Effects of main reproductive and health problems on the performance of dairy cows: a review

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Abstract

This review focuses on the potential effects of twinning, dystocia, stillbirth, abortion, retained placenta and metritis on the productive and reproductive performances in dairy cattle. These are diverse disorders that are similar in that they all can result in impaired performance of dairy cows. Reproductive problems occur frequently in lactating dairy cows and can dramatically affect reproductive efficiency in a dairy herd. Poor reproductive performance is a major cause of involuntary culling and therefore reduces the opportunity for voluntary culling and has a negative influence on the subsequent productivity of a dairy herd. Reproductive performance is influenced by the interactive effect of environment, management, health, and genetic factors. In addition, diseases mainly affect dairy cow productivity by decreasing reproductive efficiency, shortening the expected length of productive life and by lowering milk production. Deciding whether to breed, treat, or cull dairy cows showing one or more of these problems is a challenge for both veterinarians and dairy producers. In addition, there is considerable debate among dairy scientists and bovine practitioners regarding the economic impact of these problems in a dairy operation and the most effective management or therapeutic intervention for treating them. Because of this controversy, dairy managers should focus on prevention and control of risk factors associated with each problem rather than on prescriptive therapeutic interventions.

Additional key words: dairy cow; diseases; reproductive disorders; productive performance; reproductive performance.

Introduction

Reproductive efficiency is a critical component of a successful dairy operation and acts as an important component of a profitable dairy farm, whereas reproductive inefficiency is one of the most costly problems facing the dairy industry today. Reproductive problems occur frequently in lactating dairy cows and can dramatically affect reproductive efficiency in a dairy herd. Some of the most common problems include twinning, dystocia, abortion, stillbirth, retained placenta and metritis. These are diverse disorders that are similar in that they all can result in impaired reproductive function. Deciding whether to breed, treat, or cull dairy cows exhibiting one or more of these reproductive problems is a challenge for both veterinarians and dairy producers. In addition, there is considerable controversy among dairy scientists and bovine practitioners regarding the economic impact of these problems in a dairy operation and the most effective management or therapeutic intervention for treating them. Because of this controversy, dairy managers should focus on prevention and control of risk factors associated with each problem rather than on prescriptive therapeutic interventions. Dairy producers should work closely with their herd veterinarian to develop such management strategies and discuss appropriate interventions when necessary (Fricke, 2001).

Low fertility reduces the profit by decreasing the average milk production and the number of calves per cow per year. Poor reproductive performance is a major cause of involuntary culling and therefore reduces the...
opportunity for voluntary culling and has a negative effect on the future productivity of a dairy herd. Reproductive performance is influenced by the interactive effect of environment, management, health, and genetic factors (Gröhn & Rajala-Schultz, 2000; Roxström et al., 2001).

Parturition is intimately interlocked with lactogenesis in all mammals. In dairy cows, it marks the start of the lactation and therefore the beginning of the productive cycle and is essential to the long-term sustainability of the farm. However, it is also a high-risk time for both mother and offspring leading to high veterinary and labor costs for the dairy cattle industry when complications occur. While complex physiological changes are occurring in the mother, the offspring has to make the transition from fetal life to extra-uterine life which can prove to be challenging. Parturition in cattle is a complex process that is triggered by the fetus and managed by a cascade of hormonal actions and physiological changes (Senger, 2003). Therefore, it seems logical that when complications occur, this has potential effect on normal bodily functions. It also provides newborn heifers that will become future lactating animals. Calvings are therefore sources of short and long-term income to producers.

The transition period is generally recognized as the most critical period of the lactation cycle for a dairy cow. The endocrine and physiological changes that accompany parturition and the onset of milk production negatively affect immune function and dry matter intake (DMI). As a result of nutrient demand for milk production increasing faster than DMI, cows experience a period of negative energy balance of varying duration and intensity. Early lactation is also a critical time for metabolic disorders, of which most occur during the first 2 wk postpartum (Goff & Horst, 1997). The extent of negative energy balance is related to the incidence and severity of most metabolic disorders, such as ketosis, displaced abomasum, retained placenta, and susceptibility to infections (Grummer et al., 2004). In addition, improved energy balance has been proven to result in greater reproductive efficiency through earlier resumption of ovulatory cycles (Butler, 2005). Early resumption of cycles is important because conception rates increase with successive cycles (reviewed by Butler, 2003). Enhancing nutrient intake seems, therefore, imperative to maximize health and reproduction of periparturient cows.

This review addresses the possible consequences of some reproductive and health problems (twinning, dystocia, stillbirth, abortion, retained placenta and metritis) on the subsequent performance of dairy cows.

**Twinning**

Cattle (*Bos taurus*) are uniparous species meaning that, in most cases, females produce only one offspring per pregnancy (Komisarek & Dorynek, 2002). Twinning occurs relatively rarely, with the frequency generally not exceeding 1% in most beef herds. However, in dairy herds, the incidence of twin births is higher (on average 3 to 5%), and is strongly affected by age and parity of the dam (Day et al., 1995; Komisarek & Dorynek, 2002; Silva del Río et al., 2007; Ghavi Hossein-Zadeh et al., 2008, 2009). Ghavi Hossein-Zadeh et al. (2008) reported parity of dam, season of calving and previous incidence of twinning were potential risk factors for twinning in dairy cows.

