Biotechnology in Animal Husbandry 30 (1), p 79-88, 2014
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 636.082'636.39
DOI: 10.2298/BAH1401079Y

APPLICATION OF MULTIVARIATE LOGISTIC REGRESSION MODEL TO ASSESS FACTORS OF IMPORTANCE INFLUENCING PREVALENCE OF ABORTION AND STILLBIRTH IN NIGERIAN GOAT BREEDS

A. Yakubu[1*], M. M. Muhammed[2], I. S. Musa-Azara[2]

[1]Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia Campus, P.M.B. 135 Lafia, Nasarawa State, Nigeria.
[2]Department of Animal Science, College of Agriculture, Lafia, Nasarawa State, Nigeria.
*Corresponding author: abdulmojyak@gmail.com
Original scientific paper

Abstract: The aim of the study was to investigate the application of binary logistic regression to assess the potential factors associated with the prevalence of abortion and stillbirth in indigenous goat breeds in Nasarawa State, north central Nigeria. 5,268 kidding records of does from a total of 105 traditional goat herders from the year 2010-2011 were utilized in the study. The goats which were of West African Dwarf (WAD), Red Sokoto (RS), Sahel (SH) and WAD x RS crossbred (WR) genetic groups originated from different flocks and were reared under the traditional extensive system. The risk factors investigated were dam breed group, season, parity and number of foetuses. Of the 5,268 kidding records, 570 (10.8%) and 520 (9.87%) were cases of abortion and stillbirth, respectively. The logistic regression analysis revealed that season, parity and number of foetuses were the parameters of utmost importance ($P<0.05$) influencing the prevalence of abortion and stillbirth in the four genetic groups investigated. The logistic regression models were able to predict correctly 89.2 and 90.1% cases of abortion and stillbirth, respectively. The present information may be exploited in management practices to attenuate the incidence of abortion and stillbirth parturition, thereby increasing the productivity of the animals.

Key words: abortion, goats, logistic regression, Nigeria, stillbirth.

Introduction

Livestock form key components of the livelihood strategies of many of the world's poorest people, with different species fulfilling different functions in the household economy *(Anderson, 2003; Petrović et al., 2013)*. In Nigeria, goat

production plays an important role in the economic improvement of poor farmers and contributes to poverty alleviation *(Yakubu et al., 2011)*. However, one of the major constraints to a successful development of goat industry is the menace of abortion and stillbirth *(Odo, 2003; Adamu et al., 2012)*. Abortion implies expulsion of a foetus before full term and viability outside of the uterus. Stillbirth or premature delivery is expulsion of a term foetus that is considered viable. Antepartum death is characterized by variable degrees of autolysis, accumulations of blood-tinged fluids in body cavities, soft autolytic kidneys, and variable degrees of liquefaction of the brain *(Holler, 2012)*. Deaths associated with the parturition process are often less autolytic and display evidence of viability. Animals that have survived the birth process and died shortly after will have blood clots in umbilical vessels, aerated lungs, and minimal free fluid in body cavities. These early losses are associated with a wide range of physiologic, nutritional, environmental, and non-infectious causes that often go unrecognized. Abortion in goat herds at a level that significantly affects productivity is a common clinical problem *(Menzies, 2011)*. Reproductive failure due to abortion disease remains a significant revenue drain in many ruminant livestock production systems *(Simsek et al., 2012)*. Abortion rates vary among producers, production systems, and management styles, but in most situations, a rate much higher than 5% to 8% is usually deemed unacceptable and worthy of investigation *(Holler, 2012)*. Therefore, identification of the risk factors associated with abortion and stillbirth can aid in optimizing herd reproductive efficiency *(Yakubu et al., 2013)*.

There is dearth of information on links between various hypothesized risk factors and cases of abortion and stillbirth in Nigeria. The aim of this study therefore, was to investigate the application of logistic regression to assess the potential factors associated with the prevalence of abortion and stillbirth in indigenous goat breeds in north central Nigeria.

