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STUDYING CAECOTROPHY BEHAVIOUR (COMPLETE AND CENSORED) IN THREE RABBIT BREEDS AT FOUR SEASONS USING DIFFERENT SURVIVAL TECHNIQUES

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ABSTRACT

Studying different rabbit behaviour is helpful in the management and breeding process. Caecotrophy behaviour and the time taken by animals to do it is an important point to be taken into consideration for its major benefits for animals. Survival techniques are the suggested statistical methods to study the time taken by animals to do this behaviour. This study depended on the observation of 96 animals of (Newzealand, California and Rex) breeds at four seasons. The results showed that the median is better than the mean as a descriptive measure. The overall median of caecotrophy time of the three breeds at different seasons was 14 sec (95% CI = 5.46 – 22.54), 15.66 sec (95% CI = 9.45 – 21.87), 11 sec (95% CI = 0.43 – 21.57) and 17.66 sec (95% CI = 10.11 – 25.21) for spring, summer, autumn and winter respectively. Log-rank (Mantel-Cox) test is significant (0.027*) among the three breeds (Newzealand, Calfornia and Rex) at spring season. Also, caecotrophy survivor functions were highly significant 0.001**, 0.033* and 0.023* among the breeds of rabbits for summer, autumn and winter respectively as their P- values were less than 0.05. The -2 Log Likelihood = 272.308 (Chi-square = 14.306 with P-value = 0.003**) for cox proportional hazard model is highly significant. The significance of the model indicated fitness of this model for the prediction of the effect of predictors on caecotrophy time. Feed consumption showed a significant effect in the model and showed an increase in the probability of taking fecal matter with increasing feeding intake.

Keywords: Survival function, Caecotrophy time, Kaplain-Meier method, rabbit breeds, log-rank method, Cox proportional hazard models.

INTRODUCTION

Rabbit breeding is considered a good source to compensate the need for meat in many developing countries (Khalil *et al.*, 2016). There are more than 40 breeds of rabbits which are bred for meat, fur, hair and shows (Stephen *et al.*, 2013). Caecotrophy is an innate behaviour of eating soft feces named ‘caecotrophes’ which consist of protein, vitamins, and inorganic salts (Yoshida and Kandatsu, 1964). This activity is observed in small herbivores, including rabbits, in order to obtain their nutritional needs. (Van Bokhorst *et al.*, 2012).

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Survival analysis was first applied in the veterinary field by Famula (1981) for studying productive life length in dairy cattle. Survival techniques are a set of different statistical methods used to examine and model data related to time. It is used to evaluate different characteristics, which are considered hours, days, weeks, months, or years (Kachman, 1999).

Data values in survival analysis are complete (the desired event occurred) or censored (the event is not observed or did not occur at the time of observation (Gurcan and Akcay, 2007). Lee and Wang (2003) divided incomplete data (censored) into three types (Type I, type II censored observations and type III) known as right censoring, left censoring and interval censoring respectively. Survival methods are classified into non-parametric techniques such as Kaplan-Meier and log-rank test, semi-parametric such as the cox model and parametric methods which belong to different distributions such as log-normal, exponential, and Weibull distribution (Collet and Kimber, 2011).

The Cox proportional hazard model (CPH) model helps in the examination of the effects of many quantitative and qualitative variables on survival. It helps in showing the differences in survival of two groups depending on hazard ratio. The hazard ratio (HR) is the proportion of the event rate at any time in a specific group (treatment group) compared to the other (control group) (Katz and Hauck, 1993).

The main advantage of the survival technique is its ability to deal with censored observations, where the outcome is not detected at the termination of the observation duration. These censored data with low biased estimates of the effect of factors affecting the study (Del *et al.,* 2005, 2006).

The purpose of this research was to apply different survival methods (non-parametric and semi-parametric)) in explaining the caecotrophy behaviour (time and frequency) as an important behaviour in rabbits by examining some important factors affecting it.

MATERIALS AND METHODS

Source of data:

Data obtained from earlier published research related to animal behaviour and handling (Gharib, 2015).

Ethical approval:

Data values were utilized with the approval of the data owner which considered the second author of this research.

