MedCrave
Step into the World of Research
Journal of Dairy, Veterinary & Animal Research

Research Article
Open Access
CrossMark

The survival analysis of the potential risk factors affecting lamb mortality in deccani sheep

Abstract

The lamb mortality is critical component in sheep industry. The present study was carried out to determine the lamb mortality and its associated factors in Deccani sheep using survival analysis. The data records of 2168 lambs reared at ICAR-Network Project on Sheep Improvement, MPKV, Rahuri(India) were obtained from inventory and death registers for the period of January 2005 to December 2015. The survival analysis of lamb mortality using Cox proportional hazard model was undertaken to determine the potential risk factors affecting lamb mortality in the study. All statistical analyses were done using R 3.1.0 Software. The overall lamb mortality for birth to 1month age, birth to weaning age and birth to 1year age was 2.21%, 4.70% and 10.10%, respectively. It was found that lambs with low birth weight had greater risk of mortality than heavier lambs at birth. Male lambs were at higher hazards of mortality than female lambs. Furthermore, higher risk of mortality was observed in rainy season as compared to other seasons. In order to reduce the economic losses due to lamb mortality, implementation of improved farm practices according to seasonal variation, flock structures(pregnant ewes, newly born lambs etc.) is suggested.

Keywords: sheep, mortality, birth weight, survival, cox model

Volume 4 Issue 2 - 2016

YC Bangar, ST Pachpute, RG Nimase
Mahatma Phule Krishi Vidyapeeth, India

Correspondence: Yogesh Bangar, Research Associate, ICAR-Network Project on Sheep Improvement(Deccani Farm Based Unit), Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India -413722;Tel +9194 2203 5120,
Email yogeshbangar07@gmail.com

Received: August 09, 2016 | **Published:** November 15, 2016

Abbreviations: ICAR, indian council of agricultural research; CI, confidence interval

Introduction

India holds third rank in the world regarding the sheep population and possesses 65.07 million sheep with majority(94.19%) indigenous breeds.[1] The sheep with its multi-utility value such as meat, wool, skin and other byproducts play important role in Indian economy especially in semi-arid region. The sheep are among main meat producing animals in India, whose mutton is one of the highly preferred meats and had huge demand. India has exported 23, 611.55 MT of sheep and goat meat to the world for worth of Rs. 828.11 crores during 2014-15.[2] Beside that it has scope for creation of employment opportunities in rural areas. It leads to the sheep farming as an important farming system in India as compared to other species.

The lamb mortality is the critical component in sheep industry and causes direct losses to animal owners. The lamb mortality is associated with several factors such as birth weight, age, sex, ewe weight at lambing, environment and managemental practices.[3–11] Since the sheep rearing is done by the most nomadic communities in India, the animal faces many challenges particularly seasonal variations which lead to stress and risk of various infections. The morbidity may lead to indirect losses but the death of animal causes huge economic loss to shepherd. It is essential to understand the factors affecting the lamb mortality to reduce economic losses to farmer's income. Moreover, it may help to improve management strategies towards lamb survival up to weaning period and even then after.

The survival analysis is method of choice to study the lamb mortality and its associated factors because it accounts the time span up to death. Several authors[12–16] have used survival function for evaluating the lamb mortality in sheep. It provides the risk of death in an individual after particular time and also estimates the hazard function for study the risk of dying in particular group against the other group.

The aim of the study was to estimate the survival function for lamb mortality and to determine the hazards of death due to various factors affecting the lamb mortality in Deccani sheep using survival analysis.

Material and methods

The present reseach work was undertaken at ICAR- Network Project on Sheep Improvement(Deccani Farm Based Unit), Mahatma Phule Krishi Vidyapeeth, Maharashtra(India). The funding agency for this project is Indian Council of Agricultural Research, New Delhi(India). Deccani is indigenous breed of sheep in India mainly found in western Maharashtra State.

Feeding and management

The feeding and management practices followed at the project were more or less uniform throughout theyear. The ewes and rams were let loose for grazing in pasture, harvested fields and surrounding hillocks of the project in day time i.e. 10 am to 4 pm. Apart from grazing all animals including 3 to 6 and 6 to 12month of age were fed with green and dry fodder in the morning and evening as per the requirements. In addition to this, definite quantity of concentrates was also fed to all animals in the evening. The structure of sheep farm was constructed with consideration of separate pens for lambing ewes, ewes with lambs of 0 to 3months, lambs of 3 to 6months, lambs of 6 to 12months, rams, ewes of tester flock and ewes of improver flock. There was also separate isolation pen for diseased animals.

