AGB -22

Fulani Ecotype Chicken Genetic Resource under a Pastured Poultry Management System- 3-Survival Analysis and Risk Factors for Mortality

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Abstract

The objective of this study was to characterize and quantify risk factors associated with mortality in Fulani ecotype chickens (FEC) during the laying period. Survival analysis and Cox Proportional Hazards regression were used to describe the probability of mortality in two batches of laying FEC hens with body weight at the point of lay (POL) and body weight at mortality evaluated as potential risk factors. Survival function distribution showed that proportional mortality was higher in batch 1 as compared to batch 2 layers (12% vs.6%). Body weight at the POL did not significantly influence mortality in the pooled as well as in the separate analysis for each population of layers. In contrast, body weight at mortality significantly affected probability of mortality in the pooled data and in both populations. The magnitude of influence was higher in batch 2 than 1, with 0.8% vs. 0.4% increase in risk of mortality respectively for batches 1 and 2 hens, with every unit decrease in body weight below the mean (1073.08 g). This may imply that hens in batch 1 were more sensitive to body weight reduction post-POL compared to batch 2 hens. This study has demonstrated that factors causing a reduction in body weight post-POL could be risk factors for mortality in laying FEC chickens.

Keywords: Survival analysis, Cox regression model, mortality, hazard ratio, Fulani ecotype chickens

Introduction

Fulani ecotype chickens (FEC) possess good egg quality, adaptability and growth performance (Fayeye *et al.,* 2005). On the basis of its promising potentials, there is the need for detailed characterization of FEC, including its survivability under pastured conditions as this is necessary to document survival characteristics and risk factors for mortality of laying FEC hens.

Survival analysis is used to analyze data for which the outcome of interest is "time until the event" occurs (Famula, 1981). The event could be death, disease occurrence, disease recurrence, recovery, or other experience of interest. A major characteristic of survival analysis is that it considers both censored (i.e. animals that are still alive at the end of the study period or those that were culled) and uncensored (i.e. animals that died during the study period) observations in a single analysis. In survival analysis, statistical techniques such as Kaplan-Meier survival estimate (non-parametric) are used to describe the time-to-event of a particular population using the survival function $S(t)$ which describes the probability that an individual survived for longer than a specified time t (Kleinbaum, 1996).

Popular models used in survival analysis are the Weibull (parametric) and Cox proportional hazards regression (semi-parametric) with both models based on the concept of proportional hazard which defines hazard function for individual (hen) as the probability of the hen dying or culled just prior to time t (Ducrocq and Solkner, 1998*)*. For laying hens, time (t) could be mid-lay (26weeks), a particular period during the laying period or end of lay (e.g. 52 weeks). Survival analysis evaluates the relative timing of events (e.g. mortality) and can assess the relative importance of risk factors towards the events. Specifically, analysis of survival data of FEC hens during the laying period to assess risk factors for mortality using survival analysis has not been done.

The objective of this study was to conduct a survival analysis using the proportional hazard regression model of Cox (1972) to evaluate risk factors with occurrence of mortality in laying FEC.

Materials and Methods

The study was conducted using two batches of FEC (of 60 and 83 pullets), sourced from an established population stock at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria. The pullets were vaccinated against Newcastle disease, tagged and monitored until the 45th week of lay. Each hen had records on survival status (alive or dead, 0/1 at the end of the study), survival days (from start of the study to death or end of study (315 days), body weight at the point of lay (POL) and body weight at mortality. Dead hens were removed, identified, weighed and recorded.

The Cox proportional hazards model (Cox, 1972) was used to analyze time to the occurrence of mortality. A hazard function is the probability or risk of death of a chicken at time *t.* The hazard function, $h_i(t)$, for an observation is: $h_i(t)=\lambda(t;Z_i) = \lambda_0(t)\exp(Z_i\beta)$
where $\lambda_0(t)$ is a baseline hazard function that is unspecified, and z_i is the vector of covariate for individual *i* and β the vector of unknown regression parameters associated with the covariates (Aggrey and Marks, 2002). Body weight (BW) at POL and BW at mortality was used as covariates in the model. Baseline hazard function can be regarded as the hazard function for an individual whose covariates all have values of zero i.e. the probability of mortality of a hen at 45 weeks if mortality was not influenced by BW at the POL and BW at mortality.

