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Logistic Regression Analysis of Some Factors Influencing Incidence of Retained Placenta in a Holstein Dairy Herd

Research Article

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ABSTRACT

To investigate the effects of certain factors on the rate of retained placenta, 2844 calving records from 1288 Holstein cows in a herd were used. These cows calved during year period of 2001 to 2007. A generalized statistical linear model was applied to analyze the data. Logistic regression model was applied as the statistical model. In the model, fixed effects of year, season (warm or cold) and sex and birth type (single or twin) of calf and parity and gestation length of dam were included. In data file, retained placenta incidence was introduced as binary codes: zero for healthy cows and one for cows with retained placenta and probability of code one was analyzed. Incidence of retained placenta was significantly affected by all the fixed effects included in the model. Odds ratio estimation for cold season compared to warm seasons was 0.619, which means probability of occurrence of this disease in cold season, is 39% less than in the warm season. Odds ratio estimation for female calves in comparison to male calves was 0.6, which implies that the former are 40% less probable to cause retained placenta. Probability of this disease in twin calving was 5.9 times more than singles. By increasing the parity number of the dam, the probability of experiencing retained placenta in cow increased. It could be concluded that the incidence of retained placenta may be reduced by management modifications.

KEY WORDS Holstein cow, logistic analysis, odds ratio, retained placenta.

INTRODUCTION

The aim of any economic activity is to achieve profit and the profitability of dairy breeding is affected by their production and reproduction performance (Norman *et al.* 2009). Therefore, reproductive management has very important role in dairy herds. Any factor causing delay in cows' pregnancy, due to extending calving interval, directly results in reduction milk production and less number of calves born per cow per year, and ultimately, leading an increase of non-voluntary replacements in the herd (Holtsmark *et al.* 2008; Sewalem *et al.* 2008). Many factors affect the reproductive efficiency of dairy cattle such as nutrition system (Garnsworthy *et al.* 2008; Tallam *et al.* 2008; Siciliano-Jones *et al.* 2005), herd management (Olynk and Wolf, 2008; Schefers *et al.* 2010), estrus synchronization (Moore and Thatcher, 2006; Thatcher *et al.* 2001), accuracy of estrus detection (Schefers *et al.* 2010; Moore and Thatcher, 2006), insemination and the skill of inseminator (Lima *et al.* 2009) and genital disease such as retained placenta (López-Gatius *et al.* 2006). Placenta is an organ which connects a developing fetus to the mother's

uterine wall. This provides a route for the fetus to pass mother's blood, absorb nutrients and excrete wastes and gas exchange for respiration. Cotyledon placenta usually exits until 3 to 8 hours after calving, and if placenta does not expel until 12 hours, retained placenta occurs (Sammin *et al*. 2009).

Retained placenta in cattle may be associated with certain side effects such as uterine infections (Bell and Roberts, 2007; Bruun *et al*. 2002; Larson *et al*. 1985), vaginal infections (Muller and Owens, 1973), lameness (Larson *et al*. 1985), mastitis (Larson *et al*. 1985), reduced milk production (Bicalho *et al*. 2008; Gröhn and Rajala-Schultz, 2000) and increased postpartum interval until first ovulation (Fourichon *et al*. 1999; Larson *et al*. 1985), therefore, reducing the efficiency of first insemination after calving (Fourichon *et al*. 1999; Gröhn and Rajala-Schultz, 2000; López-Gatius *et al*. 2006; Tillard *et al*. 2008). Overall reproductive status of cows that suffered from retained placenta is less favorable (López-Gatius *et al*. 2006). Research results had shown that replacement rate in cows which had experienced retained placenta would increase (Lawson *et al*. 2004). The heritability of retained placenta trait is very low (0.07-0.08) (Heringstad *et al*. 2005; Ghavi Hossein-Zadeh and Ardalan, 2011a). This implies that the most of the factors that cause this disease have environmental origin. In consequence, this signifies the necessity of identification and control of environmental factors influencing the incidence of this disease.