The observation procedures were performed according to Abdel Fattah *et al.* (2013). Animals were observed for three days per week, at 3 different times throughout the day (from 0800 to 0900 h.), (from 1200 to 1300 h) and (from 4.00 to 5.00 pm), so each group had three daily observation periods. Caecotrophy (the trait under study) means that animals bent down, drove the head between their hind legs and ingested caecotrophs directly from the anus. Afterward, they rose and chewed intensively for a few moments.

-Mean observation time (sec) of Caecotrophy was recorded /3 hours.

-Mean frequency of Caecotrophy was recorded/3 hours.

Caecotrophy behaviour consists of two main parts: caecotrophy time (time taken to the occurrence of the desired event), and event occurrence.

Survival analysis is applied to the non-normal (skewed distribution) so it is suitable for continuous and discrete data (Lamuno *et al.,* 2017).

Survival time is the duration of the appearance of a studied outcome. This outcome may be the growth of an illness, reaction to a drug or death. Survival data can contain survival time, and effect to a specific treatment (Lee and Wang, 2003).

The survival time variable was caecotrophy time. The predictors used in the cox model were breeds of rabbit (categorical variable) and feed consumption (quantitative variable).

Different survival statistical methods:
Firstly it is important to explain the survival function and hazard function which are considered the core of survival analysis. The survivor function S(t):

$$S(t) = \text{Prob}\ (T \geq t) = 1 - \text{Prob}\ (T < t) = 1 – F(t).$$

It is the probability that a subject be alive more than some particular time t. where T is the survival time variable (Gurcan and Akcay, 2007). The survival time variable considered here caecotrophy time.

F(t) is the cumulative probability density function (the limiting probability that failure will occur between t and Δt (Kalbfleisch and Prentice, 1980).

The density function f(t):

$$f(t) = \lim_{\Delta t \to 0} \frac{prob(t \leq T < t + \Delta t)}{\Delta t} = -\frac{dS(t)}{dt}$$

The hazard function λ (t):

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{prob(t \leq T < t + \Delta t / T \geq t)}{dt} = \frac{f(t)}{S(t)} = -\frac{d \log S(t)}{dt}.$$

$$h(t) = \frac{\text{Number of subjects dying in the interval starting at time t}}{\text{(Number of subjects surviving at t)(interval width)}}$$

It is the risk that the condition will happen within a very short time period (s(t)) at duration t, given the individual did not have an event prior to that time (Lee, 1984).

A. Non-parametric survival analysis methods:

1. Kaplan-Meier or product-limit method:

This technique is suggested for presenting the survival curve from the studied survival times (survival time here is the caecotrophy time and the event of interest is taking the fecal matter). It is obtained by multiplying the k observed survival rates for each period.

$$S(k) = p_1 \times p_2 \times p_3 \times \ldots \times p_k.$$

where p_1 is the percentage of rabbits taking the fecal matter at the first duration, p_2 is the percentage of the desired event (taking the fecal matter) after the second duration conditional on having the desired event to the second duration, and so on. The proportion surviving duration i showing the event of interest to duration i is:

$$p_i = \frac{r_i - d_i}{r_i}.$$

where r_i is the rabbits' count showed the desired event at the beginning of the duration and d_i the rabbits' count didn’t show the desired within the period.

The Kaplan-Meier statistic of the survival function is found in the Kaplan-Meier curve. The Kaplan-Meier curve showed the relation between survivorship S (t) and survival time (here, time = caecotrophy time and event = do this behaviour). From this function and curve, the median of caecotrophy time for the overall sample as well as for each grouping of independent factors detected (Taufik and Suriyasataphorn, 2008).

Assumptions of Kaplan-Meier estimate:
This measure does not assume any claims about survival time shape and distribution. The presence of censoring or incomplete data (animals did not do the required event or the outcome of interest) does not affect the results (all the rabbits censored or compete share in the calculation process). Therefore, the accuracy of survival function statistics can be improved (Clark *et al.*, 2003). The survival probabilities are similar for subjects entered at the beginning and the finishing of the survey. The accurate time of event occurrence is not important but the status of each subject

is the most important (Koletsi and Pandis, 2017). No problem with skewed data.

2. Log-rank test:

It is a nonparametric method in survival analysis without assumptions about the distribution of survival times. It claims that the chance of an event occurring at any time point in different populations are similar (Koletsi and Pandis, 2017). The null hypothesis in this study stated that caecotrophy time in the studied groups is the same, while the alternative hypothesis stated that it is different between the studied groups.