The incidence of double births may have both positive and negative effects, which mainly depends on the purpose for which cattle are raised (Komisarek & Dorynek, 2002). A beef cow can wean more total calf weight by raising twins. Twin births offer the potential for increased beef production efficiency, if sustainable changes in management can be made to accommodate problems inherent with twinning (Kirkpatrick, 2002). In addition, increased frequency of twinning would increase the potential for obtaining more progeny from a genetically-superior female, thereby allowing those females to play a larger role in a selection program (Cady & Van Vleck, 1978). The importance of this condition can be expressed along with the application of technologies controlling the sex of calves. In the other words, the use of embryo technologies and sexed semen leads to significantly more female calves (Ghavi Hossein-Zadeh et al., 2010, 2011). This allows dairy producers to select among their herd’s potential dams and produce dairy replacement heifers from only the genetically superior animals and promotes enhanced rates of genetic gains (De Vries et al., 2008). However, most authors today would agree that twin pregnancies are undesirable in a dairy herd (Bicalho et al., 2007; Lópex-Gatius et al., 2009; Andreu-Vázquez et al., 2012). However, twin birth is disadvantageous for most beef and dairy producers because of its association with a number of unfavorable effects, including lower potential calf survival, increased culling rate and poorer cow reproductive performance (Fricke, 2001; Bell & Roberts, 2007; Ghavi Hossein-Zadeh et al., 2008).
The risk of pregnancy loss increases and the profitability of the herd diminishes drastically as the frequency of twin births increases (López-Gatius et al., 2002; López-Gatius & Hunter, 2005). One impact of twinning is a reported reduction in the number of fertile heifers available for use as replacements in the dairy herd. This decrease arises from increased neonatal calf mortality of twins and a skewed gender ratio resulting in more homozygous male pairs (Fricke, 2001). Regarding cow performance, twinning is associated with increased dystocia (Ghavi Hossein-Zadeh, 2010b), increased incidence of retained placenta, higher mortality rates, frequent occurrence of freemartins and longer interval from parturition to first estrous (Kirkpatrick, 2002; Echternkamp et al., 2007; Silva del Río et al., 2007). Freemartinism in heifers results from twinning when embryonic membranes of a male and female conceptus fuse during gestation resulting in exchange of blood between the male and female fetuses. Endocrine factors or cells from the male calf cause abnormal development of the reproductive organs of the female calf resulting in infertility. Freemartinism occurs in about 92% of heifers born as a result of heterosexual twin pregnancies (Buoen et al., 1992). Thus, about 8% of heifers from heterosexual twin pregnancies will be fertile, presumably because the fetal membranes fail to fuse or because membrane fusion occurs after the critical period of reproductive organ differentiation (Buoen et al., 1992). Dystocia with twins resulted likely from abnormal presentation of head and (or) legs for one or both twin fetuses at parturition. The increased incidence of fetal malpresentation with twins may result from the higher circulating concentrations of progesterone and estradiol found in cows gestating multiple fetuses (Echternkamp, 1992). Also, cows calving twins are at greater risk for metabolic disorders including displaced abomasum, and ketosis (Fricke, 2001). The presence of twins has been described as the main negative factor of a noninfectious nature affecting pregnancy maintenance (López-Gatius et al., 2002, 2009; López-Gatius & García-Ispierto, 2010). For example, the risk of pregnancy loss during the first trimester of gestation for cows carrying twins is three to nine times higher than for cows carrying singletons (López-Gatius et al., 2002, 2009; López-Gatius & García-Ispierto, 2010). Higher milk production related to twinning is controversial (Beerepoot et al., 1992; Bicalho et al., 2007; Ghavi Hossein-Zadeh, 2010b), and this possible benefit will never outweigh the higher incidence of dystocia, stillbirths, and retained placenta (Beerepoot et al., 1992; Echternkamp & Gregory, 1999). Wiltbank et al. (2000) proposed that high milk production increases steroid metabolism as a result of an increased blood flow to the digestive tract and the liver. The subsequent metabolism of the steroid estradiol slows down the natural decline in follicle-stimulating hormone (FSH), which means that follicles have more time to undergo physiological changes before ovulation (Wiltbank et al., 2000). The practical implication of the relationship between milk production and twinning in dairy cattle is important because current dairy-management strategies aim to maximize milk production per cow in the dairy industry. If twinning is related to milk production, this increase would not be unexpected considering the increases in milk production per cow over the years as a result of genetic selection and artificial insemination. Other studies reported a negative association or non-association between milk production and twinning in dairy cattle (Deluyker et al., 1991; Bell & Roberts, 2007). A possible explanation for reduction in milk production after twin calvings was probably due to increase in the incidences of metabolic disorders experienced by cows calving twins during the early stages of lactation. In effect, longer calving to conception intervals and higher culling rates have been reported for cows delivering twins compared with cows delivering singletons (Bicalho et al., 2007). The interval from calving to conception (days open) is a summary measure that is influenced by several factors (i.e., voluntary waiting period, estrus detection rate, conception rate) such that it is an intermediate factor and should not be considered a control point in the management of the incidence of twins. A hypothesis as to how the interval from conception to diagnosis of pregnancy may be associated with the risk of twinning is that twin pregnancies may be more fragile and both pregnancies may be lost if cows are palpated earlier. Under this hypothesis, a positive association between twinning rate and the length of this association would be found because cows pregnant with twins and palpated earlier would be more likely to abort. It is now clear that twin pregnancies reduce herd profitability. The real economic impacts of twinning are probably on the rise because twinning rates have increased considerably over the past 20 yr and estimates currently run at 9%, or even 12% in some herds (Silva del Río et al., 2007). Ghavi Hossein-Zadeh (2010b) observed twins had the lower birth weight than singletons. The reduction in
Dystocia

Dystocia, more commonly known as difficult calving and defined as prolonged or difficult parturition, is a problem most dairy producers encounter (Mee, 2004, 2008a). There is a wide range of definitions for dystocia ranging from need for assistance to considerable force or surgery to extract the newborn (Mee, 2008a). There are several ways to assess difficulty at parturition (also referred to as calving ease in cattle). Categorical scoring scales that allow for different degrees of difficulty are commonly used across species with ordinal scales with 3 to 5 rating points being popular in cattle (Mee, 2008a). Lower scores are usually given to the easiest births (also called eutocial) and highest scores to the most difficult ones. For example, in the Iran, dystocia evaluations in the Holstein Friesian breed are currently performed using the following 5 point scale: 1 = unassisted, score 2 = slight assistance, score 3 = considerable assistance, score 4 = considerable force needed, and score 5 = caesarian (Ghavi Hossein-Zadeh, 2010). On the other hand, in the UK, genetic evaluations in the Holstein Friesian breed are currently performed using the following 4 point scale: “1 = easy; 2 = assisted; 3 = difficult; 4 = vet assisted” (Eaglen et al., 2011). Because definitions of dystocia vary in the literature, it is not surprising that there is variation in the international prevalence rates of calving difficulty. Internationally, reported prevalence in dairy cattle of severe or considerable difficulty in calving vary from just below 2% to over 22%. However, assistance at calving (including lower degrees of difficulties) is much more prevalent, varying from 10% to over half of the calvings (Mee, 2008a). The evaluation of costs associated with dystocia scores enables dairy producers to predict the average future economic loss when an incident of dystocia is reported in the herd, allowing the producer to evaluate the relative importance of dystocia in individual herds. By realizing the importance of dystocia in a herd, a producer can take appropriate measures to maximize profit, such as selecting sires for calving ease for heifer matings (Dematawewa & Berger, 1997). Dematawewa & Berger (1997) concluded the use of sires that were selected for calving ease for heifer matings could improve economic gains considerably. The total economic costs attributable to a severe case of dystocia have recently been estimated at up to €500 per case (McGuirk et al., 2007).