Logistic regression used in this study is a kind of non-linear function. One of the linear regression assumptions is that the variance of response variable (Y) for each independent variable is constant. But in cases where the response variable is binary, this is not true. In addition, in regression analysis, prediction error (y-ŷ) should be normally distributed, and this is the case when responses are continuous but in the case of binary response variables, which have just two values 0 and 1, this assumption is not established.

Thus in the case of binary variables linear regression cannot be applied. Alternative distribution function for this case is logistic distribution function which is very similar to normal distribution. Estimation of response parameters of the logistic function can be done with maximum likelihood method. This estimation method is appropriate for binary data, particularly when there is large data set, then maximum likelihood estimates for logistic regression analysis, will be approximately normally distributed (Vittinghoff *et al*. 2004).

The aim of this study was evaluation of the effects of some environmental factors on the incidence of retained placenta in a Holstein cow herd by the use of a logistic regression analysis method.

MATERIALS AND METHODS

A total of 2844 calving records from 1288 Holstein cows in a semi-private herd, which had their calving from April 2001 to December 2007 were used for this study. The herd was located in Khorasan Razavi province, Iran. Age of cows ranged between 2 to 9 years (parities 1 to 7). The average number of inseminations per conception and parities per each cow in this herd were 2.6 and 3, respectively. The frequency of retained placenta for each gender, type of birth and season of birth of calves are shown in Table 1.

Table 1 Frequency of retained placenta in each gender, type and season of birth

Effect		Total number	Retained placenta
Calf sex	male	1458	118
	female	1386	79
Calf birth type	Single	2524	111
	twin	320	86
Calf birth season	warm	1652	138
	cold	1192	59

Logistic regression model for this analysis was used as following matrix format:

$$E(Y_i) = \pi_i = [1 + \exp(-X'\beta)]^{-1} + e$$

Where:
Y: the vector of binary response variable with Bernoulli distribution.
π: value is equal to E(Y), it implies the probability of Y=1, or the possibility of retained placenta.

Logit link function, which is the inverse of cumulative function of logistic distribution, was used to fit the data to the model.

$$\text{Logit}(\pi) = \log(\pi/1-\pi)$$

In fact, this random variable was related to the risk of retained placenta, which in data file, was introduced as codes zero (healthy cows) and one (cows with retained placenta). The above variable would have zero and one values, with probability of p and 1-p, respectively (in the analysis of the figures, the probability of retained placenta was aimed).

In the above model, X, the incidence matrix of the fixed effects and β is the vector of fixed effects of statistical model including calf's birth year (2001 to 2007), birth season, sex, type of birth (single or twin), and parity number and gestation length of dam. The residual part of the model has zero mean and variance of p (1-p).

In order to facilitate the comparisons, seasons of the year were divided into two 6 month periods. The first period included spring and summer (warm seasons) and second period included fall and winter (cold seasons). SPSS software was used for fitting the model SPSS (2007).

RESULTS AND DISCUSSION

Retained placenta occurrence frequency in this herd was 6.9%. The occurrence of this disease in some herds was reported about 3.1% (Fourichon *et al.* 1999) and 6.6% (Bruun *et al.* 2002) to 9% (Gröhn *et al.* 1990). All studied fixed factors had significant effect on the incidence of placenta retention (P<0.05). Odds ratio estimations are shown in Table 2.

Table 2 Odds ratio estimation of fixed factors affecting rate of placenta retention

Effect	Parameter estimate (±SE)	Odds ratio
Calf birth year	0.19	1.209
Calf birth season	-0.479	0.619
Calf sex	-0.511	0.6
Calf birth type	1.779	5.925
Parity number	0.176	1.192
Gestation length	-0.49	0.952

Calf birth year

Estimated odds ratio for calf birth year was 1.209. This value represents the increasing trend of retained placenta occurrence during years 2001 to 2007. In the other words, in 2007 the probability of placenta retention was $(1.209)^6$ or approximately 3 times more than 6 year before it (i.e. year 2001). Another research also reported significant effect of this factor (Echternkamp and Gregory, 1999). Low heritability of this disease indicates that it is greatly influenced by environmental factors. Herd management is one of the environmental factors which may change during different years and its effect on production, reproduction and disease incidence rate in herd is reported in many studies (Schefers *et al.* 2010).