Harrington (2005) showed that the log-rank test was used for comparing the estimates of survival or the hazard functions of the different classes (two or more) at every noticed event time. It calculates the observed and expected count of events in one of the classes at each observed event time and sums them to detect an overall summary across all time points where there is an event.

$$\chi^2(\log rank) = \frac{(O_1 - E_1)^2}{E_1} + \frac{(O_2 - E_2)^2}{E_2}$$

where the O_1 and O_2 represent the overall observed events in classes 1 and 2, and E_1 and E_2 are the overall expected events counts. The overall expected count of events for a class is the sum of the expected count of events at the duration of each event. The expected number of events at the time of an event is considered as the risk of dying at that time multiplied by the number of alive in the class. The risk of death (count of died/count survived) can be obtained for both classes.

The total expected number of events for class 2 is as in this equation:

$$E_2 = \sum_{i=1}^{k} \frac{d_i}{r_i} r_{2i}\,.$$

where r_{2i} is the survived count from class 2 at the time of event i. E_1 is obtained as n – E_2, where n is the total count of events. The test is contrasted with a χ^2 distribution with 1 degree of freedom (Bewick *et al.*, 2004).

B. Semi-parametric model (Cox's proportional hazard or Cox PHR or Cox regression model):

The non-parametric methods are useful in comparing survival curves between classes. Cox proportional-hazards regression helps in examining the impact of many risk factors on survival.

It is similar to linear regression in describing the relation between some predictors and a variable under study (dependent) and making the prediction process in the dependent. The Cox model predicts the hazard function, and not Y (response) itself without intercept (any intercept absorbed into the baseline hazard).

Mathematics of the model:

The likelihood of the endpoint (event of interest) is known as the hazard. The event of interest here is taking the fecal matter. The hazard is modeled as:

$$H(t) = H_0(t) \times \exp(b_1x_1 + b_2x_2 + b_3x_3 + ...+ b_kx_k)$$

where H(t) is the expected hazard at time t, X_1 ... …X_k are the independent factors and $H_0(t)$ is the baseline hazard at time t, explaining the hazard for a subject with the value zero for all the independent factors. Exp. is the exponential function (exp(x)= e^x).

$$\ln\left(\frac{H(t)}{H_0(t)}\right) = (b_1x_1 + b_2x_2 + b_3x_3 + ...+ b_kx_k)$$

H (t) / H_0(t) is known as the hazard ratio. The coefficients b_{i},..., b_k are calculated by Cox proportional hazard regression model, and can be explained as in multiple logistic regression.

The model assumptions:

The survival times between specific subjects in the sample are independent, the explanatory factors and the hazard are multiplied and a constant hazard ratio over time with non-specified baseline hazard function, ho (t). h_o (t) can be estimated accurately if S(t) is estimated (Deo *et al.*, 2021).

The hazard ratio:
Cox's model aimed to asses hazard ratio, HR (risk ratio or relative risk), which detects the ratio of the rates of desired events at the specific value compared with both rates at a reference value, respectively. If the risk of doing the desired event at a specific value was more than 1, it indicated that the rate of doing the desired event at a specific value was larger than the rate of doing the desired event of the reference value (Suriyasathaporn, 2006).
The proportionality assumption showed that the ratio of hazards in any two classes stays constant over time (Van Dijk *et al.*, 2008). It measures the effect of the explanatory variables on caecotrophy time. This proportionality assumption depended on the log minus log survival plot to be examined, where non-intersected (parallel) curves are a good indicator for proportional hazard assumption. For categorical variables, such as breeds of rabbits, the hazard ratios were compared with the reference class. The relative risk of quantitative covariates (feed consumption) reveals that for each unit change in the X variable, the hazard of the event is multiplied by e^{β}.

$$HR = \frac{h(t, x^*)}{h(t, x)}.$$

Maximum Likelihood estimation of the Cox's model:
It is a test statistic for comparing two models and taking a decision for the null model which considers all regression coefficients for covariates are zero and the alternative model. It is -2 times the variance between the first and latter model likelihood values and it follows a chi-square distribution with k degrees of freedom (number of explanatories). Only the -2 Log likelihood value is taken.

$$D = -2\ln\left(\frac{\text{likelihood for null model}}{\text{likelihood for alternative model}}\right)$$
$$= -2\ln(\text{likelihood for null model}) + 2\ln(\text{likelihood for alternative model})$$