There are different causes and risk factors associated with dystocia in dairy cattle which can result from both maternal and foetal factors. The most common reason for dystocia results from a physical incompatibility between the pelvic size of the mother and the size of the calf at birth, also called foeto-pelvic incompatibility (or FPI) (Meijering, 1984; Mee, 2008a). This is largely influenced by the weight and morphology of the dam and the calf, respectively. The pelvic area available at birth is affected by the size of pelvis but also by fatness of the dam which might partially obstruct the birth canal. The calf’s physical factors contributing to size mismatch between the calf and the dam may include a calf of a big size or malpresentation. These morphological factors are themselves dependent upon different variables including the age, breed and parity of the dam, twinning, the sex and weight of the calf, the sire and breed of the calf as well as the nutrition of the dam during gestation (Meijering, 1984; Hickson et al., 2006; Mee, 2008a; Zaborski et al., 2009; Ghavi Hossein-Zadeh, 2010b). Dams with low calving weight as well as abnormally low or high body condition score can result in difficulty at parturition as well (Philipsson, 1976b). Adequate body condition score at calving for both primiparous and multiparous dams (BCS of 2.5 to 3, when assessed on a 5 point scale) ensures optimization of ease of delivery and subsequent performance. Primiparous cows are known to have greater risk of difficulty than multiparous cows (Ghavi Hossein-Zadeh, 2010b; Gaafar et al., 2011), partly because of their smaller size and pelvic size. It is recommended that first calving takes place between 22 to 24 months of age to optimize subsequent performance and ease of delivery (Le Cozler et al., 2008; Berry & Cromie, 2009). In order to avoid cases of FPI, it is particularly important for the animal caretaker to mate primiparous animals with bulls that are not expected to sire very large calves. This can be achieved by making an informed choice on their genetic potential for their expected ease of calving. Even if FPI is the major reason leading to difficulty at calving, dystocia can result from other causes that interfere with the expulsive forces needed to expel the calf. This includes: lack of uterine contractions (weak labour), incomplete dilation of the cervix and vagina due to stenosis (narrowing and stiffening of the tissue) and
uterine torsion. Risk factors for weak labor include hormonal imbalances such as reduction in plasmatic oestradiol concentration, high levels of oestradiol-17β at parturition (Sorge et al., 2008) or high ratios of cortisol to progesterone. These imbalances can decrease expression of oxytocin receptors in the uterus as well as changing the preparation of the soft tissues, causing weak uterine contractions and weak dilatation of soft tissues (Sorge et al., 2008). Calving difficulty has a genetic underlying component certainly because many factors that are accounting for FPI are also under genetic control. The genetics of calving difficulty are complex because it is a combination of both maternal effects (also called grandsire effects) and effects from the sire of the calf (also called sire effect or direct effect) (Meijering, 1984). Thus, the sire of the calf partly explains the birth weight of the calf and its morphology. Additionally, variables such as the pelvic size of the dam, the length of gestation and calving weight result partly from the dam’s sire. The heritability of calving difficulty (which means the probability of transmission to the following generation) is quite low with estimates of both direct and maternal heritabilities being estimated between 0.03 and 0.20 (Meijering, 1984) but mostly reported below 0.12 in dairy cattle (e.g. Steinbock et al., 2003; Eaglen & Bijma, 2009; Eaglen et al., 2010a) and in beef cattle (Bennett & Gregory, 2001; Eriksson et al., 2004). There are negative correlations between direct and maternal effects (Philipsson, 1976a), which means that genetically, a heifer prone to be born easily will be more likely to have difficulty when she calves herself. It is therefore challenging to find the right balance between the ease with which a cow calves and with which her female offspring will herself calve when she reaches adulthood. This result is also controversial and has not been found consistently across populations (Eaglen & Bijma, 2009). High genetic correlations are also observed for calving difficulty between first and later parities (Carnier et al., 2000; Eriksson et al., 2004). This means that similar genes and mechanisms may be involved in both parity levels and that some cows may be more genetically predisposed to dystocia. However, the heritable variance explains only 10% of the phenotypic variance (Eaglen & Bijma, 2009). As a consequence, although selection against difficult calving is possible and should be encouraged, non-genetic factors (called environmental factors) are also of great importance in the implementation of preventive measures against dystocia (Barrier, 2012).