The Cox's proportional hazard model also provides the hazard ratio (HR). For quantitative covariates (i.e. BW at POL and BW at mortality), subtracting 1.0 from HR and multiplying by 100 gives the estimated percentage change in the hazard for each unit decrease in the covariate (Aggrey and Marks, 2002). PROC PHREG of SAS® was used to determine the baseline hazard function and to model the effects of BW at the POL and BW at mortality as risk factors i.e. to evaluate the influence of both covariates on mortality from POL to week 45 of the laying phase.

Two chi-squared statistics (likelihood ratio and Wald tests) were used to test for the significance of the overall model and for the risk factors (i.e. BW at POL and BW at mortality).

Results and Discussion

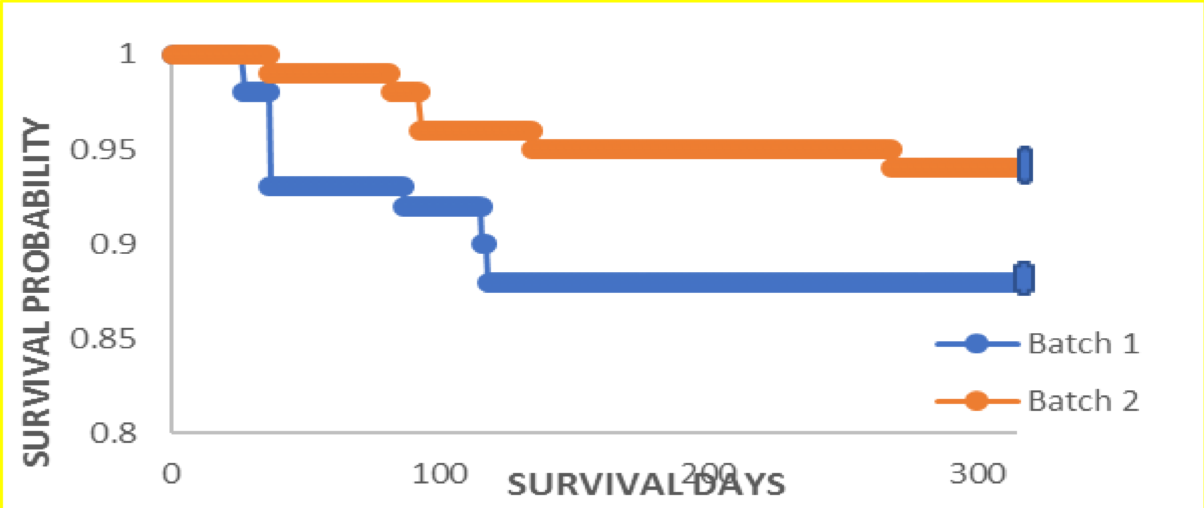
The numbers of censored and uncensored records for hens for each population used in the analysis are shown in Table1. Censored observations in this study are records for hens that survived until the end of the study (week 45 of lay). In contrast, uncensored observations are records for hens that died during the observation period (of 315 days or 45weeks of egg lay). Results showed that 131 (or 91.60%) of the 143 birds survived till the 45th week of lay, indicating that 12 (or 8.39%) mortality was observed during the study period. Fifty-three (53) of sixty (60 or 88.33%) hens in batch 1 and 79 out of 83 hens in batch 2 (93.95%) survived beyond this time-point. There has been no report on survival characteristics of laying FEC on pasture. However, Sola-Ojo and Ayorinde (2011) reported zero mortality for FEC in the cage system during the laying period. The higher percentage mortality observed in this study may be due to environmental conditions on pasture.

Figure I shows the Kaplan-Meier survival curves for the two Fulani ecotype chickens batches with the survival function distribution indicating that proportional mortality was higher in Batch 1 compared to Batch 2. Kaplan-Meier survival curves estimate survival of a population over a certain period of time and show how the probability of survival changes over time.