The full likelihood is important for deriving the form of the baseline hazard. The likelihood function L for CPHM is known as the "partial" likelihood function because it only investigates probabilities for failed individuals clearly. The Cox partial likelihood is

$$l(\beta) = \prod_{j=1}^{k} \frac{\exp(\sum_{i=1}^{p} \beta_i X_{(j)i})}{\sum_{l\in R(t_{(j)})} \exp(\sum_{i=1}^{p} \beta_i X_{li})}$$

when k different failure times t(1) < t(2) < ……< t(k) with exactly one failure at each time, [i] is the individual with an event at time t(i), and R(t) is the risk set at time t.

RESULTS

Kaplan-Meier estimate findings:
Descriptive statistics for caecotrophy time till the occurrence of the event (taking the fecal matter) of rabbits were calculated as in **Table 1**.

The median is better than the mean in the data description in the case of survival analysis for many reasons (Van Dijk *et al.*, 2008). These reasons are the process of data censoring as the mean is difficult to be calculated in case of incomplete data, no need for a mean in case of non-parametric methods, and skewness of survival time data.

Table 1: Survival function estimates or the Kaplan-Meier method for caecotrophy time in three rabbit breeds at four seasons. Means and medians for survival time of caecotrophy time.

Season	Breeds	Mean				Median			
		Estimate	SE	95% Confidence Interval (CI)		Estimate	SE	95% Confidence Interval (CI)	
				Low Bound	Upper Bound			Low Bound	Upper Bound
Spring	**Newzealand**	21.56	5.62	10.54	32.57	18.00	10.20	0.00	37.99
	Calfornia	6.42	2.57	1.37	11.46	4.00	1.17	1.71	6.29
	Rex	17.75	4.22	9.48	26.01	15.66	4.50	6.84	24.48
	Overall	16.14	3.15	9.97	22.31	14.00	4.35	5.46	22.54
Summer	**Newzealand**	27.99	3.76	20.63	35.37	27.66	6.17	15.56	39.74
	Calfornia	6.42	2.57	1.37	11.46	4.00	1.17	1.71	6.29
	Rex	17.75	4.22	9.48	26.01	15.66	4.50	6.84	24.48
	Overall	17.39	3.25	11.01	23.76	15.66	3.17	9.45	21.87
Autumn	**Newzealand**	24.26	8.27	8.06	40.47	27.66	18.25	0.00	63.43
	Calfornia	5.53	2.18	1.26	9.81	4.00	1.47	1.12	6.88
	Rex	13.99	2.73	8.65	19.34	15.66	5.72	4.46	26.86
	Overall	14.69	3.91	7.02	22.36	11.00	5.39	0.43	21.57
Winter	**Newzealand**	24.59	4.48	15.83	33.37	27.66	10.58	6.92	48.40
	Calfornia	7.22	3.46	0.45	13.99	5.00	1.91	1.26	8.75
	Rex	18.44	5.89	6.91	29.97	17.66	7.35	3.26	32.06
	Overall	18.18	3.37	11.58	24.78	17.66	3.85	10.11	25.21

-SE is the standard error

The following figure represents different survival curves for different breeds at different seasons with censored and complete data of caecotrophy time.