The ewes after lambing were kept along with lamb in lambing pen for one week. The lambs whose dam was died in early period were given special artificial rearing including milk of another ewe. After one week of age, lambs were shifted to another pen(ewes with lambs of 0 to 3months). The weaning period for lambs was typically

90days of age. The special veterinary clinic facility was taking care of ill animals. The selection of rams for breeding was based on their progeny performance. The body weight of progeny at 6month was the criteria for selection of rams. The ranked sires were utilized for genetic improvement of Deccani breed.

Data collection

The data records of 2168 Deccani lambs of 120 sires and 716 dams maintained at Network Project was collected for the period of January 2005 to December 2015. The lamb records including birth date, dam and sire of lamb, birth weight, Sex, parity of dam, type of birth(whether single or twinning), date and reason of death were taken from inventory and death registers. In the present study, birth weight(kg), sex(male/female), parity of dam(1 to 10), type of birth(single/twinning) and season of birth(rainy/dry) were considered. The rainy season was frommonth of May to October whereas dry season was frommonth of November to April.

The survival time of lamb was calculated from date of birth to date of death. The endpoint was considered as death of lamb in the study. The three study periods viz. birth to 1month(0 to 30days), birth to weaning period(0 to 90days) and birth to 1year(0 to 365days) were considered in the study. The lambs which were sold or culled during particular study period were considered as censored observations. The lambs which alive at the end of study period were also considered as censored observations. The censoring time for the lambs that sold or culled during the study period was the time up to leaving the study. For censored lambs which were alive at the end of each study period, the survival time was considered the last day of the study period. All censored lambs were coded as 0 and remaining lambs that die during study period were coded as 1.

Statistical analysis

The descriptive statistics was performed to calculate the lamb mortality(%) in respective study periods. The Kaplan-Meier estimates[17] of survival functions were obtained to understand the mortality pattern with consideration of censored data. Then mean survival time was calculated for each survival period.

To study the effects of various factors on survival of Deccani lambs, Cox proportional hazard model was used in the study. This model estimates the hazard(or risk) of death for an individual after adjustment for other explanatory variables. The hazard function $h_i(t)$ which gives the instantaneous death rate for lamb i at surviving time t is given as[18,19]

$$h_i(t) = h_0(t) \exp(b_1X_{i1} + b_2X_{i2} + \ldots\ldots + b_kX_{ik})$$

This equation can be described as a linear fixed-effects proportional hazard model by taking natural logarithms as follows,

$$\ln[h_i(t)] = \ln[h_0(t)] (b_1X_{i1} + b_2X_{i2} + \ldots\ldots + b_kX_{ik})$$

Where $h_0(t)$ represent an unspecified baseline hazard function and corresponds to the probability of dying when all the explanatory variables are zero. The ratio of $h(t)/h_0(t)$ is hazard ratio which provides an estimate of the risk per unit change in the explanatory variables relative to the baseline hazard function.[19] The regression coefficients b_i provide the proportional change that can be expected in the hazard, related to changes in the explanatory variables. In the present study, the parity of dam of lamb was used as strata in above model.

All statistical analyses were done using various packages of "survival" library of R software R 3.1.0 software(Comprehensive R Archive Network, http://cran.r-project.org). The assumption of proportional hazards was tested using "cox.zph" function and the Cox proportional hazard model was fitted using "coxph" function. The graphical representation of estimated survival functions was done using a "Survfit" function.

Results

The descriptive statistics for lamb mortality and survival time for three study periods is presented in Table 1. The lamb mortality in Deccani sheep was observed as 2.21%, 4.70% and 10.10% in birth to 1month, birth to weaning and birth to 1year respectively. The mean survival times were 29.54, 87.43 and 338.95days in birth to 1month, birth to weaning and birth to 1year respectively.

