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

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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 (Menzie, 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:

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

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 ($\chi^2 = 13.9$; $P=0.001$) and parity ($\chi^2 = 16.5$; $P=0.005$) 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 ($\chi^2 = 13.9$; $P=0$). 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: $\chi^2 = 10.3$ 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 [$\chi^2 =10.3$; P=0.242 (abortion); $\chi^2 =11.9$; 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 | 100 |
| | 1 | 570 | 0 |
| Overall percentage | | | 89.2 |
| | Stillbirth | | |
| Observed | 0 | 1 | |
| Stillbirth | 0 | 4748 | 100 |
| | 1 | 520 | 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 Rio 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 fetuses and the prevalence of abortion and stillbirth indicates that the more the number of fetuses, 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 fetuses 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

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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 mrtvorodne jaradi, čime se povećava produktivnost životinja.

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