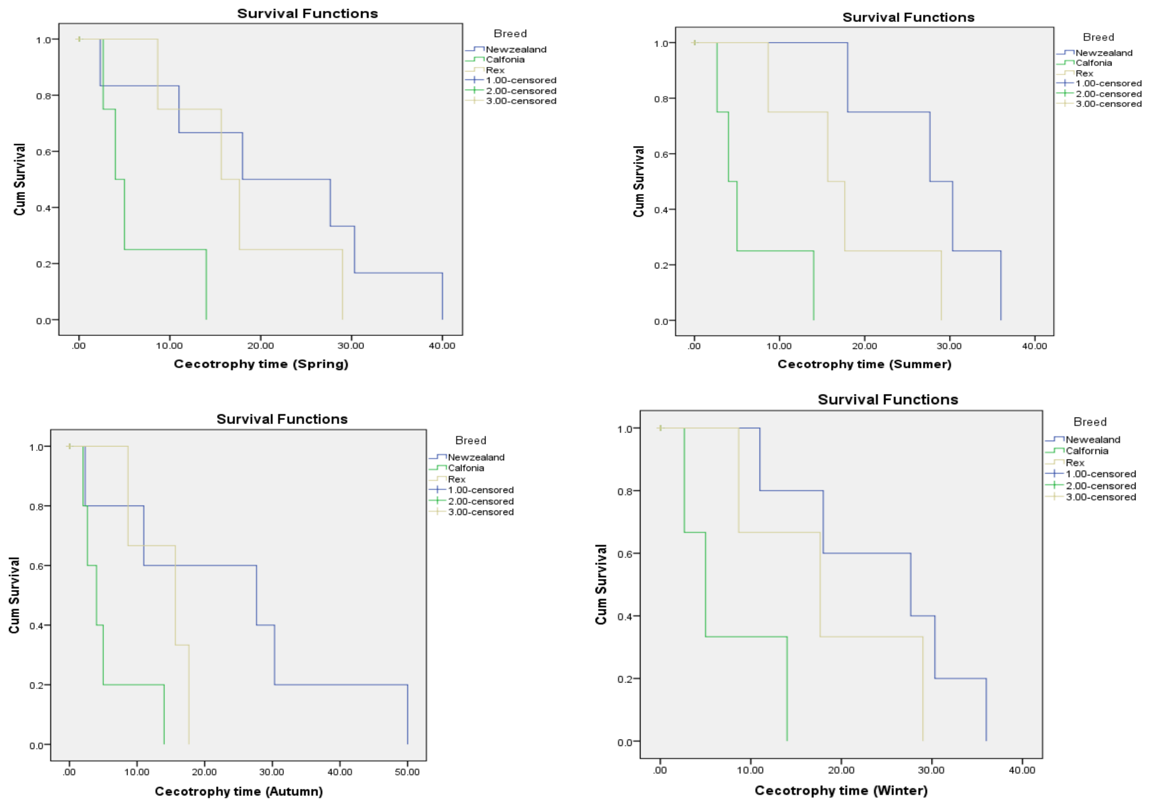

Figure 1: Survival curves of the three breeds (Kaplan-Meier plot) showing the proportion of censored data in the form of cumulative survival probability on the Y-axis along with the time to event occurrence (on the X-axis).

The log-rank (Mantel-Cox) test findings:

For comparing the survival curves of different breeds at four seasons (Table 2).

Table 2: Logrank (Mantel-Cox) for comparison of Caecotrophy time among the three rabbit breeds at different seasons.

Season	Breeds	Logrank (Mantel-Cox)		
		Chi-square	df	Sig.
Spring	Newzealand	7.20	2	0.027
	Calfornia			
	Rex			
Summer	Newzealand	13.05	2	0.001
	Calfornia			
	Rex			
Autumn	Newzealand	6.79	2	0.033
	Calfornia			
	Rex			
Winter	Newzealand	7.53	2	0.023
	Calfornia			
	Rex			

-df is the degrees of freedom – sig. is the p value.

Cox model findings:

It is shown that non-parametric survival methods were important but they didn't show any effect of other variables on the caecotrophy time, so the Cox proportional hazard regression model was applied (Bahonar *et al.,* 2009). Cox model can deal with any type of variable (quantitative with its types, or qualitative) that could be used as a factor in this model (Hallan *et al.*, 2006).

The result of log-likelihood chi-square of the overall model was 272.31 (Chi-square =14.74, df =2 and P value = 0.002**) as shown in Table (3) where a highly significant difference was found, so the covariates have a significant effect on the probability of occurring the desired event (hazard rate). This Cox proportional hazard equation is suitable for studying the effects of independent variables on caecotrophy time.

Table 3: Maximum Likelihood estimation of the Cox proportional hazard model (omnibus tests of model coefficients).

-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
	Chi-square	df	Sig.	Chi-square	df	Sig.	Chi-square	df	Sig.
272.31	14.74	3	0.002	14.31	3	0.003	14.31	3	0.003

-df is the degrees of freedom – sig. is the p-value.

The proportional hazards assumption was achieved as presented in Figure 2. The log minus log survival plot had parallel and not intersected lines for the caecotrophy time for the three rabbit breeds.