Materials and Methods

5268 kidding records of does from a total of 105 traditional goat herders within Nasarawa state north central Nigeria from the year 2010-2011 were utilized in the study. The goats which were of West African Dwarf (WAD), Red Sokoto (RS), Sahel (SH) and WAD x RS crossbred (WR) genetic groups originated from different flocks and were reared under the traditional extensive system. They grazed during the day on natural pasture containing forages such as stylo (*Stylosanthes gracilis*), leucaena (*Leucaena leucocephala*) and guinea grass (*Panicum maximum*), and scavenged on kitchen wastes such as dried yam peels whenever available. Sampling was restricted to only farmers that were able to give information on kid, buck and doe identification as well as occurrence of abortion, stillbirth (defined as a kid born dead or dying within 24 h after birth), kidding date

or period, parity and number of foetuses. Three seasons of abortion or stillbirth were generated according to the month of the year: rainy season (from May to October), dry season (from February to April) and harmattan season (from November to January). The rainy season is characterized by high temperatures, rain and abundant pasture. The dry season is characterized by high temperatures, lack of rain and scarce pasture. The harmattan season has lower temperatures with winds. No etiological diagnosis was made in aborted foetuses and stillbirths.

Statistical analysis

The logit of the probability of an abortion or stillbirth was modelled using logistic regression assuming an asymptotic binomial distribution. Logistic regression allows the prediction of group membership from a set of categorical and/or continuous variables (x). Generally, the dependent variable is dichotomous and can take the value 1 (member of the group) with a probability of success y, or the value 0 (non-member) with probability of failure 1 – y. The relationship between the dependent and independent variables is not a linear function. Instead, the logistic regression function is used, which is the logit transformation of y *(Dossa et al., 2008)*. First, the univariate analysis for all hypothesized risk factors (dam breed group, season, parity and number of foetuses) and the occurrence of abortion or stillbirth in the present study was carried out using Pearson's Chi-square (χ^2) test. Subsequently, a multivariate model was built by including every hypothesized risk factor which had p-value of $P<0.200$ from the univariate analysis, following the description of *Santos et al. (2012)* and *Ryan et al. (2012)*. Variables were retained, if p-value from the logistic regression was $P<0.05$, otherwise they were removed from the final model. Backward stepwise elimination based on Wald method was applied (Noordhuizen et al., 2001). The Chi-square goodness-of-fit test was performed to check if the multivariate logistic model fit the data well ($P>0.05$) *(Hosmer and Lemeshow, 2000)*. A further test of the accuracy of the logistic model was determined through the number of cases of abortion and stillbirth predicted correctly.

The multivariate model employed *(Czopowicz et al., 2012)* was:

$$P(Y=1) = \frac{1}{1 + \exp[-(B_0 + B_1 \times X_1 + ... + B_n \times X_n)]}$$

where,

$P(Y=1)$ = probability of a final outcome (abortion or stillbirth)
B_0 = intercept
B_1, B_n = regression coefficients for individual risk factors

X_1, X_n = risk factors (dam breed group, season, parity and number of foetuses)

The statistical package employed in the analysis was *SPSS (2010)*.

Results and discussion

The relationship between risk factors and the prevalence of abortion and stillbirth in Nigerian goats are shown in Table 1. Of the 5268 kidding records, 570 (10.8%) and 520 (9.87%) were cases of abortion and stillbirth, respectively. Following univariate statistical analysis, season (χ^2 =13.9; P=0.001) and parity (χ^2 =16.5; P=0.005) showed a clear association with the incidence of abortion while number of foetuses was the only single variable highly related to the occurrence of stillbirth (χ^2 =13.9; P=0). However, dam breed group, season, parity and number of foetuses (abortion) and season, parity and number of foetuses (stillbirth) were the eventual parameters fitted into the multivariate logistic regression models based on the significance level P<0.20.