In the most severe cases, dystocia can lead to the death of the cow, usually occurring within 48 hr (Dobson et al., 2008). Even beyond those 48 hr, cows that have experienced dystocia are more likely to die or be culled in early lactation and over the lactating period (Dematawewa & Berger, 1997; Tenhagen et al., 2007; López de Maturana et al., 2007b; De Vries et al., 2010). Furthermore, the fear that the animal might experience difficulty at her next parturition may increase weight to the farmer’s decision to cull a dystocia cow. Cows experiencing difficulty at birth are more likely to suffer from postpartum diseases such as metritis, retained placenta and milk fever (Benzaquen et al., 2007). This could be explained by the possibility of microbial contamination during assistance (Dohmen et al., 2000) combined with a depressed immune status during the peripartum period. This highlights the importance of good hygiene when intervention at calving is required. Immunodeficiency is probably enhanced in dystocia cows as a consequence of the increased duration of labour and the subsequent higher cortisol levels (Civelek et al., 2008). Nakao & Grunert (1990) studied the adrenocortical function of beef cows through adrenocorticotropic hormone (ACTH) challenge postpartum for different degrees of calving difficulty. They found higher reactivity of the hypothalamic-pituitary-adrenal axis for cows having experienced severe dystocia. They suggest that this could increase the susceptibility of the uterus to infection through the anti-inflammatory action of corticosteroids. As well, this might be responsible for causing temporary metabolic disturbances in cows and delaying ovarian recovery and uterine involution. As hormones involved in reproductive function closely interact with hypothalamic-pituitary-adrenal axis regulation, this can be related to impaired fertility. In fact, a prolonged second stage of labour resulted in depressed reproductive performance in both beef and dairy cattle (Dobson et al., 2001). An increase in the number of days open, the number of services to conception and a delay to first service has been shown after dystocia (Dobson et al., 2001; López de Maturana et al., 2007a). This impaired fertility after dystocia is thought to contribute to 30% of the cow related costs of dystocia (Dematawewa & Berger, 1997).

It has been shown that calving difficulty reduces milk yield in the cow. It is not clear however, how long the adverse effect on milk production lasts for. In fact, although some authors seem to find a deleterious effect on the overall lactation of cows (Dematawewa &
Berger, 1997; Ghavi Hossein-Zadeh, 2013), some studies have suggested that these effects disappear beyond 14 days in milk (DIM) (Rajala & Gröhn, 1998), 90 DIM (Thompson et al., 1983) or six month postpartum (Tenhagen et al., 2007). Furthermore, the degree of difficulty from which milk losses are reported ranges from slight degrees of difficulty (Dematawewa et al., 2003) up to only in severe cases when surgery is needed (Tenhagen et al., 2007). Additionally, the magnitude of losses has been suggested to be greater with increasing degrees of difficulty (Dematawewa & Berger, 1997). However, the pattern with which milk losses vary is not always obvious and other factors such as the overall yield or parity of the cow (Rajala & Gröhn, 1998) might influence it. As well, it is common for studies looking at milk production losses after a difficult calving to restrain their datasets to animals with full lactations or that have survived until a certain lactation stage.

During the lactating period, dry matter intake was shown to decrease in cows that had experienced dystocia in the months postpartum (Bareille et al., 2003) compared to cows that calved normally, but this was not seen in the first two days postpartum (Proudfoot et al., 2009). This could relate to lower milk production observed in dystocial animals but also to the greater losses in weight and body condition score found in dystocial cows during their subsequent lactation (Berry et al., 2007). According to the authors, this may be related to changes in the metabolic function and lower immunocompetency in these animals (Barrier, 2012). To that extent, the experience of dystocia in Holstein dairy cows is also associated with haematological changes at delivery relating to hepatic function. For example, dystocial Holstein heifers had higher cortisol, cholesterol, glucose, high density lipoprotein (HDL), triglycerides, creatinine and vitamin A levels than eutocial animals, which might reflect higher calving stress in these animals (Civelek et al., 2008). It is possible that such stress but also exhaustion, pain and human intervention during delivery may contribute to reduced or delayed maternal care of the calves in the first hours postpartum, as observed in ewes (Dwyer et al., 2001; Fisher & Mellor, 2002).

At birth, having to make the transition from foetal life to extra-uterine life is a challenging experience in mammals. Animals born from difficult births are more likely to fail that transition and become stillborn or die within the few days of life (Meyer et al., 2001; Johanson & Berger, 2003; Berglund et al., 2003; Eriksson et al., 2004). Within the group of calves that die perinatally, 90% would be alive at the start of the calving process and three quarters of the deaths occur within an hour of birth (Mee, 2008b,c), thus emphasizing how critical the birth process and early hours of life can be. Dystocial stillbirths usually result from internal and external trauma (Berglund et al., 2003; Aksoy et al., 2009) but also from prolonged hypoxia (deprivation of adequate oxygen supply) (Meijering, 1984; Mee, 2008c). There are also concerns about the beef and dairy calves that survive the birth process. Indeed, survival is not just compromised in the perinatal period but there is also evidence that their survival can be affected in the neonatal period (Lombard et al., 2007) and for their lifetime for the more severe degrees of difficulty (Henderson et al., 2011). In the neonatal period, severe hypoxia and acidosis (Alonso-Spilsbury et al., 2005; Civelek et al., 2008), impaired breathing (Breazile et al., 1988) and internal injuries (Berglund et al., 2003; Gundelach et al., 2009; Mee, 2010) may contribute to low vigour (Riley et al., 2004) and subsequent poor survival. Additionally, dystocial calves may not thermoregulate properly (Bellows & Lammoglia, 2000) and achieve lower passive immunity. This may relate to higher morbidity (Steenholdt & Hernández, 2004; Lombard et al., 2007) and possibly altered growth (Goonewardene et al., 2003). Furthermore, it is likely that the experience of difficulty at birth may have long-term effects on heifer calves. It is well-known that the early life experiences can have long-term implications for the performance, cognition, health and welfare of the individuals among diverse species including ruminants and cattle (Vinuela-Fernández et al., 2007). Recently, evidence has emerged from retrospective studies that dystocia could also have potentially long-term effects on dairy heifers. Reduction in survival rates and milk production were seen when they reach an adult age (Eaglen et al., 2010b; Heinrichs & Heinrichs, 2011; Henderson et al., 2011). There are many potential threats to achieving good standards of welfare for the dam and her calf (or calves) after a difficult calving. These include pain during parturition as a result of calving injuries, painful health conditions, injuries at birth but also distress following poor health, breathlessness, hypoxia and potential hypothermia. These in turn might result in poor production and survival. Possible long-term alteration of the development of the dairy calves following birth difficulty is also likely (Barrier, 2012).
Abortion