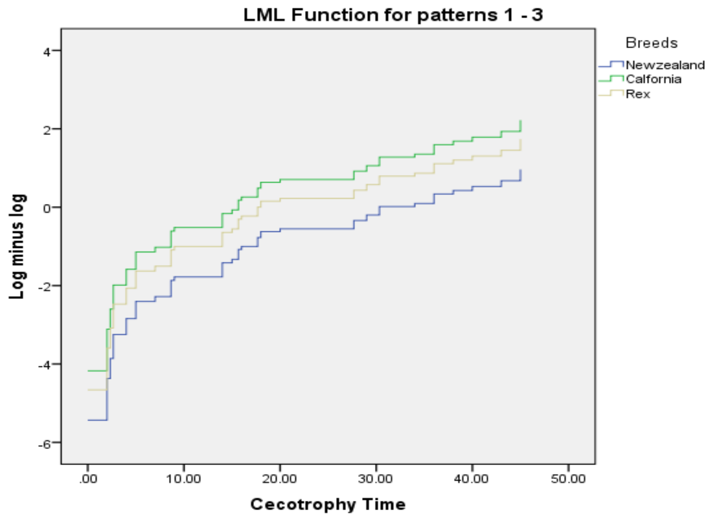

Figure 2: Log minus log plot for visual presentation of the proportional hazard assumption of the Cox regression model. It explained the log minus log survival function for caecotrophy time of different rabbit breeds.

The Cox model results for testing the effect of breed and feed consumption factors, on the caecotrophy time was shown in Table 4.

Table 4: Cox proportional hazard regression survival model (main effects) without interaction for the effect of covariates on the caecotrophy time.

Covariate	β	SE (β)	Wald $[\beta / SE(\beta)]^2$	df	Sig.	Exp(β) Hazard ratio	95.0% CI for Exp(β)	
							Lower	Upper
Breeds			10.97	2	0.004			
Newzealand	-0.78	0.38	4.098	1	0.043	0.46	0.22	0.98
Calfornia	0.48	0.38	1.66	1	0.198	1.62	0.78	3.39
Feed consumption	0.015	0.007	4.99	1	0.026	1.02	1.002	1.03

- β beta coefficient -df is the degrees of freedom – sig. is the p value – CI confidence interval

DISCUSSION

The median caecotrophy time was 18, 4, and 15.66 for New Zealand, California and Rex breeds respectively in the spring season. The median caecotrophy time was 27.66, 4, and 15.66 for New Zealand, California and Rex breeds respectively during the summer season. The median of caecotrophy time was 27.66, 4, and 15.66 for New Zealand, Calfornia and Rex breeds respectively during the autumn season. The median caecotrophy time was 27.66, 5, and 17.66 for New Zealand, California and Rex breeds respectively in the winter season.

The Kaplan-Meier graph explained the percent of rabbits which didn't take their fecal matter (censored rabbits) that were calculated by the cumulative survival probabilities at any time point in different breeds at different seasons as in Figure (1). This figure started with all rabbits and every down in the curve shows a failure (no eating fecal matter). For every breed, fifty percent of censored rabbits match the median estimates of time to take fecal matter (caecotrophy time). Any vertical line in this curve across the X-axis explains the median caecotrophy where fifty percent of rabbits have been eaten fecal matter.

The log-rank test presented highly significant differences between New Zealand, California and Rex breeds where (χ^2 = 7.20, df = 2 and P = 0.027**) at spring season. The test also gave a highly significant difference among different breeds (χ^2 = 13.05, df = 2, P = 0. 001**) during the summer season. Also, the test showed highly significant differences among different breeds (χ^2 = 6.79, df = 2, P = 0. 033**) during the autumn season. There were a showed highly significant differences among different breeds (χ^2 = 7.53, df = 2, P = 0. 023**) during the winter season.

In the Cox model, the breeds New Zealand and California were compared versus with Rex breed (last one) which is considered a reference category.

Generally, the effect of different breeds on caecotrophy behavior was highly significant (Wald Chi-square statistic = 10.97, df = 2, P = 0.004**). The hazard ratios (HR) used to explain the difference in caecotrophy time for New Zealand and California rabbit breeds with Rex. The hazard ratio for the New Zealand breed was 0.46, which indicated that rabbits taking fecal matter in New Zealand breeds were 2.17 (1 / 0.46) times lower (HR < 1, beta was negative) than those of Rex taking the fecal matter. Similarly, the hazard ratio for the California breed with Rex was 1.62 which means that the risk or the probability of taking fecal matter for rabbits is 1.62 times more than for rabbits taken in the Rex breed.