The survival function for the three periods was estimated using Kaplan-Meier Method and is given in Figure 1–3. The survival curve estimates the probability of mortality at particular day. The line marking on the survival curve indicates the censored lambs and outer dotted lines represent the confidence interval for estimated survival function.

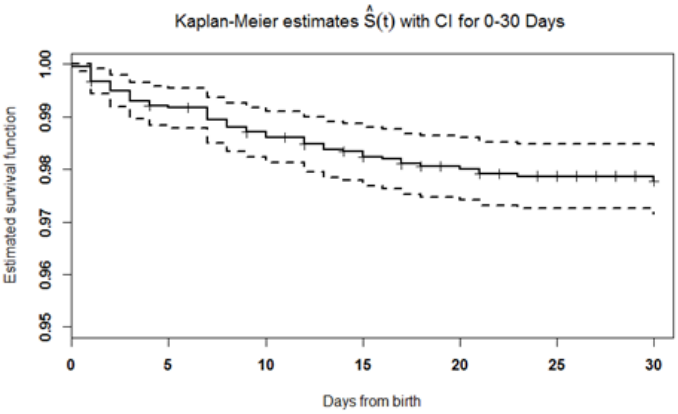

Figure 1 Estimating survival time for period of birth to 1month in deccani lambs.

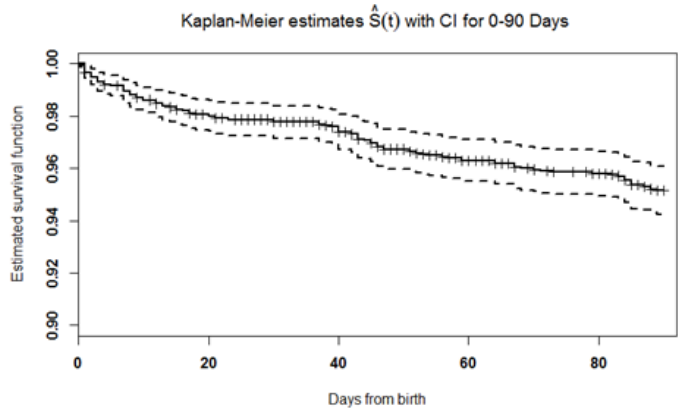

Figure 2 Estimating survival time for period of birth to weaning in deccani lambs.

The proportional hazards assumption was tested and the results

are given in Table 2. The results of testing of the proportional hazard assumption were revealed that the factors had proportional($p > 0.05$) relationship with hazard over the period. However birth to 1year period, it was found to be significant($p < 0.001$) for birth weight of lamb. The likelihood ratio test was significant($p < 0.001$) for all study periods, which indicates the goodness of fit of Cox model for lamb mortality in the study.

The Cox proportional hazard model was used to estimate the effects of various factors on survival of Deccani lambs in three study periods and the results are presented in Table 3. The birth weight of lamb was found to significant($p<0.001$) for lamb mortality during all study period($p<0.001$). The log hazard(b) was negative and it was interpreted that there was reduction of 1.69 log hazards for unit increase in birth weight. The hazard ratio for birth weight of lamb was 0.18(95% CI: 0.12, 0.30) for the period of birth to 1month which indicates that hazard of death was decreases(0.18times) as birth weight increases by one kg, after adjustment of other variable in the model. Similarly, the hazard of death was decreases 0.23(95% CI: 0.16, 0.33) and 0.53(95% CI: 0.40, 0.69) times for period of birth to weaning and birth to 1year if lamb could get 1kg extra birth weight respectively, after adjustment of other variable in the model.

Table 1 Lamb mortality (%) and average survival time in three study periods

		Study periods		
		Birth to 1month	**Birth to weaning**	**Birth to 1year**
Mortality (%)	Total	2.21(48/2168)	4.70(102/2168)	10.10(219/2168)
	Male	2.67(28/1049)	5.34(56/1049)	10.96(115/1049)
	Female	1.79(20/1119)	4.11(46/1119)	9.29(104/1119)
Mean survival time(Days)		29.54±0.07	87.43±0.28	338.95±1.79

Figures in parenthesis indicate number of observation at the start of period

Table 2 Testing of proportional hazard assumption for survival analysis in deccani lambs

