Ankara Üniv Vet Fak Derg, **61**, 55-58, 2014

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

Ismayil Safa GÜRCAN[1], Doğukan ÖZEN[1], Aytekin YAMAÇ [2], Özlem GÜLLÜ[3]

[1] Department of Biostatistics, Ankara University Faculty of Veterinary Medicine; Ankara; [2] Turkish Army NCO Collage Forces, Balıkesir; [3] Department of Health Culture and Sports of Ankara University, Ankara, Turkey.

Summary: Dystocia is an economically important problem in the 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 Kırmızısı melez sığırlarda yıl ve mevsim faktörlerinin güç doğum üzerine etkisinin incelenmesi

Özet: Güç doğum, buzağı ölümlerinin ana nedeni olduğundan sığır endüstrisinde ekonomik olarak büyük bir sorundur. Sorunun, hayvancılık sektöründe melezleme programlarında uyumsuz ırkların kullanımı ile artması dikkat çekicidir. Bu çalışmada, poisson regresyon metodu kullanılarak ile güç doğum üzerine yıl ve mevsimin etkisi incelendi. Çalışmanın verilerini, özel bir işletmede Ocak 2010 ile Kasım 2012 tarihleri arasında üç yıl süre ile, sadece ilkine buzağılayan Simmental x Güney Anadolu kırmızısı melezi sığırlardan alınan toplam 1787 adet doğum kaydı oluşturmuştur. Verilere Poisson regresyon yöntemi uyum sağlamakla birlikte az miktarda sapma görülmüştür. Elde edilen sonuçlara göre; ki-kare testi ile 2010 yılı ile 2012 yılı ve 2011 yılı ile 2012 yılları arasında istatistiksel olarak anlamlı bir fark bulunmuştur (p<0,001). Ayrıca, kış mevsimi ile yaz, sonbahar ile yaz ve ilkbahar mevsimi ile yaz mevsimi arasında istatistiksel olarak anlamlı fark bulunmuştur (p<0,001).

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

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 loses 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: Poissson 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 occurences of an event of interest or the rate of occurence 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 occurances of an event, has a poisson distribution given the explanatory variables $x_1,x_2,\ldots,x_p$,

$$P\left(Y=\frac{y}{x_1},x_2,\ldots,x_p\right)=\frac{e^{-\mu}\mu^y}{y!}, \qquad y=0,1,2,\ldots$$

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 occurances. For such data, a Poisson regression model can be written in the following form.

$$\log(\mu)=\log(N)+intercept+\beta_1.x_1+\beta_2.x_2+,\ldots+\beta_p.x_p$$

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 cattles at risk

$$\log\left({}^{n_{cases}}/_{total}\right)=intercept+\beta_1.x_1+\beta_2.x_2+,\ldots+\beta_p.x_p$$

Which is equvalent to:

$$\log(n\ cases)=\log(total)+intercept+\beta_1.x_1+\beta_2.x_2+,\ldots+\beta_p.x_p$$

Estimates of beta coefficients of the poisson model produced by PROC GENMOD proceedure 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 peason 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 Poisson 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.
Tablo 1. Uyum iyiliğini değerlendirme kriterleri.

Criterion	df	Value	Value/df
Deviance	6	0,4032	0,0672
Scaled Deviance	6	6,0000	1,0000
Pearson Chi-Square	6	0,4127	0,0688
Scaled Pearson Chi-Square	6	6,1424	1,0237
Log Likelihood		1143,3205	

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.

Table 2. Analysis of Parameter estimates.
Tablo 2. Parametre tahminlerinin analizi.

Parameter		df	Estimate	Standart Error	Chi-Square	Pr>ChiSq
Intecept		1	-3,2788	0,0755	1885,8766	<,0001
Year	2010	1	0,9585	0,0772	154,1632	<,0001
Year	2011	1	0,4932	0,0846	33,9759	<,0001
Year	2012	0	0,0000	0,0000	-	-
season	Winter	1	-0,9513	0,0939	102,5620	<,0001
season	Autumn	1	-0,4505	0,0803	31,5009	<,0001
season	Spring	1	-0,3835	0,0743	26,6419	<,0001
season	Summer	0	0,0000	0,0000	-	-
Scale		0	0,2592	0,0000	-	-

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 underdisperion 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;

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

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 DSCALE or PSCALE in the model statement estimation equation for calculating the parameter estimates is called quasi likelihood. The results on 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 incompetible 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

1. **Apaydın AM** (1997) *Güç doğumlar (Dystocia). In: Alaçam E (Ed). Evcil Hayvanlarda Doğum ve İnfertilite*. Medisan yayınevi, Ankara, pp, 197-214.
2. **Berger PJ** (1994) *Genetic prediction for calving ease in the United States: data, models, and use by the dairy industry*. J Dairy Sci, **77**, 1146-1153.
3. **Berger PJ, Cubas AC, Koehler KJ, Healey MH** (1992). *Factors affecting dystocia and early calf mortality in Angus cows and heifers*, J ANIM SCI, **70,** 1775-1786
4. **Berry DP, Lee JM,. Macdonald KA, Roche JR** (2007). *Body condition score and body weight effects on dystocia and stillbirths and consequent effects on postcalving performance*. J. Dairy Sci. **90**, 4201–4211
5. **Cole JB, Goodling RC, Wiggans Jr GR, VanRaden PM** (2005). *Genetic evaluation of calving ease for Brown Swiss and Jersey bull from purebred and crossbred calvings*. J Dairy Sci, **88**,1529-1539.