Abortion in dairy cattle is commonly defined as a loss of the fetus between the age of 42 days and approximately 260 days (Peter, 2000). The diagnosis of abortions often presents a challenge to the herd owner and the herd veterinarian. Although a gradual increase in the abortion rate in a herd may be noted over a period of many years, a sudden and dramatic increase is more commonly seen. For this reason, prompt and thorough action is required when abortions do occur. Well kept records will often be of benefit during the investigation of abortion problems. Breeding dates, parity, productive records will often be of benefit during the investigation for the dairymen and their veterinarians. Expect that only 30-50% of submissions to veterinary diagnostic laboratories will yield a definitive diagnosis. Most dairies experience an observable abortion rate of from 2-5% yearly. Despite ongoing research investigations to diagnose and evaluate the epidemiology of infectious factors that cause abortion, breeders are still confronted with abortion continuously. Hovingh (2009) listed numerous causes of abortion: infectious agents (bacteria, viruses, protozoa, and fungi), toxic agents, heat stress, and genetic abnormalities. Twin pregnancies (Nielen et al., 1989) and mastitis (Santos et al., 2003) have also been implicated. Infectious agents are the most commonly diagnosed cause. Jamaluddin et al. (1996) examined 595 abortion submissions in California and found that infectious agents accounted for 37.1%; noninfectious agents, 5.5%; and undetermined causes, 57.3%. Among the 37.1% due to infectious agents, bacteria accounted for 18.0%; protozoa, 14.6%; viruses, 3.2%; and fungi, 1.3%. In Canada, Khodakaram-Tafti & Ikede (2005) indicated that the three most common identifiable infectious agents were bacterial (24%), fungal (7%), and viral (6%). Several recessives detrimental to reproductive performance have been confirmed and documented for several dairy breeds. An example of a genetic abnormality that causes abortion is the complex vertebral malformation (CVM) gene in Holsteins (Agerholm et al., 2001). The CVM gene causes malformations in middle to late gestation. However, most of these infectious factors have been brought under control by appropriate vaccination. Moreover, successful etiology diagnosis of abortion shows less than half of the fetal death (Geoffrey et al., 1992; Markusfeld-Nir, 1997; Thurmond et al., 2005). Non-infectious factors include genetic and non-genetic disorders that have been reported in some investigations. Heat stress, production stress, and other unfavorable conditions including seasonal effect and season changes, especially summer are the most important non-genetic factors (Labernia et al., 1996; Markusfeld-Nir, 1997; Hansen, 2002; López-Gatious et al., 2002; Bitaraf Sani & Amanloo, 2007). Genetic disorders include chromosomal and single gene disorders. Contrary to human chromosomal disorders, which result in about 50% abortion, in farm animals the rate is lower, but a sterile calf can result (Geoffrey et al., 1992).
Mutation in codon 405 of the uridine monophosphate
synthase (UMPS) gene is the putative example of single
gene disorders (Fries & Ruvinsky, 1999). Different
non-infectious maternal and paternal factors have been
reported for fetal death; for example cow parity (Lee
& Hwa Kim, 2007), sire effect (Markusfeld-Nir, 1997),
age at conception (Thurmond et al., 1990, 2005;
Hanson et al., 2003), and abortion history (Hanson et
al., 2003; Thurmond et al., 2005). In a study on Iranian
Holsteins, Ghavi Hossein-Zadeh & Ardalan (2011a)
reported normal-calved cows had greater 305-d milk
production, fat yield and protein yield of milk than
abortive-calved cows. But abortive-calved cows had
the greater milk fat percentage than normal calved
cows. Also, they observed that the risk of abortion was
higher at the 5th month of pregnancy for parities 1 and
2, but this risk was greater at the 4th month of pregnancy
for cows in their third parity or beyond. Thurmond
et al. (1990) reported the greatest risk of fetal loss is
during the first trimester of gestation and then pro-
gressively decreases as gestation advances with a slight
increase in the risk toward the last month of gestation.
Forar et al. (1996) reported the cumulative incidence
of fetal loss between 31 and 260 days of gestation is
10.8%. Of this only 20% of the fetal losses are detected
by observation of an expelled fetus or fetal membranes
and the proportion detected increases with increasing
gestational age at time of fetal loss. Thurmond et al.
(2005) reported the predicted probability of abortion
increased with increasing dam age at conception, with
increasing number of previous abortions, and if the
previous pregnancy was aborted > 60 days in gestation.
Also the predicted probability of abortion decreased
with increasing number of days open.

Continued increases in milk production over the last
two decades in dairy herds have been concurrent with
an increase in abortion rate over the years so that Ghavi
Hossein-Zadeh et al. (2008) reported there was increas-
ing trend for the odds of abortion over the years in
Iranian Holsteins. Also, they observed that greater odds
of abortion existed for singleton births and cows in
their fourth and greater lactations than other parities.
Previous studies reported the greater abortion rates for
twin calves than singleton calves (Guerra-Martinez et
al., 1990; Day et al., 1995; Echternkamp & Gregory,
1999), but Mee (1991) reported the abortion frequen-
cies being 1.81% and 1.20% for single and twin births,
respectively. Bartels et al. (2006) reported 0.72 kg d⁻¹
decrease in milk production during the first 100 days
of lactation in the first year after the abortion epidemic
in Dutch dairy herds. Hanson et al. (2003) and Thur-
mond et al. (2005) observed the higher number of days
open decreases the risk of abortion. Uterine involution
in cows due to previous pregnancy’s outcome (success-
ful parturition, dystocia, retained placenta and abortion)
is different. Inhospitable uterine environment seen in dairy cows as a result of common problems such as
endometritis and retained placenta increase the risk
of abortion (Hanson et al., 2003). Additionally, in the
first two to three months of production cows are faced
with negative energy balance, especially those with
high milk yield (Ghorbani & Asadi-Alamoti, 2004).
They lose weight during this period which can cause
a reduction in body condition score with a correspon-
ding negative correlation with progesterone secretion,
harmful to fetal survival (Grimard et al., 2006). Abor-
ted cows are at 3.2 times higher risk of being culled;
however, only 1 out of 6 are recorded as “culled for
abortion”. Aborted cows if not culled have 5 times
more likely to abort subsequently than cows that never
aborted. If one calculates the conception to conception
interval, it is 173 days on an average. On average it
takes 72 days for a cow to conceive after an abortion,
however, there is a gestation age effect. As gestational
age increased, time to rebreed increased. In the first
trimester abortion it took 54 days to rebreed and 85
days in the second semester abortion and 116 days in
the third semester abortion. The basis of cost estima-
tion is to determine the number of days open plus the
gestational days at the time of abortion. It can range
from 150 to 225 days or more for a herd. Cost of open
day estimate can be used to obtain the loss and inclu-
sion of veterinary intervention and medication can pro-
vide the total loss due to abortion (Peter, 2000).