	Birth to 1month			**Birth to weaning**			**Birth to 1year**		
Factor	**rho**	**Chisq**	**p value**	**rho**	**Chisq**	**p value**	**rho**	**Chisq**	**p value**
Birth Weight	-0.07	0.12	0.73	0.13	1.65	0.2	0.36	31.22	0
Sex	0.27	3.4	0.07	0.13	1.68	0.19	-0.01	0.03	0.86
Season	-0.05	0.15	0.7	-0.2	3.97	0.05	-0.02	0.13	0.72
Type of Birth	0.03	0.04	0.84	-0.01	0.02	0.88	-0.07	1.15	0.28
Global	NA	3.63	0.46	NA	7.77	0.1	NA	31.95	0
LRT	53.19, p<0.001			63.09, p<0.001			31.39, p<0.001		

NA, non-applicable; LRT, likelihood ratio test

Table 3 Cox-PH modeling for various factors affecting survival in deccani lambs

			Parameter estimates				**Hazard ratio**	
Period (Age)	**Factor**		**b**	**SE(b)**	**z**	**p value**	**Exp(b)**	**95% CI**
Birth to 1month	Birth weight		-1.69	0.24	-7.03	0	0.18	0.12, 0.30
	Sex	Male	0.59	0.3	1.98	0.05	1.8	1.01, 3.23
		Female	0				1	
	Season	Rainy	0.79	0.39	2.02	0.04	2.19	1.02, 4.71
		Dry	0				1	
	Type of birth	Single	-0.03	0.6	-0.05	0.96	0.97	0.30, 3.15
		Twin	0				1	
Birth to weaning	Birth weight		-1.46	0.18	-8.23	0	0.23	0.16, 0.33
	Sex	Male	0.42	0.2	2.08	0.04	1.52	1.02, 2.26
		Female	0				1	
	Season	Rainy	0.17	0.22	0.77	0.44	1.18	0.77, 1.81
		Dry	0				1	
	Type of birth	Single	0.23	0.46	0.51	0.61	1.26	0.51, 3.13
		Twin	0				1	

Citation: Bangar YC, Pachpute ST, Nimase RG. The survival analysis of the potential risk factors affecting lamb mortality in deccani sheep. *J Dairy Vet Anim Res.* 2016;4(2):266–270. DOI: 10.15406/jdvar.2016.04.00114

Table Continued..

			Parameter estimates				Hazard ratio	
Period (Age)	**Factor**		**b**	**SE(b)**	**z**	**p value**	**Exp(b)**	**95% CI**
Birth to 1year	Birth weight		-0.64	0.14	-4.53	0	0.53	0.40, 0.69
	Sex	Male	0.32	0.14	2.32	0.02	1.37	1.05, 1.80
		Female	0				1	
	Season	Rainy	0.37	0.15	2.42	0.02	1.44	1.07, 1.95
		Dry	0				1	
	Type of birth	Single	-0.09	0.3	-0.29	0.77	0.92	0.51, 1.66
		Twin	0				1	

SE, standard error; Exp, exponential function; CI, confidence interval

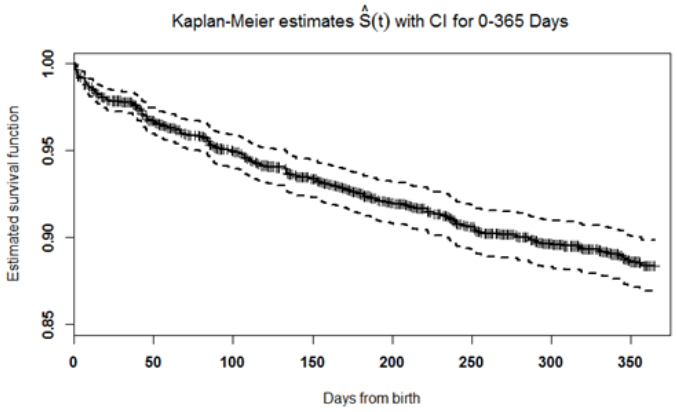

Figure 3 Estimating survival time for period of birth to 1year in deccani lambs.

The sex of lamb was also observed to be significantly($p < 0.05$) affecting survival of Deccani lamb for all three study periods. The hazard ratio between male and female category during period of birth to 1month was 1.80(95% CI: 1.01, 3.23) and it indicates that the hazard of death was 1.80 times higher in male as compared to female(1.00). The hazard of death was 1.52(95% CI: 1.02, 2.26) and 1.37(95% CI: 1.05, 1.80) times greater in male than females in period of birth to weaning and birth to 1year respectively.