Table 1. The association between risk factors and the prevalence of abortion and stillbirth in Nigerian goats

Parameters	No.of calvings	No.of abortion (%)	Chi-square (P-value)*	No.of stillbirth (%)	Chi-square (P-value)*
Breeds of goats					
Red Sokoto	1165	143 (12.3)	4.96 (0.175)	100 (8.6)	4.29 (0.232)
Sahel	1003	108 (10.8)		100 (10)	
West African Dwarf	2200	236 (10.7)		236 (10.7)	
Crossbred (WR)	900	83 (9.2)		84 (9.3)	
Season					
Rainy	2077	265 (12.8)	13.9 (0.001)	227 (10.9)	4.45 (0.108)
Dry	1480	148 (10)		139 (9.4)	
Harmattan	1711	157 (9.2)		154 (9.0)	
Parity number					
1	1668	215 (12.9)	6.54 (0.005)	179 (10.7)	7.42 (0.191)
2	1163	129 (11.1)		120 (10.3)	
3	895	92 (10.3)		90 (10.1)	
4	647	63 (9.7)		64 (9.9)	
5	500	42 (8.4)		38 (7.6)	
>5	395	29 (7.3)		29 (7.3)	
No. of foetuses					
1	2209	218 (9.9)	4.02 (0.134)	155 (7)	35.3 (0)
2	1597	178 (11.1)		196 (12.3)	
3	1462	174 (11.9)		169 (11.6)	

- Only parameters with P<0.2 were included in the subsequent multivariate logistic regression analysis.

Table 2. Logistic regression predicting the prevalence of abortion and stillbirth in Nigerian goats

Risk factor	B	S.E.	Wald's χ^2	P-value	Odds ratio	CI (95%)
Abortion						
Intercept	-1.700	0.156	119	0	0.183	-
Season	-0.197	0.054	13.5	0	0.822	0.740-0.912
Parity	-0.117	0.029	15.9	0	0.889	0.839-0.942
Number of foetuses	0.138	0.054	6.57	0.010	1.148	1.03-1.28
Stillbirth						
Intercept	-2.32	0.166	194	0	0.099	-
Season	-0.135	0.055	5.96	0.015	0.874	0.784-0.974
Parity	-0.080	0.030	7.17	0.007	0.923	0.870-0.979
Number of foetuses	0.295	0.056	27.6	0	1.343	1.20-1.50

B= regression coefficient, S.E.= standard error of B, CI= confidence interval
Hosmer and Lemeshow test: χ^2 = 10.3 versus 11.9; P= 0.242 versus 0.154 for prevalence of abortion and stillbirth, respectively.

The logistic regression models showed that season (odds ratio = 0.822 versus 0.874; P=0 versus 0.015), parity (odds ratio = 0.889 versus 0.923; P=0 versus 0.007) and number of foetuses (odds ratio =1.148 versus 1.343; P=0.010 versus 0) were associated with the prevalence of abortion and stillbirth, respectively (Table 2). The positive or negative sign of the coefficient (B) indicates the direction of the relationship between a given independent variable (X) and the dependent variable while the odds ratio gives the magnitude of the change in the odds of having the dependent variable event for a one unit change in the given independent variable. Hosmer and Lemeshow Chi-square goodness-of-fit test [χ^2 =10.3; P=0.242 (abortion); χ^2 =11.9; P=0.154 (stillbirth)] showed that the multivariate model proved to fit the observations and to explain the observed variations well.

The logistic model was quite reliable in predicting the prevalence of abortion and stillbirth in a herd, being able to identify 89.2% cases of abortion and 90.1 % cases of stillbirth, respectively (Table 3).

Table 3. Classification table for the multivariate logistic regression of risk factors affecting the prevalence of abortion and stillbirth in Nigerian goats*

		Predicted		
		Abortion		Percentage correct
Observed		0	1	
Abortion	0	4698	0	100
	1	570	0	0
Overall percentage				89.2
		Stillbirth		
Observed		0	1	
Stillbirth	0	4748	0	100
	1	520	0	0
Overall percentage				90.1

* The cut value is 0.5 in both cases of abortion and stillbirth.