Stillbirth

Stillbirth was defined as a calf loss from day 260
until the end of normal gestation period. Trait defi-
nitions vary slightly between countries, with most
defining stillbirths as those calves born dead or dying
within 24 h of parturition (Philipsson et al., 1979),
although Germany and the United States include deaths
within 48 h of birth (Berger et al., 1998). Breed diffe-
rences play a role in perinatal mortality (Philipsson,
1976b), and Rossoni et al. (2005) reported that 10%
of Italian Brown Swiss calves did not suckle by the
third meal offered postpartum, contributing to increased
postnatal mortality. Incidence rates and heritabi-
lities were similar when comparing parities across countries despite differences in trait definition, with the exception of Sweden (Steinbock et al., 2003). The overall incidence of calf stillbirth in Holstein cows of Iran was reported to be 4.9% and varied among herds from 2.9 to 9.8% (Ghavi Hossein-Zadeh et al., 2008). The incidence of stillbirth parturition in dairy cows seems to have increased in recent years (Meyer et al., 2000, 2001; Hansen et al., 2004; Bicalho et al., 2007; Ghavi Hossein-Zadeh et al., 2008). During the past 20 years an increase from about 6 to 10.3% has occurred in the incidence of stillbirth in the USA (Berglund et al., 2001). Meyer et al. (2001) reported the percentage of stillborn calves in primiparous cows increased from 9.5% in 1985 to 13.2% in 1996 and increased from 5.0% to 6.6% from 1985 to 1996 for multiparous cows. Hansen et al. (2004) reported the overall frequency of stillbirth in Danish Holsteins increased from 0.071 to 0.090 during 1985 to 2002. The great variation in the incidence of stillbirth by farm suggests that management practices (breeding, genetic selection, husbandry, etc.) adopted by individual farms may influence the incidence of stillborn calves (Bicalho et al., 2008). Ghavi Hossein-Zadeh et al. (2008) observed greater odds of stillbirth existed for calves born from primiparous cows than from multiparous cows and for calves born as twins than singletons. Hansen et al. (2004) cited that the higher incidence of stillbirth in first-parity cows was due to the disproportion between the size of the calf and the dam’s pelvis, which caused difficult calvings. Meyer et al. (2000) reported that calving difficulty, gestation length of 15 to 12 d below the mean, and male calves were important risk factors for stillbirth. Bicalho et al. (2007) and Meyer et al. (2001) reported a significant decreasing trend in the incidence of stillbirth by parity in Holstein dairy cows. Also, different studies indicated that male calves had significantly more stillbirths than heifer calves (Mee, 1991; Heins et al., 2006; Ghavi Hossein-Zadeh et al., 2008). This effect is probably due to greater body size of male calves than female ones at birth. The economic loss due to lost calves increased from 1985 to 1996 due to the increase in incidence of stillbirths from 9.5 to 13.2% in primiparous and 5.0 to 6.6% in multiparous cows (Meyer et al., 2001). The economic loss is even greater if the detrimental effects of stillbirth on the dam’s lactation performance are considered. Stillbirths were associated with increased risk of developing metritis and retained placenta (Emanuelson et al., 1993), and with decreased risk of conception (Maizon et al., 2004). Stevenson & Call (1988) reported that cows experiencing stillbirths were at increased risk for a number of postpartum disorders such as prolapsed uterus, retained placenta, metritis, and displaced abomasum. Correa et al. (1993) also reported increased odds of developing metritis and retained placenta for cows that had stillbirth. It is possible that the higher incidence of postpartum disorders may decrease the survival of cows that had stillbirths. Also, it is likely that the dead calf inside the uterus is accelerating intrauterine bacterial growth which would cause metritis. Furthermore, retained placenta and metritis have been associated with decreased milk yields. Bicalho et al. (2007) observed that cows with stillbirth were at a 41% increased hazard to die or to be culled from the herd than cows without stillbirth. Analyzing a large data set from the Quebec Dairy Herd Analysis Service, Mangurkar et al. (1984) reported that perinatal deaths led to higher culling rates due to lower milk production and impaired reproductive performance when compared to normal calvings. Few studies have attempted to determine the effects of stillbirth calvings on the dam’s subsequent survival and days open. Mangurkar et al. (1984), using a mixed linear model statistical procedure, reported that cows that gave birth to stillborn calves had increased risk of being culled and less chance of getting pregnant. Bicalho et al. (2007) reported stillbirths significantly increased the risk of death/culling throughout the lactation. Cows that gave birth to stillborn calves had a 40.9% higher hazard rate of death/culling compared with cows that gave birth to live calves. Mangurkar et al. (1984) reported a milk loss from perinatal deaths of 100-400 kg of milk, 4-11.5 kg of fat, and 2.5-13 kg of protein. Bicalho et al. (2008) estimated daily milk loss was 1.1 kg which is equivalent to 335.5 kg for a 305-day lactation. A review of the literature by Fourichon et al. (1999), reported that out of the five publications reviewed two papers reported no effect, and three papers reported a detrimental effect of stillbirth calvings on milk production. Milk losses attributed to stillbirth calvings were much higher in the beginning of the lactation and by the 9th month of lactation there was little apparent milk loss (Bicalho et al., 2008). Atashi (2011) concluded that stillbirth significantly decreased milk and fat yields in Iranian Holsteins (loss of 591.43 ± 69.19 kg milk and 13.77 ± 2.57 kg fat per cow per lactation). The biology of how stillbirth calvings may affect milk production is thus far unknown. As mentioned by Mangurkar et al. (1984), it is possible that stillbirth initiates a cascade
Retained placenta and metritis