The season of birth of lamb was also significantly affected the survival of Deccani lamb for study period of birth to 1month($p<0.05$) and birth to 1year($p<0.05$). There was no significant($p>0.05$) difference for birth to weaning period. The hazard of death was 2.19(95% CI: 1.02, 4.71) and 1.44(95% CI: 1.07, 1.95) times higher in rainy season than dry season(1.00) for birth to 1month age and birth to 1year age respectively. It was observed that the hazards rates were not significantly($p>0.05$) different between single birth and twinning. Therefore it was concluded that the lamb mortality was not affected significantly due to type of birth.

Discussion

The lamb mortality is major component in sheep rearing as it affects economically to farmers and disturbs farm replacement structure.[20] The mortality in lambs is generally estimated as a binary outcome and the effects of various explanatory variables on mortality are being estimated using binary logistic regression. However, logistic approach does not accounts the age of lamb at death and therefore, the mortality in up to 1year old lambs is calculated by considering all lambs as equal weight. Southey et al.[13] have compared survival approach with logistic approach for lamb mortality and concluded that the estimates due to survival analysis had lower standard error than logistic analysis.[13]

We have used survival approach which accounts for the time spanned by lamb up to death in this study. The Cox proportional hazard model assumes proportional hazards along with time.[19] In the present study, we have used parity of ewe as strata to get valid estimate of hazard ratios for various explanatory variables. We observed that there was violation of proportional hazard assumption for period of birth to 1year due to birth weight. This might be due to some lambs that had higher birth weights were died after weaning period, which leads to non-proportional relationship with hazard of death.

The observed lamb mortality in this study was lower than the estimates reported by several authors.[9,13] This may be due to time to time selling and culling of lambs at the project. In this study, major causes of lamb mortality were digestive, respiratory, worm load and some accidental causes. There was any no major disease outbreak during the study period.

The Cox model provided the significant effect of birth weight on survival of lamb and it indicates that birth weight was priority criteria for survival of lamb in initialdays.[11,21] The high lamb mortality was associated with low birth weight.[5,8] It also was observed that the effect of birth weight was higher in first period and then it was declining over period may be because of managerial factors at the Project.

The sex of lamb was found to be significantly affecting the survival of lamb. The higher risk of mortality in male lambs versus female lambs was also reported by several authors.[13,22,23] However, the hazard ratio between male and female was observed declining over period. The association between lamb mortality and season of birth is also reported by Mukasa-Mugerwa et al.[24] The seasonal variation leads to increase the risk of mortality in lambs which can be minimized by necessary practices such as deworming at right time and preventive measures to incidences of various infections to young animals. Vatankhah & Talebi[9] suggested that the lamb mortality should be minimized through farm management and genetic selection at farm.[9]

Conclusion

The cox proportional hazard modelling revealed that the survival of lamb was affected significantly by many factors. The birth weight had major role on survival of lamb in all three periods. The male lambs had more risk of death than the female lambs. The hazards of death were more in rainy season than in dry season. Therefore,

Citation: Bangar YC, Pachpute ST, Nimase RG. The survival analysis of the potential risk factors affecting lamb mortality in deccani sheep. *J Dairy Vet Anim Res.* 2016;4(2):266–270. DOI: 10.15406/jdvar.2016.04.00114

the implementation of farm practices mainly improving the care of pregnant ewes, newly born lambs and cautions for seasonal variation at the farm may increase the survival of lambs and ultimately boost the profitability.

Acknowledgements

The authors are thankful to the Director, ICAR-Central Sheep and Wool Research Institute, Avikanagar(Rajasthan), India for providing funding and the necessary facility to conduct this study.

Conflict of interest

Author declares that there is no conflict of interest.

