Investigation of effect of year and season factors on calving difficulty, using poisson regression model in Simmental x South Anatolian red crossbred cattle

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Summary: Dystocia is an economically important problem in cattle industry because it is a major causes of calf mortality. This problem has received increased attention by the cattle industry because of the utilization of some of the incompetible sire breeds in crossbreeding programs. The aim of this study was to investigate the effect of year and season on cattle dystocia using poisson regression methodology. Only first-calf heifer data record, including a total of 1787 birth records over three years, from January 2010 to November 2012, of Simmental x South Anatolian crossbred from a private farm, were collected. Poisson regression model provides an adequate fit for this data, however there might be acceptable level of underdispersion. According the result of the Chi-Square tests, the differences between year 2010 and 2012, 2011 and 2012 were found statistically significant (p<0,001). In addition the differences between seasons winter and summer, autumn and summer, spring and summer were found statistically significant (p<0,001).

Keywords: Dystocia, environmental effects, model fit, poisson regression model, Simmental x southanatolia red cattle.

Poisson regresyon modeli kullanılarak Simmental x Güney Anadolu Kırımızısı melez sağırlarda yıl ve mevsim faktörlerinin güç doğum üzerine etkisini incelemesi


Anahtar sözcükler: Çevresel etkiler, güç doğum, model uyumu, poisson regresyon metodu, Simmental x Güney Anadolu kırımızı.

Introduction

Dystocia is one of the most important production problems of the cattle industry and has been recognized as a major cause of early calf mortality. The economic losses resulting from dystocia are not confined to the calves. Dystocia can have a large economic impact on producers due to calf death, veterinary labour costs, decreased rebreeding efficiency, and injury or even death to the cow (1, 2, 6, 9, 10).

Dystocia is the number one cause of calf mortality in the first 96 hours of life (25) According to CHAPA (Cow-calf Health and Productivity Audit) dystocia is responsible for 33 percent of all calf losses and 15.4 percent of beef cattle breeding losses (7). In addition to the effects of dystocia on cow culling, mortality (19) and stillbirth (21), dystocia increases the likelihood of respiratory and digestive disorders, as well as retained placenta, uterine disease, mastitis and hypocalcaemia therapy. Pregnancy rates for the dam after losing a calf are lower than for dams that have not lost a calf (15,16, 24, 25). Studies also indicate that animals experiencing dystocia while delivering a live calf may have decreased rebreeding rates (18, 26, 27).

The causes of dystocia spring from many management choices ranging from breeding genetics and nutrition to management of the cow or heifer during delivery.
Many studies have been reported to identify genetic factors effecting to dystocia using linear animal models (11), Bayesian methods(17), variance component analysis (5, 28) and meta analysis (12). Yet, there have been found only a limited number of recent publications on phenotype or genetic temporal trends in dystocia in dairy herds internationally.

This study aims to determine effect of year and season on cattle dystocia using poisson regression methodology.

**Material and Method**

**Data:** A total of 1787 birth records of first- calf Simmental x South Anatolian crossbred heifers were collected at a private farm, obtained from January 2010 to November 2012. Data were classified by year and season.

**Method:** Poisson regression model aims at modeling a counting variable Y, counting the number of times that a certain event occurs during a given time period. It can be used to model the number of occurrences of an event of interest or the rate of occurrence of an event of interest, as a function of some explanatory (independent) variables.

In poisson regression it is assumed that the response (dependent) variable Y, number of occurrences of an event, has a poisson distribution given the explanatory variables x1,x2,…,xp,

\[ P(Y = y | x_1, x_2, ..., x_p) = \frac{e^{-\mu} \mu^y}{y!}, \quad y = 0,1,2,... \]

where the log of the mean µ is assumed to be linear function of the explanatory variables. In many situations the rate or incidence of an event needs to be modeled instead of the number of occurrences. For such data, a Poisson regression model can be written in the following form.

\[ \log(\mu) = \log(N) + \text{intercept} + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p \]

The maximum likelihood method is used to estimate the parameters of the written poisson regression model.

To calculate the incidence of dystocia, following equation was used. In the following equation, total, represents the total number of calves at risk in each year and season, while n cases, represents the number of dystocia reported in each year and season. Since the dystocia cases were modeled in this study, the incidence were calculated as the number of dystocia (cases) divided by the total number of cattle at risk

\[ \log \left( \frac{n \text{ cases}}{\text{total}} \right) = \text{intercept} + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p \]

Which is equivalent to:

\[ \log(n \text{ cases}) = \log(\text{total}) + \text{intercept} + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p \]

Estimates of beta coefficients of the poisson model produced by PROC GENMOD procedure in SAS version 8. All statistical analysis were considered with a minimum of %5 significance.