Diseases mainly affect dairy cow productivity in three ways: 1) by reducing reproductive efficiency, 2) by shortening the expected length of productive life \((i.e., \text{by increasing culling risk})\), and 3) by lowering milk yield \((\text{Rajala & Gröhn, 1998})\). Numerous studies \((e.g., \text{Erb et al., 1985; Gröhn et al., 1990})\) have shown that diseases related to the reproductive tract \((\text{dystocia, retained placenta, and metritis})\) are interrelated and can affect the length of calving interval, the number of days open, and the reproductive efficiency in general. These diseases can also affect the overall productivity of dairy cows by reducing milk yield. A cow was considered to have retained placenta \((\text{RP})\) when the fetal membranes were visible at the vulva or were identified in the uterus or vagina by vaginal examination more than 24 h after the first observation of the cow or heifer following calving. The condition of retained placenta occurs in 4 to 18\% of calvings \((\text{Markusfeld, 1987; Esslemont & Kossaibati, 1996})\). Ghavi Hossein-Zadeh & Ardalan \((2011b)\) reported the mean frequency of retained placenta ranged from 3.5\% in first lactation to 6.9\% in third lactation cows. In the USA, RP was reported to be the third most common health disorder in dairy cows, affecting 7.8\% of lactating cows \((\text{Goff, 2006})\). Calving problems including dystocia \((\text{Gröhn et al., 1990; Correa et al., 1993; Emanuelson et al., 1993})\), stillbirths \((\text{Markusfeld, 1987; Correa et al., 1993})\), and multiple births \((\text{Markusfeld, 1984; Correa et al., 1993})\) are associated with an increased incidence of retained placenta. In addition to these problems, abnormalities in partus, parity \((\text{Markusfeld, 1984; van Werven et al., 1992})\), gestation length \((\text{Muller & Owens, 1974; Markusfeld, 1984})\), calving season \((\text{Muller & Owens, 1974; Markusfeld, 1984})\), and nutrition \((\text{Laven & Peters, 1996})\) are also considered risk factors for retained placenta. Ghavi Hossein-Zadeh & Ardalan \((2011c)\) reported abortion was the most important risk factor for RP and other risk factors for RP were dystocia, stillbirth, milk fever, twin births, pluriparity, winter season and shorter gestation length of dairy cows in Iran. However, some researchers have found no association between dystocia \((\text{Erb et al., 1985})\), cow parity \((\text{Muller & Owens, 1974})\), or calving season \((\text{Grohn et al., 1990})\) and the incidence of retained placenta.

\text{Rajala & Gröhn (1998) reported retained placenta had a significant negative effect on milk yield for several weeks after calving, which is in agreement with results of several other studies. Lucey et al. (1986) found that retained placenta suppressed milk yield for about 4 wk after calving, and Rowlands & Lucey (1986) reported that retained placenta reduced peak yield, but also had a more lasting negative effect. They estimated a 7\% reduction in 305-d yield for cows with retained placenta.}
placenta. In the study of van Werven et al. (1992), older cows showed decreased milk yield with an increase in the duration of retention of the placenta. Simerl et al. (1992) found milk yield in first lactation to be depressed by retained placenta. Deluyker et al. (1991) reported that retained placenta was followed by lowered mean values for yield during the first 5 d after calving. Martin et al. (1986), however, found no yield effect from retained fetal membranes. They used 305 d milk yield as their milk measure. The indirect negative effect from retained fetal membranes. They used 305 d milk yield as their milk measure. The indirect negative effect of RP on milk yield mediated by puerperal metritis is reported by Könyves et al. (2009).

Retained placenta, one of the main causes of endometritis in cattle, causes economic loss (Kaneene & Miller, 1995). Kossaibati & Esslemont (1997) calculated the direct cost of a case of retained placenta to be about €96.34, with an over-all cost of €346.24. Many, often interrelated, factors have been implicated in the occurrence of retained placenta (Laven & Peters, 1996). Retained placenta is a direct risk factor for postpartum reproductive and metabolic disorders (Chassagne et al., 1999), which may affect subsequent reproductive capability of dairy cows. In fact, a negative impact of retained placenta on reproductive performance of dairy cows has been widely documented (Fourichon et al., 2000; Gröhn & Rajala-Schultz, 2000). However, others have reported that retained placenta does not significantly alter fertility (Kaneko et al., 1997). Increased occurrence of retained placenta in cows with abnormal partus might be due to lack of tone and slow involution or damage to the uterus by mechanical stress resulting from calving difficulty (Markusfeld, 1984; Markusfeld, 1987). Previous reports (Markusfeld, 1984, 1987; Chassagne et al., 1999) on the relationship between gestation length and the incidence of retained placenta showed that shorter gestation lengths are associated with a higher incidence of retained placenta. Han & Kim (2005) demonstrated that retained placenta was an important predisposing factor for development of postpartum endometritis and metabolic disorder in dairy herds, as previously reported by others (Markusfeld, 1986). The condition of the uterus at parturition or soon after may determine whether potential pathogens cause infections. At this time, retained placenta (a perfect media for bacterial growth), dystocia, or involution characteristics of the cervix and uterus may predispose cows to various infections (Bruun et al., 2002). Thus, the relationship between retained placenta and endometritis should be considered carefully; a large proportion of primary endometritis cases occurred just after the occurrence of retained placenta (Markusfeld, 1984). Erb et al. (1985) found an indirect association between the occurrence of ovarian cyst and retained placenta mediated by endometritis. Han & Kim (2005) reported the occurrence of metabolic disorder (abomasal displacement, milk fever, or ketosis) was greater in the retained placenta group than in the control group. Cows with retained placenta have previously been reported to have a higher incidence of abomasal displacement and ketosis (Markusfeld, 1987) compared to cows without retained placenta, although one report did not find a relationship between retained placenta and abomasal displacement (Correa et al., 1993). Retained placenta has been suggested to reduce fertility in two ways: first, by a direct effect through an unknown mechanism and secondly, by an indirect effect through endometritis (Stevenson & Call, 1988; Laven & Peters, 1996). Han & Kim (2005) reported the intervals from calving to first service and conception were higher in the retained placenta group than in the control group, which is consistent with other reports (Ouweltjes et al., 1996). In some studies, however, the intervals from calving to first service and/or conception were not related to the occurrence of retained placenta (Coleman et al., 1985; Kaneko et al., 1997). RP increases the risk of fatty liver syndrome and ketosis (Han & Kim, 2005); the latter, in turn, delays the postpartum resumption of cyclic ovarian function and prolongs the interval from calving to first ovulation (Opsomer et al., 2000). Könyves et al. (2009) observed negative energy balance (NEB) developing at the end of gestation markedly increased the odds of developing RP. Hur et al. (2011) concluded that there is a very close relationship between RP and postpartum diseases in dairy cattle after calving and RP increases risks for postpartum diseases such as metritis and mastitis, and culling hazards up to 60 DIM. Gaafar et al. (2010) observed retained placenta resulted in an increase in the period from parturition to first estrus (25.90 vs. 20.50 days) and first service (56.90 vs. 47.20 days), service period (57.70 vs. 46.10 days), days open (106.90 vs. 92.70 days), number of services per conception (3.50 vs. 2.60) and calving interval (395.20 vs. 372.90 days). Moreover, they observed reduction in conception rate (66.70 vs. 74.10%) and average daily milk yield (13 vs. 14 kg) compared to normally calved cows.