Calf birth season

To simplify the study of calf's birth season effect (cow's calving season) on the incidence of retained placenta, seasons of year were divided into two 6 months periods, warm and cold. Similarly to other studies, (Echternkamp and Gregory, 1999) birth season effect on retained placenta occurrence was significant. The frequencies of retained placenta occurrence in the two seasons are shown in Figure 1.

The estimated odds ratio for the cold season to warm season was 0.61. This means that by passing the warm period of year to the cold one, there is a probability of 39% decrease in occurrence of retained placenta.

Researchers also showed that the frequency of retained placenta occurrence in fall deliveries is less than 40% compared to spring deliveries (Echternkamp and Gregory, 1999). The incidence of retained placenta in the cold months of year was lower in comparison to the warm months (DuBois and Williams, 1980; Muller and Owens, 1973). In contrast, Wetherill (1965) and Ghavi-Hosseinzade and Ardalan (2011b) reported that the incidence of retained placenta in deliveries were lower in summer in compare to winter and spring.

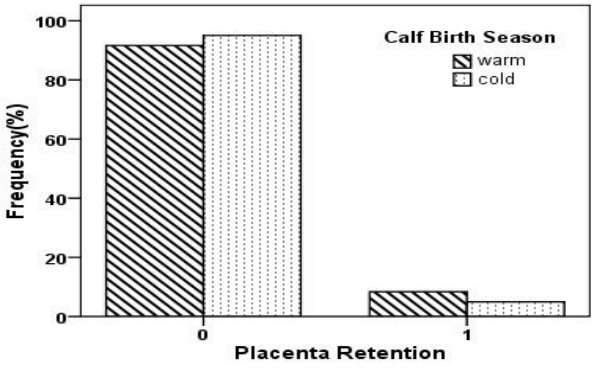

Figure 1 Relative frequency of placenta retention in two birth seasons

Sometimes the lower occurrence of retained placenta in the cold seasons of year is attributed to environmental and nutritional factors, such as temperature and concentrate to forage ratio in the diet (Echternkamp and Gregory, 1999). Forage quality and amount in the diet vary between spring and autumn. Fall calving cows receive fresh grass, rich in vitamin A and E in the major part of their gestation period. It is said that these two vitamin deficiency has major role in the incidence of retained placenta (Garnsworthy *et al.* 2008).

In this study, birth weights of calves born in cold and warm periods were compared. It was observed that calves born in cold periods have higher birth weight in comparison to those in warm periods (1.12 kg). On the other hand, it has been reported that calf birth weight has positive correlation with placental weight, (Echternkamp, 1993). Thus, heavier birth weights of calves born during the cold period means that they have bigger, physiologically more differentiated and mature placenta, which ends in reduced retained placenta (Echternkamp and Gregory, 1999; Gregory *et al.* 1996).

Calf sex

Calf sex had a significant effect on the incidence of retained placenta (P<0.05). Cows that had male calves when compared to those had female calves experienced 2.4% higher abundance of this phenomenon.

The estimated odds ratio for female to male deliveries was 0.6 which means that the incidence of retained placenta in female deliveries was 40% lower. Other researchers reported similar (Larson *et al*. 1985) results. Birth weights of male and female calves were compared, and were observed that males at birth were 3.29 kg heavier than females (P<0.05). High calve birth weight was one of the causes of dystocia which one of its consequences is placenta retention (Johanson and Berger, 2003; Olson *et al*. 2009).

Calf birth type

Birth type was an affecting factor on the incidence of retained placenta in dairy cattle (P<0.05). The frequency of this disease occurrence in cows delivered twin was 22.5% higher than those delivered single (Figure 2). It was observed that the retained placenta occurrence in twin deliveries was 5.92 times more than single deliveries. Some researchers have reported similar results (Eddy *et al.* 1991; Larson *et al*. 1985; McEvoy *et al*. 1995). In Echternkamp and Gregory (1999) study higher incidence of twin calving was accompanied with retained placenta (27.9% *vs*. 1.9%).