**Results**

The incidence of dystocia by year were calculated as 6.5% at 2010, 4% at 2011, and 2.5% at 2012 respectively, while calf mortality rates by season were calculated as 5.9% in summer, 4.4% in spring, 4.0% in fall and, 2.4% in winter. Overall incidence was calculated as 4.3%.

To assess the goodness of fit for the model, likelihood, deviance and Pearson Chi-Square statistics can be used. Deviance and Pearson Chi-Square divided by the degrees of freedom are often used to detect overdispersion or underdispersion. For Poission distribution the sample mean and the sample variance are equal, which implies that the Deviance and Pearson statistic divided by the degrees of freedom should be approximately one. Values greater than 1 indicate overdispersion, that is, the true variance is larger than the mean, since the values smaller than 1 indicate underdispersion, the true variances is smaller than the mean. Both values in the model indicated adequate fit and small underdispersion (Table 1).

Table 1. Criteria for assessing goodness of fit.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>df</th>
<th>Value</th>
<th>Value/df</th>
</tr>
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<tbody>
<tr>
<td>Deviance</td>
<td>6</td>
<td>0.4032</td>
<td>0.0672</td>
</tr>
<tr>
<td>Scaled Deviance</td>
<td>6</td>
<td>6.0000</td>
<td>1.0000</td>
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<tr>
<td>Pearson Chi-Square</td>
<td>6</td>
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<tr>
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<td>6</td>
<td>6.1424</td>
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<tr>
<td>Log Likelihood</td>
<td></td>
<td>1143,3205</td>
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</table>

The model indicated that the incidence of dystocia were higher for subjects in year 2010 and 2011 than in 2012 (the reference year), while the incidence of dystocia were found lower for subjects in winter, autumn and spring than in summer (reference season). The result of the Chi-Square tests indicated that the differences between year 2010 and 2012, and also 2011 and 2012 were statistically significant (p<0.001, all years). The result of the Chi-Square tests showed that the differences between seasons winter and summer, autumn and summer, spring and summer were found statistically significant (p<0.001, all seasons) (Table 2).

Using the estimated coefficients in Table 2, the predicted incidence for winter season of 2010 can be calculated as exp(-3.2788+0.9585+0.9513)=0.038 and for winter season of 2011 as exp(-3.2788+0.4932-0.9513)=0.024 respectively. According to the predicted incidences, there was an increased trend of dystocia from summer to winter independent from years.
According to the results, the incidence of dystocia in 2010 were found as exp (0.9585-(0.4932))=1.59, which is %59 higher than in 2011.

**Discussion and Conclusion**

Poisson regression model provides an adequate fit with small underdispersion for this data. Corrective measures use the Deviance or Pearson Chi-Square divided by degrees of freedom as an estimate of the dispersion parameter instead of setting it to 1. For this data set, the ratios were 0,0672 and 0,0688. Large positive value of standardized form of partial score test proposed by Dean and Lawless (1989) was calculated as:

\[ T = \sum_{i=1}^{n} \frac{(Y_i - \hat{\mu}_i)^2 - Y_i}{2 \sum \hat{\mu}_i^{1/2}} = -2.143 \]

which indicates underdispersion for this data set. Therefore, we can conclude that the estimates of the parameters were unchanged. Their respective standart errors multiplied by dispersion parameter. The parameter estimates are no longer based on maximizing likelihood. Using options DSSCALE or PSSCALE in the model statement estimation equation for calculating the parameter estimates is called quasi likelihood. The asymptotic normality of the parameters estimates remain valid. Wedderburn (1974) and McCullag (1983) showed that quasi likelihood, and their associated maximum quasi likelihood estimates have many properties analogous to those of likelihood and their associated maximum likelihood estimates.

The overall incidence of dystocia observed in the present study was 4.3%, which was less than other international estimates (4, 14, 22)

Olson et al. (2009) documented that there were no significant effect of season and year in their model. Also, Johanson et al. (2011) reported that incidence of dystocia were slightly higher in winter than in summer but it was found no significant. On the other hand, Berger et al. (1992) reported in their logistic regression model that incidence of dystocia was 37% higher in spring than in fall. In the present model, the rates of dystocia were found significantly lower in winter, autumn and spring than in summer which indicates that it might be related with heat stress. There may be many potential explanations for this phenomenon, although one intriguing possibility can be an effect of heat stress on placental development. Exposure to high environmental temperatures during mid-gestation or during the third trimester restricts placental development and depresses fetal development to term. Also high temperatures in summer may influence the process of parturition which might result with dystocia. The incomparable conclusions about the effect of season might also be because of different toleration levels of stress among the breeds.

A sound management program to reduce dystocia and rapidly identify cattle experiencing dystocia is critical to cattle welfare and farm profitability. This study showed that some environmental factors such as calving year and season should also be considered when dystocia are evaluated. Poisson models can also be a good option to be used in such analysis. Further studies are required to understand the complex of nature on dystocia.

**References**


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<th>Parameter</th>
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<th>Estimate</th>
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