6. **Çetin H, Kocamüftüoğlu M** (2012). *Doğum ve güç doğumlar. In: Semecan A, Kaymaz M, Fındık M, Rişvanlı A, Köker A (Eds.) Çiftlik Hayvanlarında Doğum ve Jinekoloji.* Medipres. Malatya, pp 615-639.
7. **Dargatz D** (1994). *Chapa: beef cow/calf health and productivity audit, part III: beef cow/calf health management*, Erişim: http://purl.umn.edu/32748, Erişim tarihi: 26.03.2013.
8. **Dean CB, Lawless JF** (1989). *Tests for detecting overdispersion in Poisson regression models.* J Amer Statist Assoc, **84**, 467-472.
9. **Dekkers JCM** (1994). *Optimal breeding strategies for calving ease.* J Dairy Sci, **88**, 3441-3453.
10. **Dobson H, Tebble JE, Smith RF, Ward WR** (2001). *Is stress really all that important?* Theriogenology, **55**, 65–73.
11. **Erikson S, Nasholm A, Johansson K, Philipsson J** (2004). *Genetic parameters for calving difficulty, stillbirth, and birth weight for Hereford and Charolias at first and later parities.* J Anim Sci, **82**, 375-383.
12. **Fourichon C, Seegers, H, Mahler X** (2000). *Effect of dystocia on reproduction in the dairy cow: a meta-analysis*. Theriogenology, **53**, 1729–1759.
13. **Johanson JM, Bergeri PJ, Tsuruta S, Misztal I** (2011): *A bayesian threshold-linear model evaluation of perinatal mortaliti, dystocia, birth weight and gestation in a Holstein herd*, J.Dairy Sci. **94**, 450-460.
14. **Linden TC, Bicalho RC, Nydam DV** (2009). *Calf birth weight and its association with calf and cow survivability, disease incidence, reproductive performance, and milk production.* J. Dairy Sci. **92,** 2580–2588.
15. **Lombard JE, Garry, FB, Tomlinson, SM, Garber LP** (2003). *Relationship of dystocia to dairy cow health and productivity.* J Dairy Science, **86** (Suppl. 1), 32.
16. **Lombard JE, Garry FB, Tomlinson, SM, Garber LP** (2007). *Impacts of dystocia on health and survival of dairy calves.* J Dairy Science, **90**, 1751–1760.
17. **Luo MF, Boettcher PJ, Schaffer LR, Dekkers JCM** (2002). *Estimation of geneetic parameters of calving ease in first and second parities of Canadian Holsteins using Bayesian methods.* Lives Prod Sci, **74**, 175-184.
18. **Mangurkar BR, Hayes JF, Moxley JE** (1984). *Effects of calving ease-calf survival on production and reproduction in Holsteins.* J Dairy Sci, **67,** 1469.
19. **McClintock SE** (2004). *A genetic evaluation of dystocia in Australian Holstein–Friesian cattle.* Ph.D., University of Melbourne.
20. **McCullagh P** (1983). Quasi-likelihood functions, Ann Statist, **11**, 59-67.
21. **Mee JF** (2004). *Managing the dairy cow at calving time.* Veterinary Clinics of North America Food Animal Practice, **20**, 521–546.
22. **Mee JF** (2008). *Prevalence and risk factors for dystocia in dairy cattle*: *A review*. Vet. J. **176,** 93–101.
23. **Olson KM, Cassell BG, Mcallister AJ, Washburn SP** (2009): *Dystocia, stillbirth, gestation length, and birth weight in Holstein, Jersey, and reciprocal crosses from a planned experiment* , J.Dairy Sci, **92**, 6167-6175.
24. **Oltenacu PA, Frick A, Lindhe B** (1988). *Use of statistical modeling and decision analysis to estimate financial losses due to dystocia and other disease in Swedish cattle.* In: Proceedings of the 5th International Symposium on Veterinary Epidemiology and Economics, Copenhagen, Denmark. pp. 353–355.
25. **Patterson DJ, Bellows RA, Burfening, PJ, Carr, JB** (1987). *Occurrence of neonatal and postnatal mortality in range beef cattle. Theriogenology,* **28**, 557-71.
26. **Tenhagen A, Helmbold A, Heuwieser W** (2007). *Effect of Various Degrees of Dystocia in Dairy Cattle on Calf Viability, Milk Production, Fertility and Culling.* J Vet. Med A **54**, 98–102.
27. **Thompson JR, Pollak EJ, Plessier CL** (1983). *Interrelationships of parturition problems, production and subsequent lactation, reproduction, and age of first calving.* J Dairy Sci, **66**, 1119.
28. **Van Tassel CP, Wiggangs GR, Misztal I** (2003). *Implemantation of a sire-maternal grandsire model for evaluation of calving ease in the United States.* J Dairy Sci, **86**, 3366-3373.
29. **Wedderburn RWM** (1974). *Quasi-likelihood functions, generalized linear models, and the gauss-newton method*, Biometrica, **61**, 439-447.

Geliş tarihi: 25.02.2013 / Kabul tarihi: 27.06.2013

Address for correspondence:
Dr. İ.Safa Gürcan
Ankara University,
Faculty of Veterinary Medicine,
Department of Biostatistics,
06110, Dışkapı, Ankara, Turkey