References

1. Anonymous. *Basic Animal Husbandry & Fishery Statistics*. Department of Animal Husbandry, Dairying and Fisheries. Govt. of India. 2014.
2. Agricultural and Processed Food Products Export Development Authority.
3. Yapi CV, Boylan WJ, Robinson RA. Factors associated with causes of pre-weaning lamb mortality. *Prev Vet Med*. 1990;10(1–2):145–152.
4. Gama LT, Dickerson GE, Young LD, et al. Effects of breed, heterosis, age of dam, litter size, and birth weight on lamb mortality. *J Anim Sci*. 1991;69(7):2727–2743.
5. Morris CA, Hickey SM, Clarke JN. Genetic and environmental factors affecting lamb survival at birth and through to weaning. *New Zeal J Agr Res*. 2000;43(4):515–524.
6. Christley RM, Morgan KL, Parkin TD, et al. Factors related to the risk of neonatal mortality, birth-weight and serum immunoglobulin concentration in lambs in the UK. *Prev Vet Med*. 2003;57(4):209–226.
7. Everett-Hincks JM, Lopez-Villalobos N, Blair HT, et al. The effect of ewe maternal behavior score on lamb and litter survival. *Liv Prod Sci*. 2005;93(1):51–61.
8. Mandal A, Prasad H, Kumar A, et al. Factors associated with lamb mortalities in Muzaffarnagari sheep. *Small Rumin Res*. 2007;71(1–3):273–279.
9. Vatankhah M, Talebi MA. Genetic and Non-genetic Factors Affecting Mortality in Lori-Bakhtiari Lambs. *Asian-Australian J Anim Sci*. 2009;22(4):459–464.
10. Chniter M, Hammadi M, Khorchani T, et al. Phenotypic and seasonal factors influence birth weight, growth rate and lamb mortality in D'man sheep maintained under intensive management in Tunisian oases. *Small Rumin Res*. 2011;99(2–3):166–170.
11. Oldham CM, Thompson AN, Ferguson MB, et al. The birthweight and survival of Merino lambs can be predicted from the profile of liveweight change of their mothers during pregnancy. *Anim Prod Sci*. 2011;51:776–783.
12. Lopez-Villalobos N, Garrick DJ. Genetic parameter estimates for survival in Romney sheep. *Proc New Zeal Soc Anim Prod*. 1999;59:121–124.
13. Southey BR, Rodriguez-Zas SL, Leymaster KA. Survival analysis of lamb mortality in a terminal sire composite population. *J Anim Sci*. 2001;79(9):2298–2306.
14. Cloete SWP, Greeff JC, Lewer RP. Environmental and genetic aspects of survival and early liveweight in Western Australian Merino sheep. *South African J Anim Sci*. 2001;31(2):123–130.
15. Southey BR, Rodriguez-Zas SL, Leymaster KA. Discrete time survival analysis of lamb mortality in a terminal sire composite population. *J Anim Sci*. 2003;81(6):1399–1405.
16. Piwczyński D, Mroczkowski S, Sitkowska B. Survival analysis of lambs using Cox's proportional hazards' modeling and Kaplan-Meier method. *Rocz Nauk PTZ*. 2010;6(4):81–89.
17. Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. *J American Stat Assoc*. 1958;53(282):457–481.
18. Cox DR. Regression models and life tables. *J R Stat Soc Series B*. 1972;34:187–220.
19. Collett D. *Modelling Survival Data in Medical Research*. 2nd ed. London: Chapman & Hall/CRC; 2003.
20. Morel PCH, Morris ST, Kenyon PR. Effects of birth weight on mortality in triplets born lambs. *Aust J Exp Agric*. 2008;48:984–987.
21. Schreurs NM, Kenyon PRS, Morris T, et al. Effect of birth weight on survival of lambs born to ewe lambs. *Proc New Zeal Soc Anim Prod*. 2010;70:101–103.
22. Nash ML, Hungerford LL, Nash TG, et al. Risk factors for perinatal and postnatal mortality in lambs. *Vet Rec*. 1996;139(3):64–67.
23. Sawalha RM, Conington J, Brotherstone S, et al. Analysis of lamb survival of Scottish Blackface sheep. *Animal*. 2007;1(1):151–157.
24. Mukasa-Mugerwa E, Lahlou-Kassi A, Anindo D, et al. Between and within breed variation in lamb survival and the risk factors associated with major causes of mortality in indigenous Horro and Menz sheep in Ethiopia. *Small Rumin Res*. 2000;37(1–2):1–12.