Metritis (MET) is inflammation of the uterus resulting in systemic signs of sickness, including fever, red-brown watery foul-smelling uterine discharge, dull-
ness, inappetance, elevated heart rate, and low production (Sheldon et al., 2006). Ghavi Hossein-Zadeh & Ardalan (2011b) reported the mean frequency of MET ranged from 6.6% in first lactation to 9.6% in third lactation cows of Iran. Also, Ghavi Hossein-Zadeh & Ardalan (2011c) indicated risk factors for MET included RP, dystocia, stillbirth, twin births, primparity, winter season and male calves in Iranian Holsteins. Metritis in dairy cows is an important disease, because it can increase the calving to conception interval (Erb et al., 1981; Fourichon et al., 2000) and decrease milk yield (Coleman et al., 1985). Also, cows with severe metritis ate 2-6 kg dry matter less than healthy cows in the 2-3 weeks preceding the clinical signs of metritis (Huzzey et al., 2007), and to negatively affect reproductive performance (Opsomer et al., 2000; Melendez et al., 2004). The largest risk factor for metritis is RP, but other conditions that may impair feed intake and immune function also increase the risk of metritis (LeBlanc, 2008). Some discrepancy exists in the literature about the effect of metritis on milk yield. Some studies have reported decreased yield (Deluyker et al., 1991; Simerl et al., 1992; Rajala & Grohn, 1998), but others show no or equivocal effects of the disease on yield (Goshen & Shpigel, 2006). This discrepancy may be partially explained by differences in parity. Østergaard & Gröhn (1999) found that multiparous cows, but not primiparous cows, with metritis produced less milk than healthy cows up to 6 wk after diagnosis. This parity effect has remained unexplained, but may be due to differences in feed intake. Huzzey et al. (2007) found that ill cows consumed less feed than healthy cows; yet, this has not been tested in primiparous and multiparous cows separately. Metritis and other infections of the reproductive tract can harm reproductive performance (Sheldon et al., 2006). Cows with metritis have increased days between first service after calving and conception, increasing the efforts and resources required to induce pregnancy (Erb et al., 1981; Fourichon et al., 2000). Reproductive status is the most important influence on culling decisions (Grohn et al., 2003), so it seems likely that uterine infections increase the risk of culling. Wittrock et al. (2011) demonstrated that metritis reduces acute feed intake, long-term milk yield, and increases the chance of culling in multiparous cows but not primiparous cows. Metritis decreased daily milk production from 2 to 13 kg during a period that can vary from 2 to 20 wk after parturition (Rajala & Grohn, 1998; Fourichon et al., 1999; Wittrock et al., 2009). The effect of metritis on milk production was reported to be influenced by parity and stage of lactation (Overton & Fetrow, 2008; Wittrock et al., 2009). The reported effect of uterine diseases on culling is variable. Some studies found an increased risk of culling (Overton & Fetrow, 2008), whereas others found no effect (Grohn et al., 2003). Disease definition, duration of the follow-up period, sample size (power), and accounting for related diseases are important factors contributing to this discrepancy. In studies in which uterine diseases increased culling, this was suggested to be the result of either decreased milk production or reduced reproductive performance (Grohn & Rajala-Schultz, 2000; Overton & Fetrow, 2008). Dubuc et al. (2011) reported uterine disease decreased pregnancy rate, which was a substantial risk factor for culling; however, if affected cows became pregnant they were not at greater risk of culling. Also, in a study on Danish Holsteins, Elkjær et al. (2013) reported cows with metritis in early lactation presented a significant delay in first insemination (hazard ratio of 0.80) and a significantly reduced probability of success at first insemination.

Conclusions

There appears to be an agreement in the literature that health and reproductive problems mentioned in the current paper have adverse effects on the health, production and reproduction indices of the dairy cow. Because the current goal of dairy operations is to maximize milk yield per cow through genetic selection and artificial insemination, the practical implication of the association between health problems and milk production and identification of potential risk factors for corresponding problems in dairy cattle is substantial. Development of practical management strategies to cope with the negative effects associated with reproductive and health problems on dairies is critical. Because health and reproductive problems mentioned in the current study are the most important conditions that limits cow’s performance and considerably erode the profit, maintaining the general health and immune function of the cattle is also important in minimizing the risk of health problems. Providing an adequate amount of a properly formulated and delivered ration, and providing a clean, comfortable and minimal-stress environment is also essential to accomplishing this task.
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