The probabilities of taking the fecal matter of rabbits were significant (P = 0.043) for the New Zealand breed and non-significant (P = 0.198) for the California breed depending on the Wald test values (Table 4).

The other quantitative (continuous) factor is considered a hazard determinant for caecotrophy time (Table 4). Feed consumption has a significant effect on caecotrophy time (Wald chi-square value = 4.99, df = 1, P = 0.026). Taking the hazard ratio estimate (1.02) for feed consumption indicated that the probability of taking fecal matter was increased by 15 % [β] for every one-unit increase in feed consumption.

The negative sign of the parameter estimates (negative β) indicated the reduction in the expected log of the relative hazard for every one-unit increase in the explanatory factor, maintaining the other factors fixed (Zhao, 2008).

The positive sign of the Cox model coefficient meant the positive correlation between feed consumption and the probability of doing the event of interest. There was an increase in the incidence of taking fecal matter with the increase in feed consumption.

CONCLUSION

This study focused on using different techniques of survival analysis. These methods are important in studying data related to time. It is used to study caecotrophy time as an important behavior in rabbits. Kaplan-Meier non-parametric methods showed the survival curves caecotrophy time in different breeds while the log-rank test compared the survival curves between the New Zealand, California and Rex breeds. The Cox model explained the effect of different covariates (qualitative and quantitative) on caecotrophy time. The hazard ratios were used to distinguish between covariates affecting the time variable to detect which variables cause an increase or decrease in the probability of event occurrence. So survival analysis is suggested for studying any important behavior related to time.

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دراسة سلوك تناول البراز (البيانات الكاملة والمبتورة) في ثلاث سلالات من الأرانب في الفصول الأربعة باستخدام اساليب تحليل البقاء المختلفة

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دراسة سلوكيات الأرانب المختلفة تعتبر مفيدة في عمليات الرعاية والتربية. يعتبر سلوك تناول البراز والوقت المستغرق للقيام به نقطة مهمة يجب أخذها بعين الإعتبار لفوائدها الرئيسية للحيوان. تعتبر أساليب تحليل البقاء هي الأساليب الإحصائية المقترحة لدراسة الوقت الذي تستغرقه الحيوانات للقيام بهذا السلوك.

اعتمدت هذه الدراسة على ملاحظة ٩٦ حيوان من سلالات (نيوزيلندا، كالفورنيا، وركس) في أربعة مواسم. أظهرت النتائج أن الوسيط أفضل من المتوسط كمقياس وصفي. كان الوسيط الكلي لوقت تناول البراز في السلالات الثلاثة في الفصول المختلفة كان ١٤ ثانية بحدود ثقة ٩٥% (٥,٤٦-٢٢,٥٤) و ١٥,٦٦ ثانية بحدود ثقة ٩٥% (٩,٤٥-٢١,٨٧) و ١١ ثانية بحدود ثقة ٩٥% (٠,٤٣-٢١,٥٧) و ١٧,٦٦ ثانية بحدود ثقة ٩٥% (١٠,١١-٢٥,٢١) لفصول الربيع والصيف والخريف والشتاء علي التوالي.

اعتبر اختبار Log-rank (Mantel-Cox) معنويا بقيمة (٠,٠٢٧) بين السلالات الثلاثة (نيوزيلندا، كالفورنيا وريكس) في فصل الربيع. كما كانت دالة البقاء معنوية للغاية بقيمة ٠,٠٠١ و٠,٠٣٣ و٠,٠٢٣ بين سلالات الأرانب لفصل الصيف والخريف والشتاء على التوالي حيث كانت قيمة P أقل من ٠,٠٥.

كانت قيمة 2- Log Likelihood تساوي ٢٧٢,٣٠٨ حيث كانت قيمة مربع كاي تساوي ١٤,٣٠٦ وقيمة P تساوي ٠,٠٠٣ بالنسبة لنموذج cox proportional hazard model الذي يعتبر معنوي جدا. معنوية هذا النموذج دلت علي ملاءمته للتنبؤ بتأثير العوامل المؤثرة علي وقت تناول البراز. استهلاك الطعام أوضح تأثير معنوي في النموذج حيث أنه أوضح احتمالية زيادة تناول البراز مع زيادة تناول الطعام.