Table 1: Censored and uncensored records of two populations of Fulani ecotype chickens

Mortality record	Population		
	Pooled	Batch 1	Batch 2
Censored	131 (91.60%)	53 (88.33%)	78 (93.95%)
Uncensored	12 (8.39%)	7 (11.77%)	5 (6.15%)
Total	143 (100%)	60 (100%)	83 (100%)

Censored = hens alive at day 315; Uncensored = hens dead before day 315 (or 45 weeks); Pooled= combined dataset



+= Alive at day 315 (45th week of lay)
Fig. I: Kaplan-Meier Survival curves of two pastured FEC populations

Table 2 shows the results of the Cox proportional-hazard regression when the data were pooled and also for both populations of hens separately. Body weight at POL and BW at Mortality were used as risk factors for mortality in the model following Aggrey and Marks (2002). When the data were pooled across both populations, BW at mortality significantly affected the probability of mortality (p<0.0001) while BW at POL was not a significant risk factor in the pooled and separate populations. There was a significant negative relationship between BW at mortality and the chance of mortality (β=-0.00438; p<0.0001). The chance of mortality increased when body weight after POL decreased as reflected in decreased BW at mortality, indicating that any factor that causes a decrease in body weight from POL may have a negative impact on the chance of mortality. With every unit decrease in body weight post-POL, the chance of mortality increased by 0.4% (HR= 1.004**)** in the pooled dataset**.** Body weight at mortality significantly affected probability of mortality in the pooled data and in both populations. However, the magnitude was higher in population 2 than 1 i.e. 0.8% vs. 0.4% increase in risk of mortality with every unit decrease in body weight below the mean (1073.08g) of POL. This result may indicate that hens in batch 1 were more sensitive to body weight reduction post-POL compared to batch 2. These results are in line with the report of Aggrey and Marks (2002) on Japanese quails where a negative relationship was established between the probability of mortality and body weight at death for control group and divergently selected quails with the probability of mortality increasing with every unit decrease in body weight post-hatch as reflected by the body weight at mortality.

Table 2: Cox proportional-hazard regression of mortality in pastured Fulani ecotype chickens

Risk factor	df	Parameter estimate	SE	Chi-square	Pr > ChiSq	Hazard Ratio
Pooled (LR3:$x^2_{df=2}$=57.7574; $P\leq0.0001$; Wald: $\chi^2_{df=2}$ = 41.8169; $P\leq0.0001$)						
BW_POL	1	0.00843	0.00333	6.4018	0.0114	0.992
BW_Mortality	1	-0.00438	0.0007427	34.7269	<.0001**	1.004
Batch 1(LR3:$x^2_{df=2}$=31.3121; $P\leq0.0001$; Wald: $\chi^2_{df=2}$ = 17.3467; $P\leq0.0001$)						
BW_POL	1	0.00924	0.00548	2.8457	0.0916	0.991
BW_Mortality	1	-0.00402	0.00106	14.3951	<.0001**	1.004
Batch 2(LR3:$x^2_{df=2}$=27.5818; $P\leq0.0001$; Wald: $\chi^2_{df=2}$ = 14.9086; $P\leq0.0001$)						
BW_POL	1	0.00870	0.00820	1.1299	0.2878	1.012
BW_Mortality	1	-0.00619	0.00190	10.5607	<.0.0012*	1.008

Hazard ratio (HR): [(HR-1) x100] = change in risk for each unit increase in risk factor; **p<0.0001; *p<0.01
BW_POL= Body weight the at Point-of-lay; BW_Mortality= Body weight at mortality

Conclusion

Body weight at mortality is a risk factor for mortality in laying FEC. It was highly significant as a key risk factor for mortality in the pooled data, as well as in the separate analysis for each batch. It is recommended that body weight changes during the laying period should be monitored as factors that cause a decrease in body weight post-POL are potential risk factors for mortality in laying FEC hens**.**

Acknowledgement

Funding support from the EU-Funded iLINOVA project (www.ilinova.org) is gratefully acknowledged.

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