.4%) of the twin pregnancies lost one of the corpora lutea or one of the embryos before day 60. Of the 132 twin pregnancies, 34 (25.8%) lost a corpus luteum together with an embryo (corpus luteum reduction occurred in the ovary on the same side as the horn of the uterus that underwent embryo reduction). As dead embryos and their debris are not detectable when they die in early pregnancy this represents a "hidden rate of twinning" that we have otherwise overlooked.

There is an opportunity to change the incidence of twinning in Holstein cattle when the candidate bulls are provided with a breeding value for twinning rate [70]. With heritability at 8.71%, genetic evaluation of sires is possible [26]. Centered about a mean twinning rate of 5.02%, PTA of sires ranged from 1.6 to 8.0%. Therefore, use of sires with a low PTA for twinning rate can be expected to reduce the incidence of twins. Some increase in income can also be expected with a reduced incidence of twins [71]. From a national perspective, this translates into a cost of $55 million per year to the dairy industry in the United States; assuming 5% incidence of twins, 10 million dairy cows in the United States, and $110 less income per head.

Trying to make a profit from increasing the incidence of twinning within a herd, would be very difficult due to the time and money increase associated with twin births. The benefits of twinning cannot be capitalized on without some degree of cost, either financial or reproductive. This can be mainly seen at parturition and post-partum because of the complications associated with twin births.

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Figure 1:

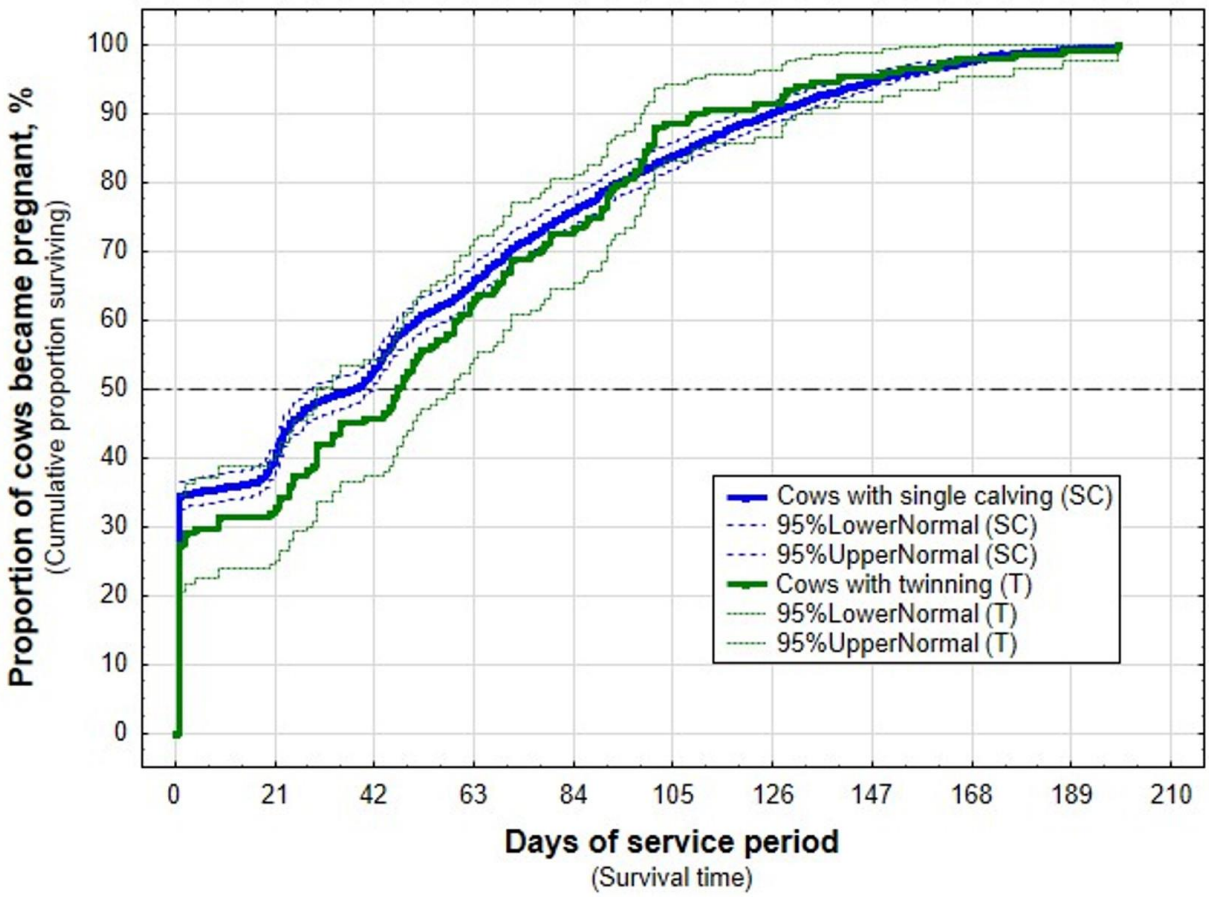

Table 1:

Multiples, %	Mean litter size (realized number of calves)	Triplet %	Quadruplet %
5	1.050	0.0	0.0
10	1.101	0.1	0.0
20	1.203	0.3	0.0
30	1.309	0.9	0.0
40	1.421	2.1	0.0
50	1.546	4.6	0.0
60	1.696	9.4	0.1
70	1.894	18.3	0.5
75	2.020	24.6	1.2

Table 2.

Reproductive traits	Cows with single calving/n	Cows with twin calving/n	p-value
Age at first breeding, month	17.88 3569	17.92 392	0.753
Age at first conception, month	18.32 3410	18.34 376	0.868
Age at first calving, month	27.45 3632	27.47 395	0.830
Calving to first service interval BF, day	73.90 6208	73.92 722	1.000
Calving to first service interval AF, day	73.59 5207	78.09 275	0.043
Open days BF	109.3 5318	104.6 642	0.047
Open days AF	109.3 5207	123.1 275	0.001
Gestation period BF, day	278.7 9940	274.0 724	<0.001
Gestation period AF, day	278.8 5207	279.0 275	0.511
Calving interval BF, day	404.2 5698	392.2 680	<0.001
Calving interval AF, day	397.5 5207	410.3 275	<0.001
Total life span, month	60.12 3581	75.97 386	<0.001

Table 3

Reasons for culling	Proportion of production cycles interrupted due to Selling or curling depending on type of pregnancy	
	Single pregnancy (%)	Multiple pregnancy (%)
Production cycles interrupted due to selling or culling (n, %)	20548 (27.74%)	458 (40.71%)
Sold for further breeding	13.81	9.61
Low yield	3.82	2.62
Udder diseases	11.83	13.54
Fertility and reproductive diseases	34.58	37.99
Infectious diseases (leukaemia)	2.79	1.97
Old age	1.09	1.31
Metabolic and digestive diseases	2.06	3.93
Respiratory diseases	0.12	0.00
Diseases of the locomotor system	3.22	4.37
Accidents	21.27	17.25
Other	5.14	7.42

Table 4:

Type of birth	Sex of calf		Parturition				
		n	unassisted	easy	difficult	very difficult	Cesarian section
Single chi^2=1243.78 P<0.01	heifer bull	69789 75452	34.9 27.67	61.88 66.63	3.12 5.4	0.09 0.22	0.02 0.09
Twin chi^2= 13.54	heifer+heifer bull+bull heifer+bull	872 841 1417	28.78 30.68 32.46	67.2 64.09 71.26	3.9 5.23 6	0.11 0 0.14	0 0 0.14
Triplet chi^2=3.61	3 heifers 3 bulls bulls+heifers	3 3 8	0 0 12.5	33.33 66.67 75.00	66.67 33.33 12.5	0 0 0	0 0 0