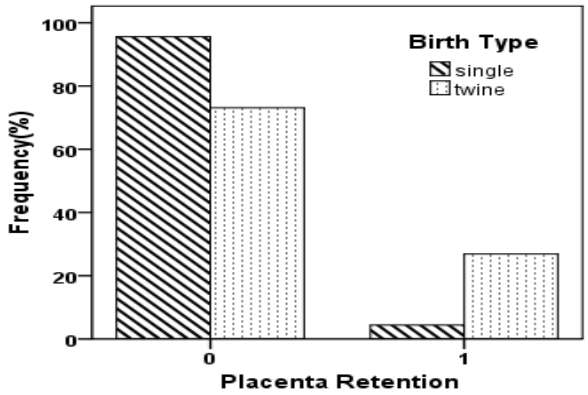

Figure 2 Relative frequency of placenta retention by birth type

A number of studies explained that this difference is due to the shorter gestation length in twin calving (Bell and Roberts, 2007; Echternkamp and Gregory, 1999). In this herd twin calves had born 4.98 days earlier than singles. Retained placenta occurs due to physiological immaturity of placenta at the time of delivery (Chew *et al.* 1977) that can be as a rationalization for retained placenta occurrence in twins who have a shorter gestation length (Echternkamp and Gregory, 1999). Furthermore, at birth time twins were smaller and physiologically were more immature than singles (Gregory *et al*. 1996).

Parity number

Parity is also a factor that had significant effect on the rate of retained placenta incidence (P<0.05). The estimated odds ratio for parity number was 1.19, which represents 19 percent increased risk of retained placenta due to increase of parity number. Similar (Heringstad *et al*. 2005; Ghavi Hosseinzadeh and Ardalan, 2011a; Echternkamp and Gregory, 1999) and different (Larson *et al.* 1985) results are reported in previous studies. In addition, in other studies, estimated genetic correlation of retained placenta occurrence between first and second parity was about 0.79 (Schnitzenlehner *et al.* 1998). If a cow had retained placenta in her first calving, in order to minimize the probability of placenta retention in her subsequent parity, manager must provide a completely sterile environment without any stress during delivery.

Gestation length

The average gestation length in this herd, was 275 days. The estimated odds ratio for this significant effect was 0.952, which indicates the lower probability of retained placenta occurrence in cows with longer gestation length. In this herd, the gestation length of cows which had retained placenta after delivery was 3 days shorter.

Short gestation length can affect the incidence of retained placenta in two ways: first, by shortening gestation length, dry days of cows decrease and therefore, there is less time to achieve a suitable body condition at delivery time. According to a report, most of the cows that their drying off period was associated with poor body condition had suffered from retained placenta (Markusfeld *et al.* 1997). Second, placenta retention occurs due to physiological immaturity of placenta at delivery time (Chew *et al.* 1977). Increased probability of physiological immaturity of placenta at delivery time is due to shortening the gestation period, therefore cotyledon and caruncle connections do not completely separate and a part of the placenta remains in the genital. It was reported that the gestation period in cows with retained placenta were 3.3 to 5.25 days shorter than healthy cows (DuBois and Williams, 1980; Muller and Owens, 1973). Gestation period shorter than 274 days caused a doubling incidence of retained placenta rate (Boyd and Sellers, 1948). Sometimes it is observed that gestation period duration has no effect on the incidence of retained placenta (Larson *et al.* 1985).

CONCLUSION

This study indicated that calf's birth season affects the incidence of retained placenta in cows. Thus, farm management would benefit from an increase in the percentage of births in cold seasons. In addition, using sexed semen in order to increase female birth rate in herd could be beneficial to the farm economy and may play an important role in reducing the incidence of this reproductive disease. In this study, a positive association between the number of parturitions and the incidence of this disease was observed. Therefore, re-

placing these cows with younger ones could present some advantages besides reducing the incidence of retained placenta, such as shortening of generation interval, and estimating the breeding value of these cows' daughters and therefore, achieving faster genetic progress in the herd.

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