Prenatal mortality is an important cause of production losses in the livestock industry *(Segura-Correa and Segura-Correa, 2009)*. Abortions can occur as outbreaks, but more often, they are sporadic. The present abortion rates are lower than the range 16.6-74.1% recorded for Mexican goats *(Villa et al., 2008)*. An abortion rate between 2% and 5% suggests that endemic disease may be present *(Menzies, 2011)*. This study reveals that the incidence of abortion and stillbirth is an important health problem in goat breeding in Nigeria. Therefore, the evaluation of contributory factors is justified. However, the present findings in goats are contrary to the report of *Odo (2003)* in southeastern Nigeria, where WAD x RS crossbreds had greater prevalence of abortion/stillbirth. It would appear that the risk factors for abortion and stillbirth vary widely in different parts of Nigeria, and that this local epidemiological knowledge together with knowledge of the infecting serovars, is very important from a herd health and disease control point of view. This may be a case for future investigation.

Season of kidding was a significant factor in the logistic regression model and seem to affect the prevalence of abortion and stillbirth in a similar fashion, as this appear lower in the harmattan and dry seasons compared to the rainy season. *Cantas et al. (2011)* found a seasonal variation in the occurrence of abortions in ruminants in northern Cyprus. The highest occurrence was experienced in October which gradually declined to the lowest in December. This trend follows the steady fall of temperatures that characterizing the transition from autumn to winter. However, in a related study in cattle, *Silva del Rıo et al. (2007)* reported greater calf mortality occurred during the cold seasons compared with warmer seasons. The regression coefficients for parity were negative in both cases of abortion and stillbirth. This is an indication that the greater the number of times a doe has given birth, the lesser the tendency to abort and record stillbirth. Research in sheep has shown that first parity animals had smaller and less efficient placentas resulting in

less viable lambs than those of older sheep. Similar report has been documented in beef cattle *(Segura-Correa and Segura-Correa, 2009)*. *Atashi (2011)* also reported that the stillbirth frequency was found to be significantly higher for first parity cows. The high stillbirth rate for the first kidding may be partly because of a disproportion between the size of the kid and the pelvic area, which causes a difficult kidding and increases stillbirth parturition incidence. The positive association between the number of foetuses and the prevalence of abortion and stillbirth indicates that the more the number of foetuses, the greater the propensity for abortion and stillbirth rate in the goat populations. However, *Segura-Correa and Segura-Correa (2009)* reported low values for the incidence of abortion and stillbirth in cattle. The high percentage of prediction of abortion as well as stillbirth is a justification of the fitness of the logistic regression model, which is increasingly being used in biological studies such as diagnosis decision processes and epidemiology *(Solorio-Rivera et al., 2007; Kalil et al., 2010; Ryan et al., 2012; Czopowicz et al., 2012)*.

The prospects for increased productivity based on efficient and sustainable exploitation of goats inherent unique features, such as adaptability, ability to thrive in harsh environmental conditions, resistance to disease etc should have the objective of increasing goat population in harmony with the carrying capacity of the veldt. Herd managers should review calving procedures with their veterinarian to ensure that proper timing and calving assistance techniques are used when providing assistance during parturition *(Atashi, 2011)*. In addition, providing a good environment for heifers and does to minimize stress before parturition can reduce stillbirth incidence. It is noteworthy that appropriate precautions should be taken to avoid zoonotic infection of personnel (in clinical or diagnostic settings) with reproductive pathogens. Biosecurity is an important consideration for any abortion control program, and should be promoted regardless of whether an abortion problem exists in the flock *(Menzies, 2011)*. Appropriate immunization to prevent infection often can reduce reproductive losses in domestic animals *(Givens and Marley, 2008)*. Prospective field studies of abortion or stillbirth are very expensive and not routinely applicable in the field. Therefore, the present study on Nigerian goats has significant implications for farmers and veterinary practitioners/herd health consultants as informed risk analysis is the key to successful decision making in relation to reproductive problem control on farms.

Conclusion

In the present study, the multivariate logistic models showed that season, parity and number of foetuses were the most important parameters affecting the prevalence of abortion and stillbirth in WAD, RS, SH and WR goats. The present

information may therefore be exploited in management practices to reduce to the minimum the incidence of abortion and stillbirth parturition in order to improve the production level of the goat farmers.

Primena multivarijacionog logističkog regresionog modela za utvrđivanje faktora koji imaju značajan uticaj na rasprostranjenost abortusa i prevremenog porođaja u nigerijskoj rasi koza

A. Yakubu, M.M. Muhammed, I.S. Musa-Azara

Rezime

Cilj studije bio je da se istraži primena binarne logističke regresije za procenu potencijalne faktora povezanih sa rasprostranjenošću abortusa i prevremenog porođaja u autohtonim rasama koza u državi Nasarava, u severno-centralnoj Nigeriji. Podaci o 5.268 jarenja od ukupno 105 koza tradicionalnih uzgajivača iz 2010-2011 godine su korišćeni u studiji. Koze rasa/genetskih grupa West African Dwarf (WAD), Red Sokoto (RS), Sahel (SH) i melezi WAD x RS (WR) poreklom iz različitih stada su držane u tradicionalnom ekstenzivnom sistemu. Faktori rizika koji su ispitivani su sledeći: grupa rasa ženskih grla, sezona, paritet i broj fetusa. Od 5.268 podataka o jarenju, 570 (10,8 %) i 520 (9.87 %) su bili slučajevi abortusa i prevremenog porođaja, respektivno. Logistička regresiona analiza pokazala je da sezona, paritet i broj fetusa su parametri od izuzetnog značaja ($P < 0.05$) koji utiču na rasprostranjenost abortusa i prevremenog porođaja u četiri ispitivane genetske grupe. Logistički regresioni modeli su bili u stanju da predvide ispravno 89,2 i 90,1 % slučajeva abortusa i prevremenog porođaja, respektivno. Ove informacije se mogu eksploatisati u praksi upravljanja da ublaže pojavu abortusa i mrtvorođene jaradi, čime se povećava produktivnost životinja .

References

ADAMU M., MSHELIA G.D., ELELU N., OUDA L., EGWU G.O. (2012): Studies on farmer awareness on caprine abortion and the presence of Brucella abortus and Brucella melitensis in selected flocks in an arid zone of Nigeria. Journal of Veterinary Medicine and Animal Health, 4, 17-21.

ANDERSON S. (2003): Animal genetic resources and livelihoods. Ecological Economics 45, 331-339.

ATASHI H. (2011): Factors affecting stillbirth and effects of stillbirth on subsequent lactation performance in a Holstein dairy herd in Isfahan. Iranian Journal of Veterinary Research 1, 24-30.
CANTAS H., MUWONGE A., SAREYYUPOGLU B., YARDIMCI H., SKJERVE E. (2011) : Q fever abortions in ruminants and associated on-farm risk factors in northern Cyprus. BMC Veterinary Research, 7, 13, http://www.biomedcentral.com/1746-6148/7/13
CZOPOWICZ M., KABA J., SZALUŚ-JORDANOW O., NOWICKI M., WITKOWSKI L. AND FRYMUS T. (2012): Multivariate model for the assessment of risk of fetal loss in goat herds. Polish Journal of Veterinary Science, 15, 67-75.
DOSSA L. H., RISCHKOWSKY B., BIRNER R. AND WOLLNY C. (2008): Socio-economic determinants of keeping goats and sheep by rural people in southern Benin. Agriculture and Human Values, 25, 581–592.
GIVENS M.D. AND MARLEY M.S.D. (2008): Infectious causes of embryonic and fetal mortality. Theriogenology, 70, 270-285.
HOLLER L. D. (2012): Ruminant abortion diagnostics. Veterinary Clinic of North America: Food Animal Practice 28, 407–418.
HOSMER, D. W. AND LEMESHOW S. (2000): Applied Logistic Regression. 2nd ed. John Wiley and Sons, New York, USA. p 375.
KALIL A.C., MATTEI J., FLORESCU D.F., SUN, J., KALIL R.S. (2010): Recommendations for the assessment and reporting of multivariable logistic regression in transplantation literature. American Journal of Transplantation, 10, 1686-1694.
MENZIES P. I. (2011): Control of important causes of infectious abortion in sheep and goats. Veterinary Clinic of North America: Food Animal Practice, 27, 81–93.
NOORDHUIZEN J.P., THRUSFIELD M.V., FRANKENA K., GRAAT E.A.M. (2001): Application of quantitative methods in veterinary epidemiology. 2nd ed., Wageningen Pers, Wageningen, Holland.
ODO B. I. (2003): Comparative study of some prevalent diseases of ecotype goats reared in southeastern Nigeria. Small Ruminant Research, 50, 203-207.
PETROVIĆ M.M., ALEKSIĆ S., PETROVIĆ M.P., PETROVIĆ M., V. PANTELIĆ V., NOVAKOVIĆ Z., RUŽIĆ-MUSLIĆ D. (2013): Potentials of Serbian livestock production- outlook and future. Biotechnology in Animal Husbandry, 29, 1-17.
RYAN E.G., LEONARD N., O'GRADY L., DOHERTY M.L., MORE S.J. (2012): Herd-level risk factors associated with Leptospira Hardjo seroprevalence in Beef/Suckler herds in the Republic of Ireland. Veterinary Journal 65, 6, (http://www.irishvetjournal.org/content/65/1/6).
SANTOS C.S.A.B., PIATTI R.M., AZEVEDO S.S., ALVES C.J., HIGINO, S.S.S., SILVA M.L.C.R., BRASIL A. W.L., GENNARI S.M. (2012): Seroprevalence and risk factors associated with Chlamydophila abortus infection in

dairy goats in the Northeast of Brazil. Pesquisa Veterinária Brasileira, 32, 1082-1086.
SEGURA-CORREA J.C., SEGURA-CORREA V.M. (2009): Prevalence of abortion and stillbirth in a beef cattle system in Southeastern Mexico. Tropical Animal Health and Production, 41, 1773–1778.
SILVA DEL RIO N., STEWART S., RAPNICKI P., CHANG, Y.M. AND P.M. FRICKE (2007): An observational analysis of twin births, calf sex ratio, and calf mortality in Holstein dairy cattle. Journal of Dairy Science 90, 1255-1264.
SIMSEK S., RISVANLI A., ZONTURLU A.G., DEMIRAL O., SAAT N. (2012): Absence of link between abortion and seropositivity of cystic hydatid disease in ewes and female goats in Turkey. Veterinaria Italiana, 48, 323-327.
SOLORIO-RIVERA J.L., SEGURA-CORREA J.C., SANCHEZ-GIL L.G. (2007): Seroprevalence of and risk factors for brucellosis of goats in herds of Michoacan, Mexico. Preventive Veterinary Medicine, 82, 282–290.
SPSS (2010): Statistical Package for Social Sciences. SPSS Inc., 444 Michigan Avenue, Chicago, IL60611.
VILLA R., PEREA M., APARICIO E.D., MOBARAK A.S., ANDRADE L.H., GÜEMES F.S. (2008): Abortions and stillbirths in goats immunized against brucellosis using RB51, rfbK and Rev 1 vaccines. Tec Pecu Mex, 46, 249-258.
YAKUBU A., SALAKO A.E., IMUMORIN I.G. (2011): Comparative multivariate analysis of biometric traits of West African Dwarf and Red Sokoto goats. Tropical Animal Health and Production, 43, 561-566.

Received 25 November 2013; accepted for publication 31 January 2014